UFC 3-310-04
1 May 2012

UNIFIED FACILITIES CRITERIA (UFC)

SEISMIC DESIGN OF BUILDINGS

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SEISMIC DESIGN OF BUILDINGS

U.S. ARMY CORPS OF ENGINEERS (Preparing Activity)

NAVAL FACILITIES ENGINEERING COMMAND

AIR FORCE CIVIL ENGINEER SUPPORT AGENCY

Record of Changes (changes are indicated by **\1** ... **/1/**)

Change No.	Date	Location

This UFC supersedes UFC 3-310-04, dated June 22, 2007, with Change 1, dated January 27, 2010. The format of this document does not conform to UFC 1-300-01.

FOREWORD

The Unified Facilities Criteria (UFC) system is prescribed by MIL-STD-3007 and provides planning, design, construction, sustainment, restoration, and modernization criteria, and applies to the Military Departments, the Defense Agencies, and the DoD Field Activities in accordance with USD (AT&L) Memorandum dated 29 May 2002. UFC will be used for all DoD projects and work for other customers where appropriate. All construction outside of the United States is also governed by Status of Forces Agreements (SOFA), Host Nation Funded Construction Agreements (HNFA), and in some instances, Bilateral Infrastructure Agreements (BIA.) Therefore, the acquisition team must ensure compliance with the most stringent of the UFC, the SOFA, the HNFA, and the BIA, as applicable.

UFC are living documents and will be periodically reviewed, updated, and made available to users as part of the Services' responsibility for providing technical criteria for military construction. Headquarters, U.S. Army Corps of Engineers (HQUSACE), Naval Facilities Engineering Command (NAVFAC), and Air Force Center for Engineering and the Environment (AFCEE) are responsible for administration of the UFC system. Defense agencies should contact the preparing service for document interpretation and improvements. Technical content of UFC is the responsibility of the cognizant DoD working group. Recommended changes with supporting rationale should be sent to the respective service proponent office by the following electronic form: Criteria Change Request (CCR). The form is also accessible from the Internet sites listed below.

UFC are effective upon issuance and are distributed only in electronic media from the following source:

- Whole Building Design Guide web site http://dod.wbdg.org/.

Hard copies of UFC printed from electronic media should be checked against the current electronic version prior to use to ensure that they are current.

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TABLE OF CONTENTS

TABLES

FIGURES

CHAPTER 1 SEISMIC DESIGN FOR BUILDINGS

1-1 PURPOSE AND SCOPE.

These Unified Facilities Criteria (UFC) provide technical guidance for the earthquake-resistant ("seismic") design of new buildings, and nonstructural systems and components in those buildings, for the Department of Defense (DoD), based on an adaptation of the 2009 Edition of the *International Building Code* (2009 IBC) and the structural standard referenced by it: ASCE 7-05 *Minimum Design Loads for Buildings and Other Structures*. The criteria further provide limited technical guidance for seismic evaluation and strengthening of existing buildings. This information shall be used by structural engineers to develop design calculations, specifications, plans, and Design-Build Requests for Proposals (RFPs), and it shall serve as the minimum seismic design requirement for DoD buildings.

1-2 APPLICABILITY

This UFC applies to all service elements and contractors involved in the planning, design, and construction of DoD facilities worldwide.

1-3 CONFLICTS AND MODIFICATIONS.

The 2009 IBC provisions are directed toward public health, safety, and general welfare, presenting minimum standards that must be met by the private sector construction industry. The use of industry standards for DoD projects promotes communication in the marketplace, improves competition, and results in cost savings. However, the military sometimes requires higher standards to achieve unique building performance, or to construct types of facilities that are not used in the private sector. In addition, the construction of military facilities outside the United States can introduce requirements that are not addressed in national model building codes. Modifications to the 2009 IBC and ASCE 7-05 provisions contained herein are intended to fulfill those unique military requirements. When conflicts between the 2009 IBC or ASCE 7-05 and this UFC arise, the UFC shall prevail.

In addition, for construction outside the United States, conflicts between host nation building codes and the UFC may arise. In those instances, the more stringent design provisions shall prevail. Any apparent conflicts shall be brought to the attention of the Authority having Jurisdiction.

1-4 IMPLEMENTATION.

This UFC is effective immediately.

Chapter 2 of the UFC lists modifications for specific 2009 IBC and ASCE 7-05 sections for use in seismic design of DoD buildings. A few of these modifications implement changes that will occur in ASCE 7-10.

1-5 STRUCTURE OF THE UFC.

This UFC cites the 2009 IBC as the primary basis for seismic design of new DoD buildings and their integral nonstructural systems and components. The 2009 IBC shall serve as the basic seismic design document for new DoD buildings. Where needed, modifications to the 2009 IBC and its referenced structural standard, ASCE 7-05, are provided in this UFC. Brief descriptions of the various chapters and appendices of this UFC follow.

- Chapter 2 – 2009 BUILDING CODE MODIFICATIONS FOR CONVENTIONAL SEISMIC DESIGN FOR DOD BUILDINGS. Chapter 2 provides supplemental requirements for applying the 2009 IBC and ASCE 7-05 seismic provisions to conventional DoD building design by listing required modifications for specific 2009 IBC and ASCE 7-05 sections. The 2009 IBC sections that are not referenced in Chapter 2 or otherwise modified by provisions of Chapters 3 and 4 shall be applied as they are written in the 2009 IBC.

- Chapter 3 – ALTERNATE DESIGN PROCEDURE FOR BUILDINGS AND OTHER STRUCTURES IN OCCUPANCY CATEGORY IV. For buildings in Occupancy Category IV, those that are "essential" because of their military function or the need for them in post-earthquake recovery efforts, the 2009 IBC /ASCE 7-05 requires higher design lateral loads and more stringent structural detailing procedures than those for buildings in Occupancy Category I, II & III. Applying nonlinear analysis procedures may result in more economical or better-performing Occupancy Category IV buildings than linear elastic procedures will provide. While the 2009 IBC/ASCE 7-05 permits nonlinear analysis procedures, it provides little guidance on how to perform them. Chapter 3 presents optional nonlinear analysis procedures that may be used for Occupancy Category IV buildings. The optional nonlinear procedures outlined in Chapter 3 shall be applied only with the approval of the Authority having Jurisdiction.

- CHAPTER 4 – DESIGN FOR ENHANCED PERFORMANCE OBJECTIVES: Occupancy Category V. The 2009 IBC addresses Occupancy Category I, II, III, & IV for seismic design of buildings. Occupancy Category IV is the "highest" occupancy category listed in the 2009 IBC, and includes such facilities as hospitals and fire stations. In DoD, Occupancy Category IV buildings also include installation command posts and other functions that are critical to installation function. UFC 3-301-01, *Structural Engineering*, creates an Occupancy Category V for nationally strategic assets, those that are singular and irreplaceable and must function to support strategic defense of the United States. Facilities associated with the National Missile Defense System exemplify Occupancy Category V. The criticality of these facilities extends beyond the normal "life-safety" and "operational" scope of national model building codes, creating the need for military-unique design requirements. Table 2-2 of UFC 3-301-01 lists building occupancies that are included in Occupancy Category V. Any classification of a building as Occupancy Category V shall require the approval of the Authority having Jurisdiction. Chapter 4 provides Occupancy Category V seismic design requirements and requires that a building's structural system remain linearly elastic when exposed to specified earthquake ground motions. It also requires that all critical installed equipment remain fully functional during and after those motions. It is anticipated that the number of buildings that will be designated Occupancy Category V will be small.

- Appendix A – REFERENCES. The UFC has an extensive list of referenced public documents. The primary references for this UFC are the 2009 IBC and ASCE 7-05.

- Appendix B – GUIDANCE FOR SEISMIC DESIGN OF ARCHITECTURAL, MECHANICAL, AND ELECTRICAL COMPONENTS. Appendix B provides guidance for seismic design of nonstructural components. Requirements for design of nonstructural components in Chapters 2, 3, and 4 are supplemented by guidance provided in Appendix B.

- Appendix C – MECHANICAL AND ELECTRICAL COMPONENT CERTIFICATION. Appendix C provides guidance in addition to what is available in ASCE 7-05 Section 13.2.2 on certification of mechanical and electrical components.

1-6 COMMENTARY.

Limited commentary has been added in the chapters. Section designations for such commentary are preceded by a "[C]", and the commentary narrative is shaded.

1-7 PROCEDURES FOR APPLYING UFC 3-310-04 FOR STRUCTURAL DESIGN.

Most DoD seismic design requirements are based on the 2009 IBC. The 2009 IBC is in turn based on ASCE 7-05. The first step in seismic design is to determine the Occupancy Category for the building that is under consideration, based on its function. The appropriate Occupancy Category is determined from Table 2-2 of UFC 3-301-01. Earthquake loading (spectral acceleration) data for sites within the United States, its territories, and its possessions, are found in Table E-2 of UFC 3-301 -01. Earthquake loading data for sites outside the United States, its territories, and its possessions, are found in Tables F-2 and G-1 of UFC 3-301-01. For buildings classified in Occupancy Category I, II, III, & IV, structural design shall be accomplished in accordance with the provisions of Chapter 2, which modifies the 2009 IBC and ASCE 7-05 for application to DoD buildings. For buildings classified in Occupancy Category IV, Chapter 2 permits optional use of the nonlinear procedure outlined in Chapter 3. For buildings classified in Occupancy Category V, designers shall apply the provisions of Chapter 4. The structural provisions of Chapters 2 and 3 shall not be used for buildings classified in Occupancy Category V, except when specifically stipulated in Chapter 4. It is expected that designers might highlight or otherwise mark those paragraphs of the 2009 IBC and ASCE 7-05 that are modified by this UFC.

1-7.1 Progressive Collapse Analysis and Design.

UFC 4-023-03, *Design of Buildings to Resist Progressive Collapse*, shall apply in the design of DoD buildings that are three stories or more in height, if required by UFC 4-010-01, *DoD Minimum Antiterrorism Standards for Buildings*. UFC 3-310-04 and UFC 4-023-03 shall both apply in that case. Design in accordance with one does not guarantee compliance with the other.

1-8 APPLYING UFC 3-310-04 FOR DESIGN OF NONSTRUCTURAL COMPONENTS.

For Buildings classified in Occupancy Category I, II, III (see Section 1-6), design of architectural, mechanical, and electrical ("nonstructural") components shall be accomplished in accordance with the provisions of Chapters 2, 3, 4, which modify the provisions of the 2009 IBC and ASCE 7-05 for application to DoD buildings. Chapter 3 lists modifications of Chapter 2 for use in the alternative design procedure for Occupancy Category IV buildings. Chapter 4 lists modifications of Chapter 2 for use in the design of Occupancy Category V buildings. Appendix B provides guidance for nonstructural component design. Appendix C provides guidance on the certification of electrical and mechanical equipment requiring certification. It is expected that designers might highlight or otherwise mark those paragraphs of the 2009 IBC and ASCE 7-05 that are modified by this UFC.

1-9 ACRONYMS AND ABBREVIATIONS

3-D	Three dimensional
ACI	American Concrete Institute
AFCESA	Air Force Civil Engineer Support Agency
AISC	American Institute of Steel Construction
ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
BSO	Basic Safety Objective
BSSC	Building Seismic Safety Council
CBC	California Building Code
CCB	Construction Criteria Base
CEFAPP	CERL Equipment Fragility and Protection Procedure
CERL	Construction Engineering Research Laboratory (formerly USACERL)
CISCA	Ceilings & Interior Systems Construction Association
DoD	Department of Defense
DoE	Department of Energy
EB	Existing Building
EIA	Electronic Industries Alliance
ELF	Equivalent Lateral Force
EPRA	Electric Power Research Institute
ERDC	U.S. Army Engineer Research and Development Center

ERO	Enhanced Rehabilitation Objective
FEMA	Federal Emergency Management Agency
GERS	Generic Equipment Ruggedness Spectra
GIP	Generic Implementation Procedure
GSREB	Guidelines for Seismic Retrofit of Existing Buildings
HQUSACE	Headquarters, U.S. Army Corps of Engineers
HVAC	Heating, Ventilating, and Air Conditioning
IBC	International Building Code
ICC-ES	International Code Council – Evaluation Service
IEEE	Institute of Electrical and Electronics Engineers
IMF	Intermediate Moment Frame
IO	Immediate Occupancy (performance objective/level)
ISAT	International Seismic Application Technology
LS	Life Safety (performance objective/level)
MC-1	Mission-Critical Level 1
MC-2	Mission-Critical Level 2
MCE	Maximum Considered Earthquake (ground motions)
MDD	Maximum In-Plane Diaphragm Deflection
MRSA	Modal Response Spectrum Analysis
MSJC	Masonry Standards Joint Committee
NAVFAC	Naval Facilities Engineering Command
NDP	Nonlinear Dynamic Procedure
NMC	Non-Mission-Critical
NEHRP	National Earthquake Hazards Reduction Program
NFPA	National Fire Protection Association
NRC	Nuclear Regulatory Commission

NSP	Nonlinear Static Procedure
OC	Occupancy Category
OMF	Ordinary Moment Frame
PUC	Provisions Update Committee
RFPs	Request for Proposals
RRS	Required Response Spectrum
SDC	Seismic Design Category
SDWG	Structural Discipline Working Group
SEI	Structural Engineering Institute
SQUG	Seismic Qualification Utility Group
SSRAP	Senior Seismic Review and Advisory Panel
TDLF	Total Design Lateral Force
TI	Technical Instruction
TIA	Tentative Interim Agreement; Telecommunications Industry Association
TMS	The Masonry Society
UFC	Unified Facilities Criteria
UFGS	Unified Facilities Guide Specifications
USACERL	former acronym for ERDC-CERL
USGS	U.S. Geological Survey
USACE	U.S. Army Corps of Engineers
UUT	Unit Under Test
ZIP	Zoning Improvement Plan

CHAPTER 2 2009 IBC MODIFICATIONS FOR SEISMIC DESIGN FOR DOD BUILDINGS

The 2009 International Building Code (2009 IBC) is adopted as the building code for DOD projects. UFC 3-310-04 supplements the requirements of UFC 1-200-01, *General Building Requirements*, by defining modifications to the 2009 IBC related specifically to seismic design of buildings. In the following narrative, required modifications to the provisions of the 2009 IBC are listed. The modifications are referenced to specific sections in the 2009 IBC that must be modified. Any section in the 2009 IBC that is not specifically referenced shall be applied as it is written in the 2009 IBC. The 2009 IBC adopts by reference extensive portions of ASCE/SEI 7-05, *Minimum Design Loads for Buildings and Other Structures* (ASCE 7-05). This UFC modifies some sections in ASCE 7-05 in the same manner as is described for the 2009 IBC. An example section number in this chapter is 2-1603.1.5 or 2-13.6.7. The first number, 2, refers to Chapter 2 of this UFC. 1603.1.5 refers to 2009 IBC Section 1603.1.5 and 13.6.7 refers to ASCE 7-05 Section 13.6.7. It is expected that designers may highlight or otherwise mark those paragraphs of the 2009 IBC, RP 8, and ASCE 7-05 that are modified by this UFC. The required 2009 IBC, RP 8, and ASCE 7-05 section modifications are one of four actions, according to the following legend:

[Addition] – New section added, includes new section number not shown in the 2009 IBC, RP 8, or ASCE 7-05.

[Deletion] – Delete referenced 2009 IBC, RP 8, or ASCE 7-05 section.

[Replacement] – Delete referenced 2009 IBC, RP 8, or ASCE 7-05 section and replace it with the narrative shown.

[Supplement] – Add narrative shown as a supplement to the narrative shown in the referenced section of the 2009 IBC, RP 8,or ASCE 7-05.

In a number of instances, provisions of ASCE/SEI 7-10, *Minimum Design Loads for Buildings and Other Structures*, are adopted herein. These adopted provisions represent substantive changes from ASCE/SEI 7-05 to ASCE/SEI 7-10. With the tri-services adoption of the 2012 *International Building Code* (2012 IBC), the ASCE/SEI 7-10 provisions will be adopted by reference, and those provisions will no longer be listed in future editions of this UFC.

2-16 STRUCTURAL DESIGN

2-1603 CONSTRUCTION DOCUMENTS

2-1603.1.5 [Supplement] Earthquake Design Data.

Item 2 covering mapped spectral response accelerations shall be modified to indicate the source of the acceleration data, including source date and author. If the data are based on site-specific response analysis, that shall be noted. Site-specific source data shall also note whether response spectrum or time-history analyses were performed.

2-1603.1.9 [Replacement] Systems/Components Requiring Special Inspection for Seismic Resistance.

Construction documents or specifications shall be prepared for those systems and components requiring special inspection for seismic resistance, as specified in 2009 IBC Section 1707 and modified by Section 2-1707 of this UFC, by the Registered Design Professional responsible for their design. Reference to seismic standards in lieu of detailed drawings is acceptable.

2-1604.5 UFC [Supplement] Occupancy Category.

2009 IBC Table 1604.5 shall be replaced by UFC 3-301-01 Table 2-2.

2-1612 FLOOD LOADS

2-1612.6 [Addition] Tsunami.

Occupancy Category (OC) I, II, III, and IV facilities are recommended to be designed to mitigate the effects of Tsunami in conformance with Appendix M to the 2012 IBC reproduced below. All mitigation methods will require approval by the AHJ. Approval by the AHJ will be required for an Occupancy Category III or IV facility to be located within Tsunami inundation zones. In 2012 IBC Section M101.4 below, replace “Risk Category” with “Occupancy Category.”

2012 IBC SECTION M101
TSUNAMI-GENERATED FLOOD HAZARD

M101.1 General. The purpose of this appendix is to provide tsunami regulatory criteria for those communities that have a tsunami hazard and have elected to develop and adopt a map of their tsunami hazard inundation zone.

M101.2 Definitions. The following words and terms shall, for the purposes of this appendix, have the meanings shown herein.

TSUNAMI HAZARD ZONE MAP. A map adopted by the community that designates the extent of inundation by a design event tsunami. This map shall be based on the tsunami inundation map which is developed and provided to a community by either the applicable State agency or the National Atmospheric and Oceanic Administration (NOAA) under the National Tsunami Hazard Mitigation Program, but shall be permitted to utilize a different probability or hazard level.

TSUNAMI HAZARD ZONE. The area vulnerable to being flooded or inundated by a design event tsunami as identified on a community’s Tsunami Hazard Zone Map.

M101.3 Establishment of Tsunami Hazard Zone. Where applicable, if a community has adopted a Tsunami Hazard Zone Map, that map shall be used to establish a community’s Tsunami Hazard Zone.

M101.4 Construction within the Tsunami Hazard Zone. Construction of structures designated Risk Category III and IV as specified under Section 1604.5 shall be prohibited within a Tsunami Hazard Zone.

Exceptions:

1. A vertical evacuation tsunami refuge shall be permitted to be located in a Tsunami Hazard Zone provided it is constructed in accordance with FEMA P646.
2. Community critical facilities shall be permitted to be located within the Tsunami Hazard Zone when such a location is necessary to fulfill their function, providing suitable structural and emergency evacuation measures have been incorporated.

2012 SECTION M102
REFERENCED STANDARDS

FEMA P646-08	Guidelines for Design of Structures for Vertical Evacuation from Tsunamis	M101.4

2-1613 EARTHQUAKE LOADS

2-1613.1 [Supplement] Scope.

For structures in Occupancy Categories (OCs) I through IV, wherever ASCE 7-05 Table 12.2-1 is referenced, it shall be replaced by Table 2-1 of this Chapter.

[C] 2-1613.1 [Supplement] Scope.

Although Chapter 14 of ASCE 7-05 is not adopted by the 2009 IBC, occasional references to ASCE 7-05 Chapter 14 sections are made in this UFC.

2-1613.3 [Supplement] Existing Buildings.

Additions, alterations, repairs, changes of occupancy, relocations, or acquisitions of existing buildings or portions of existing buildings shall be in accordance with 2009 IBC Chapter 34 as modified by this Chapter.

[C] 2-1613.3 [Supplement] Existing Buildings.

IBC section 1613.3 was changed in the 2009 IBC to resolve confusion and potential conflict between Chapter 16 and Chapter 34. Its only purpose is to direct users to Chapter 34. Alternative provisions for existing buildings are given with the modifications to Chapter 34. The various project types, some of which are addressed by Chapter 34 and some by alternative criteria, are listed here for clarity and completeness.

2-1613.4 [Supplement] Special Inspections*.*

2009 IBC Chapter 17 shall be applied as modified by Sections 2-1701 – 2-1710 of this UFC.

2-1613.8 [Addition] Procedure for Determining MCE and Design Spectral Response Accelerations.

Ground motion accelerations, represented by response spectra and coefficients derived from these spectra, shall be determined in accordance with the procedure of ASCE 7-05 Sections 11.4.1-11.4.5, or the site-specific procedure of ASCE 7-05 Section 11.4.7. Subject to approval by the Authority having Jurisdiction, a site-specific response analysis using the procedure of ASCE 7-05 Section 11.4.7 may be used in determining ground motions for any structure. Such analysis shall include justification for its use in lieu of the mapped ground motion data that are described below.

A site-specific response analysis using the procedures of ASCE 7-05 Section 11.4.7 shall be used for structures on sites classified as Site Class F (see 2009 IBC Table 1613.5.2), unless the following condition is applicable:

Both the mapped Maximum Considered Earthquake (MCE) spectral response acceleration at short periods, S_s, is less than or equal to 0.25, and the mapped MCE spectral response acceleration at 1-second period, S_1, is less than or equal to 0.10, as determined in accordance with UFC 3-301-01.

S_s and S_1 shall be determined for installations within the United States from Section 2-1.6.1 of UFC 3-301-01.For installations located outside the United States, S_s and S_1 shall be determined from Section 2-1.6.2 of UFC 3-301-01.

Note that this section is superseded by Section 4-11.1 of this UFC for OC V structures.

NOTE: Numbering system changes to reflect ASCE 7-05 organization. For example, Section 2-11 will cover topics from Chapter 11 of ASCE 7-05.

2-11.1.2 [Supplement] Scope.

The design and detailing of the components of the seismic force-resisting system shall comply with the applicable provisions of ASCE 7-05 Section 11.7 and ASCE 7-05 Chapter 12, as modified by this UFC, in addition to the nonseismic requirements of the 2009 IBC.

Note that this section is superseded by Section 4-11.1 of this UFC for OC V structures.

2-11.2 [Replacement] DEFINITIONS - DESIGNATED SEISMIC SYSTEMS.

The seismic force-resisting system in all structures and those architectural, electrical, and mechanical systems or their components in OC II, III, and IV structures that require design in accordance with Chapter 13 and for which the component importance factor, I_p, is greater than 1.0. This designation applies to systems that are required to be operational following the Design Earthquake for OC II, III, and IV structures and following the MCE for OC V structures. All systems in OC V facilities designated as MC-1 (see Chapter 4) shall be considered part of the Designated Seismic Systems. Designated Seismic Systems will be identified by Owner and will have an Importance Factor $I_p = 1.5$ for OC II, III, and IV structures.

2-11.2 [Replacement] DEFINITIONS - IMPORTANCE FACTOR.

A factor assigned to each structure according to its Occupancy Category as prescribed in UFC 3-301-01 Table 2-2.

2-11.5.1 [Replacement] Importance Factor.

A seismic importance factor, *I*, shall be assigned to each structure in accordance with UFC 3-301-01 Table 2-2. Importance factors for wind load, snow load and ice load, as applicable, shall also be assigned to each structure in accordance with UFC 3-301-01 Table 2-2.

Note that this section is modified by Section 4-11.5.1 of this UFC for OC V structures.

2-11.7 [Supplement] Design Requirements for Seismic Design Category A.

ASCE 7-05 Section 11.7 shall not apply to buildings in OC V.

2-12.6 [Supplement] Analysis Procedure Selection.

Table 2-2, Replacement for ASCE 7-05 Table 12.6-1, shall be used in lieu of ASCE 7-05 Table 12.6-1.

Note that this section is superseded by Section 4-12.6 of this UFC for OC V structures.

2-12.8 [Supplement] Equivalent Lateral Force Procedure.

When the ELF procedure is used, provisions of ASCE 7-05 Section 12.8 shall be used. This procedure may be applied to the design of buildings in OCs I through IV as permitted by Table 2-2.

[C] 2-12.8 [Supplement] Equivalent Lateral Force Procedure for Seismic Design of Buildings.

The ELF procedure is the primary design method for seismic design of military buildings. Several restrictions on using the ELF procedure for buildings in SDCs D - F are imposed by Table 2-2. These restrictions are predicated on the presence of horizontal and vertical irregularities. The Simplified Design Procedure (SDP) of ASCE 7-05 Section 12.14 is a simplification of the ELF procedure that may be applied to low-rise buildings that meet a set of pre-conditions given in ASCE 7-05 Section 12.14. The SDP adopts a more conservative design approach than the ELF procedure.

2-12.8.7 [Replacement] P-Delta Effects.

Replace Equation 12.8-16 with the following:

$$\theta = \frac{P_x \Delta I}{V_x h_{sx} C_d} \qquad (12.8\text{-}16)$$

[C] 2-12.8.7 [Replacement] P-Delta Effects.

Equation 12.8-16 is adopted from ASCE 7-10. Equation 12.8-16 of ASCE 7-05 did not include the Importance Factor, *I*, in the numerator. Note that this [Replacement] is applicable only where the ELF itself is applicable.

2-12.12.4 [Replacement] Deformation Compatibility for Seismic Design Categories D Through F.

For components that are not included in seismic force resisting system ensure that ductile detailing requirements are provided such that the vertical load-carrying capacity of these components is not compromised by induced moments and shears resulting from the design story drift (see Part 2 Commentary - FEMA 750 Section C12.12.4).

Note that this requirement is superseded by Section 4-12.12.4 of this UFC for OC V structures.

2-13.1.2 [Supplement] Seismic Design Category.

Unless specifically noted otherwise in this UFC, for all subsections of ASCE 7-05 Chapter 13, when SDCs are referenced, any provision that directs OC IV design measures shall also be applied to OC V. Appendix B of this UFC provides supplementary guidance on architectural, mechanical, and electrical component design requirements. Section B-2 provides guidance on architectural component design, including interior and exterior wall elements. Section B-3 provides guidance on electrical and mechanical systems design. To the extent that is possible, subsections of Appendix B reference relevant sections of ASCE 7-05.

2-13.1.3 [Addition] Component Importance Factor – Item 4.

The component is in or attached to an OC V structure designated as MC-1 or MC-2.

2-13.2.2 [Supplement] Special Certification Requirements for Designated Seismic Systems.

Appendix C of this UFC provides verification and certification guidance.

When shake table testing is performed, the demand RRS shall be developed from a site-specific in-structure response time history based study. The capacity RRS for each axis shall be generated from the time histories defined in Section 4-11.4 of this UFC, and shall be peak broadened by 15%. The in-structure demand response spectra per Section 4-13.7.4 of this UFC shall be used to determine demand if the Nonstructural Component is not supported at grade.

Exception – For OC II, III, and IV structures, the demand RRS may be derived using ICC-ES AC156.

Testing shall be performed in accordance with nationally recognized testing procedures such as:

1. The requirements of the International Code Council Evaluations Service (ICC-ES), *Acceptance Criteria for Seismic Qualification by Shake-Table Testing of Nonstructural Components*, ICC-ES AC156, November 2010.
2. The *CERL Equipment Fragility and Protection Procedure (CEFAPP)*, USACERL Technical Report 97/58, Wilcoski, J., Gambill, J.B., and Smith, S.J., March 1997. The test motions, test plan, and results of this method require peer review.
3. For power substation equipment only, Institute of Electrical and Electronics Engineers (IEEE), *Recommended Practices for Seismic Design of Substations*, IEEE 693-2005.

Shake table tests shall include triaxial motion components that result in the largest response spectral amplitudes at the natural frequencies of the equipment for each of the three axes of motion. The Test Response Spectrum (TRS) test motions, demand RRS, test plan, and testing results shall be reviewed independently by a team of Registered Design Professionals. The design professionals shall have documented experience in the appropriate disciplines, seismic analysis, and seismic testing. The independent review shall include, but need not be limited to, the following:

1. Review of site-specific seismic criteria, including the development of the site-specific spectra and ground motion histories, and all other project-specific criteria;
2. Review of seismic designs and analyses for both the equipment and all supporting systems, including the generation of in-structure motions;
3. Review of all testing requirements and results; and,
4. Review of all equipment quality control, quality assurance, maintenance, and inspection requirements.

2-13.2.2 [Supplement] Component Certification and O&M Manual.

For any electrical or mechanical component required by ASCE 7-05 Section 13.2.2 to be certified, evidence demonstrating compliance of the requirement shall be maintained in a file identified as "Equipment Certification Documentation." This file shall be a part of the Operations & Maintenance Manual that is turned over to the Authority having Jurisdiction. The project specifications shall require the Operations & Maintenance Manual state that replaced or modified components need to be certified per the original certification criteria. OC V NMC components are exempt from this requirement – see Section 4-13.8 of this UFC.

2-13.2.2 [Supplement] Component Identification Nameplate.

Any electrical or mechanical component required by ASCE 7-05 Section 13.2.2 to be certified shall bear permanent marking or nameplates constructed of a durable heat and water resistant material. Nameplates shall be mechanically attached to such nonstructural components and placed on each component for clear identification. The nameplate shall not be less than 5" x 7" with red letters 1" in height on a white background stating "Certified Equipment." The following statement shall be on the nameplate: "This equipment/component is certified. No modifications are allowed unless authorized in advance and documented in the Equipment Certification Documentation file." The nameplate shall also contain the component identification number in accordance with the drawings/specifications and the O&M manuals. Continuous piping and conduits in OC V shall be similarly marked as specified in the contract documents. OC V NMC components are exempt from this requirement – see Section 4-13.9 of this UFC.

2-13.2.7 [Supplement] Construction Documents.

Construction documents for architectural, mechanical, and electrical components shall be prepared by a Registered Design Professional for all buildings in OCs IV and V.

2-13.3.2 [Supplement] Seismic Relative Displacements.

The rigidity of stairways relative to their supporting structures shall be evaluated to determine loads and deformations imposed on the stairs, and unintended loads or constraints imposed on the building. Alternatively, stairways may be isolated from building motions in accordance with the relative displacements defined in ASCE 7-05 Section 13.3.2.2.

2-13.5.6 [Supplement] Suspended Ceilings.

For buildings in OCs IV and V, suspended ceilings shall be designed to resist seismic effects using a rigid bracing system, where the braces are capable of resisting tension and compression forces, or diagonal splay wires, where the wires are installed taut. Particular attention should be given in walk-down inspections (see Section 2-1707.7 in this UFC) to ensure splay wires are taut. Positive attachment shall be provided to prevent vertical movement of ceiling elements. Vertical support elements shall be capable of resisting both compression and tensile forces. Vertical supports and braces designed for compression shall have a slenderness ratio, *Kl/r*, of less than 200. Additional guidance on suspended ceiling design is provided in Section B-2.3.8 of this UFC.

2-13.5.7 [Supplement] Access Floors.

Access floor components installed on access floors that have importance factors, I_p, greater than 1.0 shall meet the requirements of Special Access Floors (ASCE 7-05 Section 13.5.7.2). Note: Equipment that requires certification (see Section 2-13.2.2 in this UFC) shall account for the motion amplification that occurs because of any supporting access flooring.

2-13.6.1 [Supplement] General.

Stacks attached to or supported by buildings shall be designed to meet the force and displacement provisions of ASCE 7-05 Sections 13.3.1 and 13.3.2. They shall further be designed in accordance with the requirements of ASCE 7-05 Chapter 15 and the special requirements of ASCE 7-05 Section 15.6.2. Guidance on stack design may be found in Section B-3.3.

2-13.6.3 [Supplement] Mechanical Components.

Guidance on the design of piping supports and attachments is found in Section B-3.2.4 of this UFC.

Guidance on the design of electrical equipment supports, attachments, certification is found in Appendices B & C of this UFC.

2-13.6.5.5 [Addition] Additional Requirements – Item 9.

The local regions of support attachment for all mechanical and electrical equipment shall be evaluated for the effects of load transfer on component walls and other structural elements.

2-13.6.7 [Replacement] HVAC Ductwork – Item a.

a. Where trapeze assemblies are used to support ductwork, the total weight of the ductwork supported by trapeze assemblies is less than 10 lb/ft (146 N/m). Where the ductwork is supported by hangers, each hanger in the duct run is 12 in. (305 mm) or less in length from the duct support point to the supporting structure. Where rod hangers are used, they shall be equipped with swivels to prevent inelastic bending in the rod.

2-13.6.10.3 [Supplement] Seismic Switches.

For buildings that are in OC IV, or in SDCs E or F, the trigger level for seismic switches shall be set to 50% of the acceleration of gravity in both horizontal perpendicular axes.

Elevator systems (equipment, systems, supports, etc) in OC IV, or in SDCs E or F, shall have an I_p = 1.5 and shall be designed to ensure elevator operability at accelerations below 50% of the acceleration of gravity in both horizontal perpendicular axes. For buildings that are in OC V, seismic switches shall not be used. Elevator system design for OC V buildings shall ensure elevator operability at accelerations computed in building response modeling. Additional guidance on the design of elevator systems is found in Section B-3.4 of this UFC.

[C] 2-13.6.10.3 [Supplement] Seismic Switches.

Note that the 0.50*g* is consistent with Article 3137, Seismic Requirements for Elevators, Escalators and Moving Walks, Subchapter 6, Elevator Safety Orders, California Code of Regulations, Title 8 (http://www.dir.ca.gov/title8/3137.html).

2-13.6.12 [Addition] Lighting Fixtures in OC IV and V Buildings.

For buildings that are in OC IV and V, guidance on the design of lighting fixtures is found in Section B-3.5 of this UFC.

2-13.6.13 [Addition] Bridges, Cranes, and Monorails.

Structural supports for those crane systems that are located in buildings and other structures assigned to SDC C with I_p greater than 1.0, or assigned to SDC D, E, or F, shall be designed to meet the force and displacement provisions of ASCE 7-05 Section 13.3. Seismic forces, F_p, shall be calculated using a component amplification factor, a_p, of 2.5 and a component response modification factor, R_p, of 2.5, except that crane rail connections shall be designed for the forces resulting from an R_p of 1.5 in all directions. When designing for forces in either horizontal direction, the weight of crane components, W_p, need not include any live loads, lifted loads, or loads from crane components below the bottom of the crane cable. If the crane is not in a locked position, the lateral force parallel to the crane rails can be limited by the friction forces that can be applied through the brake wheels to the rails. In this case, the full rated live load of the crane plus the weight of the crane shall be used to determine the gravity load that is carried by each wheel. Guidance on the design of these systems is found in Section B-3.6 of this UFC.

2-13.6.14 [Addition] Bridges, Cranes, and Monorails for OC IV and V Buildings.

In addition to the requirements of Section 2-13.6.13 of this UFC, for bridges, cranes, and monorails for all OC IV and V buildings, vertical earthquake-induced motions shall be considered. For OC V structures, a site-specific vertical spectrum shall be used (see Section 4-11.4.5.2 of this UFC). For OC IV structures, when a site-specific vertical spectrum is not used, the vertical response spectrum may be developed following the rules specified in FEMA P-750, NEHRP *Recommended Seismic Provisions for Buildings and Other Structures*, Chapter 23, Vertical Ground Motions for Seismic Design, except it shall be based on the MCE ground motion of ASCE 7-05/2009 IBC, not the MCE_R motion of the 2009 NEHRP.

2-15.5.6.1 [Supplement] General.

UFC 4-152-01, Design: Piers and Wharves, governs the seismic design of piers and wharves for the DoD.

NOTE: Numbering system changes to reflect 2009 IBC organization.

2-17 STRUCTURAL TESTS AND SPECIAL INSPECTIONS

2-1701 GENERAL

2-1701.1 [Supplement] Scope.

Contractual relationships and the composition of the architect / engineer / construction (AEC) team differ from that contemplated by the language of the 2009 IBC, when doing DoD construction. When performing design or construction using typical methods for in-house design, AE design, and contracting for construction, the 2009 IBC/ASCE 7-05 terms of Authority having Jurisdiction and Building Official shall be as defined in UFC 1-200-01.

2-1705 STATEMENT OF SPECIAL INSPECTIONS

2-1705.1 [Supplement] General.

Any requirements for statement of special inspections for structures assigned to SDC C or higher shall also apply to structures assigned to OC V.

2-1707 SPECIAL INSPECTIONS FOR SEISMIC RESISTANCE

2-1707 [Supplement]

All requirements for Special Inspections for Seismic Resistance shall apply to structures assigned to Occupancy Category V.

2-1707.7 [Supplement] Mechanical and Electrical Components.

Special inspection and verification are required for Designated Seismic Systems and shall be performed as required by this section and Table 2-3.

The Registered Design Professional in responsible charge shall prepare a Statement of Special Inspections in accordance with 2009 IBC Section 1705 for the Designated Seismic Systems. The Statement of Special Inspections shall define the periodic walk-down inspections that shall be performed to ensure that the non-structural elements satisfy life safety mounting requirements. The walk-down inspections shall be performed by design professionals who are familiar with the construction and installation of architectural, mechanical, and electrical components, and their vulnerabilities to earthquakes. The selection of the design professional shall be subject to the approval of the Authority having Jurisdiction.

Designated Seismic Systems shall require a final walk-down inspection by the Registered Design Professional in responsible charge and by the Nonstructural Component Design Review Panel for OC V installations (see Section 4-1601.2.2 of this UFC). The final review shall be documented in a report. The final report prepared by the Registered Design Professional in Responsible Charge shall include the following:

- Record/observations of final site visit
- Documentation that all required inspections were performed in accordance with the Statement of Special Inspections.
- Documentation that the Designated Seismic Systems were installed in accordance with the construction documents and the requirements of 2009 IBC Chapter 17, as modified by this Chapter.

2-1707.10 [Addition] Special Inspector of Record.

The services of a Special Inspector of Record (SIOR) shall be retained by the Contractor as a third party quality assurance agent (see Section 2-17.1 of UFC 1-200-01). The SIOR shall be a licensed professional engineer in a state acceptable to the Authority having Jurisdiction. The SIOR shall submit qualifications acceptable to the Authority having Jurisdiction.

The duties of the SIOR shall include the following:

- Supervise all Special Inspectors required by the contract documents and the IBC.
- Submit a letter to the Authority having Jurisdiction attesting to acceptance of the duties of SIOR. The letter shall be signed and sealed by the SIOR.
- Verify the qualifications of all of the Special Inspectors.
- Verify the qualifications of fabricators.
- Develop the Special Inspection Project Manual, which will identify the specific special inspection requirements for that project and include the applicable directives from the Registered Design Professional and the Authority having Jurisdiction. The Special Inspection Project Manual will form the basis for the preconstruction meeting and become part of the construction documents. The information in the Special Inspection Project Manual will be reviewed to verify that all parties have a clear understanding of the special inspection provisions and the individual duties and responsibilities of each party.
- Organize and preside over a Special Inspection Meeting in which representatives of the Authority having Jurisdiction, the Contractor, and the Registered Design Professional in Responsible Charge shall sign the log-in-sheet documenting their presence at the meeting. A copy of the Special Inspection Project Manual shall be made available on the job site during construction.

- Attend preconstruction meetings.
- Create a file (3- ring binder) for the Special Inspector's daily and biweekly reports and the SI Project Manual. This file shall be located in a conspicuous place in the project trailer/office to allow review by the Building Official and the Registered Design Professional in Responsible Charge. The file shall be kept up-to-date.
    - Submit a report to Authority having Jurisdiction and the Registered Design Professional in Responsible Charge biweekly until all work requiring Special Inspections is complete. A report is required for each biweekly period in which Special Inspection activity occurs, and shall include the following:
    - A brief summary of the work performed during the reporting time frame.
    - Changes and/or discrepancies with the mechanical or electrical component certification reviewed drawings and specifications that were observed during the reporting period.
    - Discrepancies which were resolved or corrected.
    - A list of nonconforming items requiring resolution.
    - All applicable test results.
- When the work requiring Special Inspections is completed and all nonconforming items have been resolved to the satisfaction of the Registered Design Professional in Responsible Charge, the Contractor shall notify the SIOR to submit a Final Special Inspection Report to the Authority having Jurisdiction, the Registered Design Professional in Responsible Charge, and the Contractor. The Final Special Inspection Report shall attest that all work performed requiring Special Inspection has been performed and all nonconforming work was resolved to the satisfaction of the Registered Design Professional in Responsible Charge. The Final Special Inspection Report shall be signed, dated, and shall bear the seal of the SIOR.

2-1708 STRUCTURAL TESTING FOR SEISMIC RESISTANCE

2-1708.1 [Supplement] Testing and Qualification for Seismic Resistance.

Requirements for testing and qualification of masonry materials and assemblies shall, as a minimum, be in accordance with MSJC 1.18 and shall be included in the contract documents.

2-1708.2 [Supplement] Testing and Qualification for Seismic Resistance.

Any requirements for structural testing for structures assigned to SDC C or higher shall also apply to structures assigned to OC V.

2-1710 STRUCTURAL OBSERVATIONS

2-1710.2 [Supplement] Structural Observations for Seismic Resistance.

Any requirements for structural observations for structures assigned to SDC C or higher shall also apply to structures assigned to OC V.

2-21 MASONRY

2-2106 SEISMIC DESIGN

2-2106.2 [Addition] Additional Requirements for Masonry Systems.

2-2106.2.1 [Addition] Minimum Reinforcement for Special or Intermediate Masonry Walls, SDC B-F.

In addition to the minimum reinforcement requirements of Sections 1.17.3.2.5 and 1.17.3.2.6 of TMS 402-08/ACI 530-08/ ASCE 5-08, the following shall apply:

1. Reinforcement shall be continuous around wall corners and through wall intersections, unless the intersecting walls are separated. Reinforcement that is spliced in accordance with applicable provisions of TMS 402-08/ACI 530-08/ ASCE 5-08 shall be considered continuous.

2. Only horizontal reinforcement that is continuous in the wall or element shall be included in computing the area of horizontal reinforcement. Intermediate bond beam steel properly designed at control joints shall be considered continuous.

2-2106.2.2 [Addition] Joints in Structures assigned to SDC B or Higher.

Where concrete abuts structural masonry, and the joint between the materials is not designed as a separation joint, the joint shall conform to the requirements of ASCE 7-05 Section 14.4.5.1.

2-2106.2.3 [Addition] Minimum Reinforcement for Deep Flexural Members, SDC B-F.

Flexural members with overall depth-to-clear span ratios greater than 2/5 for continuous spans or 4/5 for simple spans shall conform to the requirements of ASCE 7-05 Section 14.4.7.4.

2-2106.2.4 [Addition] Coupling Beams in Structures assigned to SDC D or higher.

Structural members that provide coupling between shear walls shall conform to the requirements of ASCE 7-05 Section 14.4.7.3.

2-22 STEEL

2-2209 COLD-FORMED STEEL

2-2209.1 [Replacement] General.

The seismic design of cold-formed steel structural members shall be in accordance with the provisions of ASCE 7-10 Section 14.1.3 and the associated reference standards in ASCE 7-10 Chapter 23. The text is reproduced below. Cold-formed steel light-frame construction shall also comply with 2009 IBC Section 2210.

ASCE 7-10 14.1.3 Cold-Formed Steel

14.1.3.1 General
The design of cold-formed carbon or low-alloy steel structural members shall be in accordance with the requirements of AISI S100 and the design of cold-formed stainless steel structural members shall be in accordance with the requirements of ASCE 8. Where required, the seismic design of cold-formed steel structures shall be in accordance with the additional provisions of Section 14.1.3.2.

14.1.3.2 Seismic Requirements for Cold-Formed Steel Structures
Where a response modification coefficient, *R*, in accordance with Table 12.2-1 is used for the design of cold-formed steel structures, the structures shall be designed and detailed in accordance with the requirements of AISI S100, ASCE 8, and AISI S110 as modified in Section 14.1.3.3.

14.1.3.3 Modifications to AISI S110
The text of AISI S110 shall be modified as indicated in Sections 14.1.3.3.1 through 14.1.3.3.5. Italics are used for text within Sections 14.1.3.3.1 through 14.1.3.3.5 to indicate requirements that differ from AISI S110.

14.1.3.3.1 AISI S110, Section D1 Modify Section D1 to read as follows:

D1 Cold-Formed Steel Special Bolted Moment Frames (CFS-SBMF)

Cold-formed steel–special bolted moment frame (CFS-SBMF) systems shall withstand significant inelastic deformations through friction and bearing at their bolted connections. Beams, columns, and connections shall satisfy the requirements in this section. CFS-SBMF systems shall be limited to one-story structures, no greater than 35 feet in height, without column splices and satisfying the requirements in this section. *The CFS-SBMF shall engage all columns supporting the roof or floor above. The single size beam and single size column with the same bolted moment connection detail shall be used for each frame. The frame shall be supported on a level floor or foundation.*

14.1.3.3.2 AISI S110, Section D1.1.1 Modify Section D1.1.1 to read as follows:

D1.1.1 Connection Limitations

Beam-to-column connections in CFS-SBMF systems shall be bolted connections with snug-tight high-strength bolts. The bolt spacing and edge distance shall be in accordance with the limits of AISI S100, Section E3. *The 8-bolt configuration shown in Table D1-1 shall be used. The faying surfaces of the beam and column in the bolted moment connection region shall be free of lubricants or debris.*

14.1.3.3.3 AISI S110, Section D1.2.1 Modify Section D1.2.1 and add new Section D1.2.1.1 to read as follows:

D1.2.1 Beam Limitations

In addition to the requirements of Section D1.2.3, beams in CFS-SBMF systems shall be *ASTM A653A653M galvanized 55 ksi (374 MPa) yield stress* cold-formed *steel* C-section members with lips, and designed in accordance with Chapter C of AISI S100. *The* *beams shall have a minimum design thickness of 0.105 in. (2.67 mm). The beam depth shall be not less than 12 in. (305 mm) or greater than 20 in. (508 mm).* The flat depth-to-thickness ratio of the web shall not exceed 6.18 E/F_y.

D1.2.1.1 Single-Channel Beam Limitations

When single-channel beams are used, torsional effects shall be accounted for in the design.

14.1.3.3.4 AISI S110, Section D1.2.2 Modify Section D1.2.2 to read as follows:

D1.2.2 Column Limitations

In addition to the requirements of D1.2.3, columns in CFS-SBMF systems shall be *ASTM A500/A500M Grade B* cold-formed *steel* hollow structural section (HSS) members *painted with a standard industrial finished surface,* and designed in accordance with Chapter C of AISI S100. *The column depth shall be not less than 8 in. (203 mm) or greater than 12 in. (305 mm).* The flat depth-to-thickness ratio shall not exceed *1.40* E/F_y.

14.1.3.3.5 AISI S110, Section D1.3 Delete text in Section D1.3 to read as follows:

D1.3 Design Story Drift

Where the applicable building code does not contain design coefficients for CFS-SBMF systems, the provisions of Appendix 1 shall apply.

For structures having a period less than T_S, as defined in the applicable building code, alternate methods of computing Δ shall be permitted, provided such alternate methods are acceptable to the Authority having Jurisdiction.

ASCE 7-10 Chapter 23

1. **ANSI/AISI S100** *North American Specification for the Design of Cold-Formed Steel Structural Members,* 2007

2. **ANSI/AISI S110** *Standard for Seismic Design of Cold-Formed Steel Structural Systems—Special Bolted Moment Frames*, 2007

3. **ASCE 8** *Specification for the Design of Cold-Formed Stainless Steel Structural Members*, 2002

2-23 WOOD

2-2308 CONVENTIONAL LIGHT-FRAME CONSTRUCTION.

2-2308.2 Limitations [Replacement].

Limitation 6 shall be rewritten as follows:

6. The use of the provisions for conventional light-frame construction in this section shall not be permitted for OC IV buildings assigned to Seismic Design Category C, D, E, or F, as determined in 2009 IBC Section 1613.

2-34 EXISTING STRUCTURES

2-3401 GENERAL

2-3401.5 [Replacement] Alternative Compliance.

Work performed in accordance with the *International Existing Building Code* (IEBC) shall not necessarily be deemed to comply with the provisions of this chapter.

[C] 2-3401.5 [Replacement] Alternative Compliance.

IBC Chapter 34 allows the use of IEBC as a deemed-to-comply alternative. For purposes of seismic evaluation and rehabilitation, the IEBC has slightly different triggers, scope exemptions, and criteria. The main advantage of the IEBC is that it explicitly allows the use of the ASCE 31, *Seismic Evaluation of Existing Buildings* and ASCE 41, *Seismic Rehabilitation of Existing Buildings*. Since those standards are allowed by added section 3401.6, and to avoid confusion and inconsistency, the IBC's blanket allowance of the IEBC is not needed here.

2-3401.6 [Addition] Seismic Evaluation and Rehabilitation of Existing Buildings.

ICSSC RP 8 /NIST GCR 11-917-12, Standards of Seismic Safety for Existing Federally Owned and Leased Buildings, cited herein as RP 8, as modified by this chapter and applicable service regulations, is hereby adopted and made part of this chapter. Where the provisions of RP 8 and IBC Chapter 34 are in conflict, those of RP 8 shall govern. Where RP 8 makes no specific provision, the provisions of IBC Chapter 34, as modified by this Chapter, shall govern.

RP 8 is applicable to all existing DoD owned and leased buildings.

RP 8 Section 2.1 (b) [REPLACEMENT]. For Seismic Design Category C buildings, a project is planned, which totals more than 50 % of the replacement value of the building.

RP 8 Section 2.1 (c) [REPLACEMENT]. For Seismic Design Category D, E, or F buildings, a project is planned, which totals more than 30 % of the replacement value of the building.

Where seismic evaluation is required, ASCE/SEI 31-03, Seismic Evaluation of Existing Buildings, shall be used. Where seismic rehabilitation is required, ASCE/SEI 41-06, Seismic Rehabilitation of Existing Buildings, shall be used. Performance objectives for evaluation or rehabilitation shall be as specified in the following subsections.

[C] 2-3401.6 [Addition] Seismic Evaluation and Rehabilitation of Existing Buildings.

The first sentence of this added section clarifies the intended relationship between IBC Chapter 34 and RP 8. RP 8 gives exemptions, triggers, scope, and criteria applicable to alterations, repairs, changes of occupancy, acquisitions, and (in general terms) historic buildings; in these cases, where the IBC has different provisions or no provisions at all, the RP 8 provisions (as modified by this Chapter) shall be used, whether they are more restrictive or less restrictive than the IBC. Key differences between RP 8 and IBC Chapter 34 are noted in commentary to Sections 3404, 3405, 3408, and 3413.

RP 8 does not contain provisions for additions or relocated buildings; in these cases, IBC provisions apply, as modified by this Chapter.

This Chapter clarifies certain terms used in RP 8 and the application of RP 8 to various Occupancy Categories. Modifications to RP 8's exemptions and benchmarking provisions are given in added Section 2-3401.7.

2-3401.6.1 [Addition] Performance Objectives for Evaluation, Rehabilitation of OC I and II Buildings.

The LS Performance Level delineated in Section 2.4 of ASCE 31-03 shall be applied for building evaluation. The Basic Safety Objective (BSO) delineated in Section 1.4.1 of ASCE/SEI 41-06 shall be applied for rehabilitation.

2-3401.6.2 [Addition] Performance Objectives for Evaluation, Rehabilitation of OC III Buildings.

The LS Performance Level delineated in Section 2.4 of ASCE 31-03 shall be applied for building evaluation, with all computed earthquake-induced forces increased by 25% over ASCE 31-03 amplitudes for any calculations that are required in Tier 1, 2, or 3 evaluations. The BSO delineated in Section 1.4.1 of ASCE/SEI 41-06 shall be applied for rehabilitation, with all computed earthquake-induced forces increased by 25% over ASCE/SEI 41-06 amplitudes for both specified performance levels.

2-3401.6.3 [Addition] Performance Objectives for Evaluation, Rehabilitation of OC IV Buildings.

The Immediate Occupancy (IO) Performance Level delineated in Section 2.4 of ASCE 31-03 shall be applied for building evaluation. Two Enhanced Rehabilitation Objectives (EROs), ERO-1 and ERO-2, shall be applied, as delineated in Section 1.4.2 of ASCE/SEI 41-06, *Seismic Rehabilitation of Existing Buildings*, for rehabilitation. ERO-1 shall achieve the ASCE/SEI 41-06 rehabilitation goal of an IO Performance Level (1-B) for the BSE-1 Earthquake Hazard Level. ERO-2 shall achieve the ASCE/SEI 41-06 rehabilitation goal of a LS Performance Level (3-C) for the BSE-2 Earthquake Hazard Level. These performance levels and earthquake hazard levels are presented in ASCE/SEI 41-06 Table C1-1.

2-3401.6.4 [Addition] Performance Objectives for Evaluation, Rehabilitation of OC V Buildings.

OC V structures shall be designed to ensure that during the MCE their superstructures and installed mission-essential non-structural elements remain elastic, and following the MCE their installed equipment remains operational. See Chapter 4 of this UFC for MCE ground motions. ASCE 31-03 shall not be used for evaluating existing buildings that are classified as OC V facilities. For any evaluations of existing OC V buildings, the analysis procedures of Chapter 4 of this UFC shall apply. All strengthening of existing buildings and additions to existing buildings that must satisfy OC V performance requirements shall satisfy the requirements of Chapter 4 of this UFC.

2-3401.7 [Addition] Exemptions and Benchmark Buildings

2-3401.7.1 [Addition] Exemptions.

The exemptions in RP 8 Section 1.3 do not apply to OC V facilities.

Where applied to projects involving change of occupancy, exemptions in RP8 Section 1.3 based on occupancy or use apply to the new or intended occupancy.

RP 8 Section 1.3 item a [REPLACEMENT]. a. All SDC A buildings.

RP 8 Section 1.3 item b [REPLACEMENT]. b. All SDC B buildings.

RP 8 Section 1.3 item c [REPLACEMENT]. c. Detached one- and two-family dwellings located where S_{DS}<0.4 g.

RP 8 Section 1.3, item d [REPLACEMENT]. d. Occupancy Categories I or II building structures intended for incidental human occupancy or that are occupied by persons for a total of less than 2 hours a day.

RP 8 Section 1.3 item e [REPLACEMENT]. e. Occupancy Categories I or II one-story buildings of steel light frame or wood construction with areas less than 280 m2 (3000 ft2).

[C] 2-3401.7.1 [Addition] Exemptions.

The revisions to RP 8 Section 1.3 provide the enforcing agency guidance referenced in RP 8 Section C1.3 that is related to performance objectives. The performance objective for Occupancy Category I, II, or III DoD projects is Life Safety and that for Occupancy Category IV DoD projects is Immediate Occupancy. OC V structures are required to be designed to ensure that during the MCE their superstructures and installed mission-essential non-structural elements remain elastic, and following the MCE their designated equipment remains operational.

2-3401.7.2 [Addition] Benchmark Buildings.

Where the Benchmark Building provisions of ASCE/SEI 31-03 apply, Table 2-4 of this Chapter shall replace ASCE/SEI 31-03 Table 3-1, Benchmark Buildings, and RP 8 Table 1-1, Benchmark Buildings.

2-3403 ADDITIONS

2-3403.1.1 [Addition] Combined Projects.

Alteration work performed in conjunction with an addition project shall comply with the provisions for alteration projects. Repair work performed in conjunction with an addition project shall comply with the provisions for repair projects.

[C] 2-3403.1.1 [Addition] Combined Projects.

In general, IBC Chapter 34 and RP 8 make provisions based on the intended project type. Added Section 2-3403.1.1 addresses cases where multiple project types, one of which is an addition, are intended. The provision is primarily a pointer to the supplemental requirements in Sections 3404 and 3405.

2-3403.4 [Replacement] Existing Structural Elements Carrying Lateral Load.

Where the *addition* is structurally independent of the *existing structure*, existing seismic force-resisting structural elements shall be permitted to remain unaltered. Where the *addition* is not structurally independent of the *existing structure*, the *existing structure* and its *addition* acting together as a single structure shall be shown to meet the requirements of 2009 IBC Sections 1609 and 1613.

> **Exception:** Any existing seismic force-resisting structural element whose demand-capacity ratio with the *addition* considered is no more than 10 percent greater than its demand-capacity ratio with the *addition* ignored shall be permitted to remain unaltered provided the addition neither creates new structural irregularities, as defined in ASCE 7-05 Section 12.3.2, nor makes existing structural irregularities more severe. For purposes of calculating demand-capacity ratios, the demand shall consider applicable load combinations with design lateral loads or forces in accordance with 2009 IBC Sections 1609 and 1613. For purposes of this exception, comparisons of demand-capacity ratios and calculation of design lateral loads, forces and capacities shall account for the cumulative effects of additions and alterations since original construction.

2-3404 [SUPPLEMENT] ALTERATIONS AND 2-3405 [SUPPLEMENT] REPAIRS.

The following requirements shall apply to projects involving additions to existing buildings.

If no repairs or alterations are made to an existing structure that receives a new structurally independent addition, then seismic evaluation of the existing structure is not required. If repairs or alterations are made to an existing structure that receives a new structurally independent addition, the requirements of RP 8 shall be met for the existing structure.

[C] 2-3404 [SUPPLEMENT] ALTERATIONS AND 2-3405 [SUPPLEMENT] REPAIRS. RP 8 addresses the triggers, exemptions, scope, and criteria for seismic evaluation and rehabilitation associated with alteration and repair projects. Therefore, per Section 2-3401.6, the RP 8 provisions generally replace those of IBC Sections 3404 and 3405.

Note that the RP 8 trigger for alteration projects (RP 8 Section 2.1.b) is based on the extension of "useful life" and on the cost of the alteration relative to the facility's replacement value, whereas the IBC trigger is based on changes to demand-capacity ratios resulting from the intended work. The RP 8 triggers for repair projects (RP 8 Sections 2.1.b and 2.1.c) are based on extended useful life and on the degree of structural damage, whereas the IBC trigger is based only on the degree of structural damage.

2-3408 CHANGE OF OCCUPANCY

[C] 2-3408 CHANGE OF OCCUPANCY

RP 8 addresses the triggers, exemptions, scope, and criteria for seismic evaluation and rehabilitation associated with change of occupancy projects. Therefore, per Section 2-3401.6, the RP 8 provisions generally replace those of IBC section 3408.

Note that the RP 8 trigger for change of occupancy projects (RP 8 Section 2.1.a) is based on a case-by-case understanding of the proposed change, "as determined by the agency," whereas the IBC trigger is based only on a change of Occupancy Category. The exceptions of IBC section 3408 may be used as guidance in applying RP 8.

2-3409 HISTORIC BUILDINGS

[C] 2-3409 HISTORIC BUILDINGS

RP 8 addresses historic buildings in section 4.7. Therefore, per Section 2-3401.6, the RP 8 provisions generally replace those of IBC Section 3409.

Note that the RP 8 provisions for historic buildings generally require compliance, whereas the IBC provisions exempt compliance.

2-3413 [ADDITION] ACQUISITION

Leased, purchased, or donated buildings, or portions of buildings, shall comply with applicable provisions of RP 8.

[C] 2-3413 [ADDITION] ACQUISITION

RP 8 addresses leased, purchased, and donated buildings and portions of buildings in Sections 1.3.2, 1.3.3, and 2.1.e. Since the IBC does not address acquisitions, this section is added for clarity and completeness.

Table 2-1 Replacement For ASCE 7-05 Table 12.2-1
Design Coefficients And Factors For Basic Seismic Force-Resisting Systems

BASIC SEISMIC FORCE-RESISTING SYSTEM	DETAILING REFERENCE SECTION	RESPONSE MODIFICATION COEFFICIENT R[a]	SYSTEM OVERSTRENGTH FACTOR, Ω_0[g]	DEFLECTION AMPLIFICATION FACTOR, C_d[b]	SYSTEM LIMITATIONS AND BUILDING HEIGHT LIMITATIONS (FEET) BY SEISMIC DESIGN CATEGORY[c]				
					B	C	D[d]	E[d]	F[e]
A. Bearing Wall Systems									
1. Special reinforced concrete shear walls	***(21.1.1.7)***[l]	5	2-1/2	5	NL	NL	160	160	100
2. Ordinary reinforced concrete shear walls	***(21.1.1.7)***[l]	4	2-1/2	4	NL	NL	NP	NP	NP
3. Detailed plain concrete shear walls	***(1908.1.7)***[p]	2	2-1/2	2	NL	NP	NP	NP	NP
4. Ordinary plain concrete shear walls	***(Chapter 22)***[l]	1-1/2	2-1/2	1-1/2	NL	NP	NP	NP	NP
5. Intermediate precast shear walls	***(21.1.1.7)***[l]***, (1908.1.3)***[p]	4	2-1/2	4	NL	NL	40[o]	40[o]	40[o]
6. Ordinary precast shear walls	***(Chapters 1 - 18)***[l]	3	2-1/2	3	NL	NP	NP	NP	NP
7. Special reinforced masonry shear walls	***(1.17.3.2.6)***[n]	5	2-1/2	3-1/2	NL	NL	160	160	100
8. Intermediate reinforced masonry shear walls	***(1.17.3.2.5)***[n]	3-1/2	2-1/2	2-1/4	NL	NL	NP	NP	NP
9. Ordinary reinforced masonry shear walls	***(1.17.3.2.4)***[n]	2	2-1/2	1-3/4	NL	160	NP	NP	NP
10. Detailed plain masonry shear walls	***(1.17.3.2.3)***[n,o]	2	2-1/2	1-3/4	***NP***	NP	NP	NP	NP
11. Ordinary plain masonry shear walls	***(1.17.3.2.2)***[n,o]	1-1/2	2-1/2	1-1/4	***NP***	NP	NP	NP	NP
12. Prestressed masonry shear walls	***(1.17.3.2.10, 1.17.3.2.11, 1.17.3.2.12)***[n]	1-1/2	2-1/2	1-3/4	NL	NP	NP	NP	NP

Table 2-1 (Continued) Replacement For ASCE 7-05 Table 12.2-1
Design Coefficients And Factors For Basic Seismic Force-Resisting Systems

BASIC SEISMIC FORCE-RESISTING SYSTEM	DETAILING REFERENCE SECTION	RESPONSE MODIFICATION COEFFICIENT R[a]	SYSTEM OVERSTRENGTH FACTOR, Ω_0[g]	DEFLECTION AMPLIFICATION FACTOR, C_d[b]	SYSTEM LIMITATIONS AND BUILDING HEIGHT LIMITATIONS (FEET) BY SEISMIC DESIGN CATEGORY[c]				
					B	C	D[d]	E[d]	F[e]
13. Ordinary reinforced AAC masonry shear walls	***(1.17.3.2.9)[n]***	***2***	***2-1/2***	***2***	***NL***	***35***	***NP***	***NP***	***NP***
14. Ordinary plain AAC masonry shear walls	***(1.17.3.2.7)[n]***	***1-1/2***	***2-1/2***	***1-1/2***	***NL***	***NP***	***NP***	***NP***	***NP***
15. Light-framed walls sheathed with wood structural panels rated for shear resistance or with steel sheets	***(2210, 2301-2307)[p]***	6-1/2	3	4	NL	NL	65	65	65
16. Light-framed walls with shear panels – all other materials	***(2210, 2301-2307)[p]***	2	2-1/2	2	NL	NL	35	NP	NP
17. Light-framed wall systems using flat strap bracing	***(2210, 2301-2307)[p]***	4	2	3-1/2	NL	NL	65	65	65
B. Building Frame Systems									
1. Steel eccentrically braced frames, moment-resisting, connections at columns away from links	***(15)[j]***	8	2	4	NL	NL	160	160	100
2. Steel eccentrically braced frames, non-moment-resisting, connections at columns away from links	***(15)[j]***	7	2	4	NL	NL	160	160	100
3. Special steel concentrically braced frames	***(13)[j]***	6	2	5	NL	NL	160	160	100
4. Ordinary steel concentrically braced frames	***(14)[j]***	3-1/4	2	3-1/4	NL	NL	35[m]	35[m]	NP[m]
5. Special reinforced concrete shear walls	***(21.1.1.7)[l]***	6	2-1/2	5	NL	NL	160	160	100

Table 2-1 (Continued) Replacement For ASCE 7-05 Table 12.2-1
Design Coefficients And Factors For Basic Seismic Force-Resisting Systems

BASIC SEISMIC FORCE-RESISTING SYSTEM	DETAILING REFERENCE SECTION	RESPONSE MODIFICATION COEFFICIENT R^a	SYSTEM OVERSTRENGTH FACTOR, Ω_0^g	DEFLECTION AMPLIFICATION FACTOR, C_d^b	SYSTEM LIMITATIONS AND BUILDING HEIGHT LIMITATIONS (FEET) BY SEISMIC DESIGN CATEGORY[c]				
					B	C	D[d]	E[d]	F[e]
6. Ordinary reinforced concrete shear walls	***(21.1.1.7)***[l]	5	2-1/2	4-1/2	NL	NL	NP	NP	NP
7. Detailed plain concrete shear walls	***(1908.1.7)***[p]	2	2-1/2	2	NL	NP	NP	NP	NP
8. Ordinary plain concrete shear walls	***(Chapter 22)***[l]	1-1/2	2-1/2	1-1/2	NL	NP	NP	NP	NP
9. Intermediate precast shear walls	***(21.1.1.7)***[l], ***(1908.1.3)***[p]	5	2-1/2	4-1/2	NL	NL	40[o]	40[o]	40[o]
10. Ordinary precast shear walls	***(Chapters 1 - 18)***[l]	4	2-1/2	4	NL	NP	NP	NP	NP
11. Composite steel and concrete eccentrically braced frames	***(14)***[k]	8	2	4	NL	NL	160	160	100
12. Composite steel and concrete concentrically braced frames	***(12)***[k]	5	2	4-1/2	NL	NL	160	160	100
13. Ordinary composite steel and concrete braced frames	***(13)***[k]	3	2	3	NL	NL	NP	NP	NP
14. Composite steel plate shear walls	***(17)***[k]	6-1/2	2-1/2	5-1/2	NL	NL	160	160	100
15. Special composite reinforced concrete shear walls with steel elements	***(16)***[k]	6	2-1/2	5	NL	NL	160	160	100
16. Ordinary composite reinforced concrete shear walls with steel elements	***(15)***[k]	5	2-1/2	4-1/2	NL	NL	NP	NP	NP
17. Special reinforced masonry shear walls	***(1.17.3.2.6)***[n]	5-1/2	2-1/2	4	NL	NL	160	160	100
18. Intermediate reinforced masonry shear walls	***(1.17.3.2.5)***[n]	4	2-1/2	4	NL	NL	NP	NP	NP

Table 2-1 (Continued) Replacement For ASCE 7-05 Table 12.2-1
Design Coefficients And Factors For Basic Seismic Force-Resisting Systems

BASIC SEISMIC FORCE-RESISTING SYSTEM	DETAILING REFERENCE SECTION	RESPONSE MODIFICATION COEFFICIENT R^a	SYSTEM OVERSTRENGTH FACTOR, Ω_0^g	DEFLECTION AMPLIFICATION FACTOR, C_d^b	SYSTEM LIMITATIONS AND BUILDING HEIGHT LIMITATIONS (FEET) BY SEISMIC DESIGN CATEGORY[c]				
					B	C	D[d]	E[d]	F[e]
19. Ordinary reinforced masonry shear walls	***(1.17.3.2.4)[n]***	2	2-1/2	2	NL	160	NP	NP	NP
20. Detailed plain masonry shear walls	***(1.17.3.2.3)[n,o]***	2	2-1/2	APPENDIX A 2	***NP***	NP	NP	NP	NP
21. Ordinary plain masonry shear walls	***(1.17.3.2.2)[n,o]***	1-1/2	2-1/2	1-1/4	***NP***	NP	NP	NP	NP
22. Prestressed masonry shear walls	***(1.17.3.2.10, 1.17.3.2.11, 1.17.3.2.12)[n]***	1-1/2	2-1/2	1-3/4	NL	NP	NP	NP	NP
23. Light-framed walls sheathed with wood structural panels rated for shear resistance or with steel sheets	***(2210, 2301-2307)[p]***	7	2-1/2	4-1/2	NL	NL	65	65	65
24. Light-framed walls with shear panels – all other materials	***(2210, 2301-2307)[p]***	2-1/2	2-1/2	2-1/2	NL	NL	35	NP	NP
25. Buckling-restrained braced frames, non-moment resisting beam-column connections	***(16)[j]***	7	2	5-1/2	NL	NL	160	160	100
26. Buckling-restrained braced frames, moment-resisting beam-column connections	***(16)[j]***	8	2-1/2	5	NL	NL	160	160	100
27. Special steel plate shear walls	***(17)[j]***	7	2	6	NL	NL	160	160	100
C. Moment-Resisting Frame Systems									
1. Special steel moment frames	***(9)[j]***	8	3	5-1/2	NL	NL	NL	NL	NL
2. Special steel truss moment frames	***(12)[j]***	7	3	5-1/2	NL	NL	160	100	NP

Table 2-1 (Continued) Replacement For ASCE 7-05 Table 12.2-1
Design Coefficients And Factors For Basic Seismic Force-Resisting Systems

BASIC SEISMIC FORCE-RESISTING SYSTEM	DETAILING REFERENCE SECTION	RESPONSE MODIFICATION COEFFICIENT R[a]	SYSTEM OVERSTRENGTH FACTOR, Ω_0[g]	DEFLECTION AMPLIFICATION FACTOR, C_d[b]	SYSTEM LIMITATIONS AND BUILDING HEIGHT LIMITATIONS (FEET) BY SEISMIC DESIGN CATEGORY[c]				
					B	C	D[d]	E[d]	F[e]
3. Intermediate steel moment frames	***(10)***[j]	4-1/2	3	4	NL	NL	35[h,i]	NP[h]	NP[i]
4. Ordinary steel moment frames	***(11)***[j]	3-1/2	3	3	NL	NL	NP[h,r]	NP[h,r]	NP[i,r]
5. Special reinforced concrete moment frames	***(21.1.1.7)***[l]	8	3	5-1/2	NL	NL	NL	NL	NL
6. Intermediate reinforced concrete moment frames	***(21.1.1.7)***[l]	5	3	4-1/2	NL	NL	NP	NP	NP
7. Ordinary reinforced concrete moment frames	***(21.1.1.7)***[l]	3	3	2-1/2	NL	NP	NP	NP	NP
8. Special composite steel and concrete moment frames	***(9)***[k]	8	3	5-1/2	NL	NL	NL	NL	NL
9. Intermediate composite steel and concrete moment frames	***(10)***[k]	5	3	4-1/2	NL	NL	NP	NP	NP
10. Composite partially restrained moment frames	***(8)***[k]	6	3	5-1/2	160	160	100	NP	NP
11. Ordinary composite moment frames	***(11)***[k]	3	3	2-1/2	NL	NP	NP	NP	NP
12. Cold-formed steel—special bolted moment frame[s]	***(2209)***[q]	***3-1/2***	***3***[t]	***3-1/2***	***35***	***35***	***35***	***35***	***35***
D. Dual Systems with Special Moment Frames Capable of Resisting at Least 25% of Prescribed Seismic Forces [ASCE 7-05 12.2.5.1]									
1. Steel eccentrically braced frames	***(15)***[j]	8	2-1/2	4	NL	NL	NL	NL	NL
2. Special steel concentrically braced frames	***(13)***[j]	7	2-1/2	5-1/2	NL	NL	NL	NL	NL

Table 2-1 (Continued) Replacement For ASCE 7-05 Table 12.2-1
Design Coefficients And Factors For Basic Seismic Force-Resisting Systems

BASIC SEISMIC FORCE-RESISTING SYSTEM	DETAILING REFERENCE SECTION	RESPONSE MODIFICATION COEFFICIENT R^a	SYSTEM OVERSTRENGTH FACTOR, $\Omega_0{}^g$	DEFLECTION AMPLIFICATION FACTOR, $C_d{}^b$	SYSTEM LIMITATIONS AND BUILDING HEIGHT LIMITATIONS (FEET) BY SEISMIC DESIGN CATEGORY[c]				
					B	C	D[d]	E[d]	F[e]
3. Special reinforced concrete shear walls	*(21.1.1.7)*[l]	7	2-1/2	5-1/2	NL	NL	NL	NL	NL
4. Ordinary reinforced concrete shear walls	*(21.1.1.7)*[l]	6	2-1/2	5	NL	NL	NP	NP	NP
5. Composite steel and concrete eccentrically braced frames	*(14)*[k]	8	2-1/2	4	NL	NL	NL	NL	NL
6. Composite steel and concrete concentrically braced frames	*(12)*[k]	6	2-1/2	5	NL	NL	NL	NL	NL
7. Composite steel plate shear walls	*(17)*[k]	7-1/2	2-1/2	6	NL	NL	NL	NL	NL
8. Special composite reinforced concrete shear walls with steel elements	*(16)*[k]	7	2-1/2	6	NL	NL	NL	NL	NL
9. Ordinary composite reinforced concrete shear walls with steel elements	*(15)*[k]	6	2-1/2	5	NL	NL	NP	NP	NP
10. Special reinforced masonry shear walls	*(1.17.3.2.6)*[n]	5-1/2	3	5	NL	NL	NL	NL	NL
11. Intermediate reinforced masonry shear walls	*(1.17.3.2.5)*[n]	4	3	3-1/2	NL	NL	NP	NP	NP
12. Buckling-restrained braced frames	*(16)*[j]	8	2-1/2	5	NL	NL	NL	NL	NL
13. Special steel plate shear walls	*(17)*[j]	8	2-1/2	6-1/2	NL	NL	NL	NL	NL
E. Dual Systems with Intermediate Moment Frames Capable of Resisting at Least 25% of Prescribed Seismic Forces [ASCE 7-05 12.2.5.1]									

Table 2-1 (Continued) Replacement For ASCE 7-05 Table 12.2-1
Design Coefficients And Factors For Basic Seismic Force-Resisting Systems

BASIC SEISMIC FORCE-RESISTING SYSTEM	DETAILING REFERENCE SECTION	RESPONSE MODIFICATION COEFFICIENT R[a]	SYSTEM OVERSTRENGTH FACTOR, Ω_0[g]	DEFLECTION AMPLIFICATION FACTOR, C_d[b]	SYSTEM LIMITATIONS AND BUILDING HEIGHT LIMITATIONS (FEET) BY SEISMIC DESIGN CATEGORY[c]				
					B	C	D[d]	E[d]	F[e]
1. Special steel concentrically braced frames[f]	*(13)*[j]	6	2-1/2	5	NL	NL	35	NP[h,i]	NP[h,i]
2. Ordinary steel concentrically braced frames[f]	*(14)*[j]	5	2-1/2	4-1/2	NL	NL	160	100	NP
3. Special reinforced concrete shear walls	*(21.1.1.7)*[l]	6-1/2	2-1/2	5	NL	NL	160	100	100
4. Ordinary reinforced concrete shear walls	*(21.1.1.7)*[l]	5-1/2	2-1/2	4-1/2	NL	NL	NP	NP	NP
5. Ordinary reinforced masonry shear walls	*(1.17.3.2.4)*[n]	3	3	2-1/2	NL	160	NP	NP	NP
6. Intermediate reinforced masonry shear walls	*(1.17.3.2.5)*[n]	3-1/2	3	3	NL	NL	NP	NP	NP
7. Composite steel and concrete concentrically braced frames	*(12)*[k]	5-1/2	2-1/2	4-1/2	NL	NL	160	100	NP
8. Ordinary composite steel and concrete braced frames	*(13)*[k]	3-1/2	2-1/2	3	NL	NL	NP	NP	NP
9. Ordinary composite reinforced concrete shear walls with steel elements	*(15)*[k]	5	3	4-1/2	NL	NL	NP	NP	NP
F. Shear Wall-Frame Interactive System with Ordinary Reinforced Concrete Moment Frames and Ordinary Reinforced Concrete Shear Walls	*(21.1.1.7)*[l]	4-1/2	2-1/2	4	NL	NP	NP	NP	NP
G. Cantilevered column systems detailed to conform to the requirements for [ASCE 7-05 12.2.5.2]:									

Table 2-1 (Continued) Replacement For ASCE 7-05 Table 12.2-1
Design Coefficients And Factors For Basic Seismic Force-Resisting Systems

BASIC SEISMIC FORCE-RESISTING SYSTEM	DETAILING REFERENCE SECTION	RESPONSE MODIFICATION COEFFICIENT R[a]	SYSTEM OVERSTRENGTH FACTOR, Ω_0[g]	DEFLECTION AMPLIFICATION FACTOR, C_d[b]	SYSTEM LIMITATIONS AND BUILDING HEIGHT LIMITATIONS (FEET) BY SEISMIC DESIGN CATEGORY[c]				
					B	C	D[d]	E[d]	F[e]
1. Special steel moment frames	***(9)***[j]	2-1/2	1-1/4	2-1/2	35	35	35	35	35
2. Intermediate steel moment frames	***(10)***[j]	1-1/2	1-1/4	1-1/2	35	35	35[h]	NP[h,i]	NP[h,i]
3. Ordinary steel moment frames	***(11)***[j]	1-1/4	1-1/4	1-1/4	35	35	NP	NP[h,i]	NP[h,i]
4. Special reinforced concrete moment frames	***(21.1.1.7)***[l]	2-1/2	1-1/4	2-1/2	35	35	35	35	35
5. Intermediate reinforced concrete moment frames	***(21.1.1.7)***[l]	1-1/2	1-1/4	1-1/2	35	35	NP	NP	NP
6. Ordinary reinforced concrete moment frames	***(21.1.1.7)***[l]	1	1-1/4	1	35	NP	NP	NP	NP
7. Timber frames	***(2301 – 2307)***[p]	1-1/2	1-1/2	1-1/2	35	35	35	NP	NP
H. Structural Steel Systems Not Specifically Detailed for Seismic Resistance, Excluding Cantilevered Column Systems	***AISC 360***	3	3	3	NL	NL	NP	NP	NP

FOR SI: 1 foot (ft) = 304.8 mm, 1 pound per square foot (psf) = 0.0479 kN/m^2

a. Response modification coefficient, R, for use throughout. Note R reduces forces to a strength level, not an allowable stress level.

b. Deflection amplification factor, C_d, for use in ***ASCE 7-05*** Sections 12.8.6, 12.8.7, and 12.9.2.

c. NL= Not limited and NP = Not permitted. For metric units, use 30 m for 100 ft and 50 m for 160 ft. ***Height is measured from the base of the structure.***

d. See ***ASCE 7-05*** Section 12.2.5.4, ***as modified by 2009 IBC Section 1613.6.6***, for a description of seismic force-resisting systems limited to buildings with a height of 240 feet (75 m) or less.

e. See ***ASCE 7-05*** Section 12.2.5.4, ***as modified by 2009 IBC Section 1613.6.6***, for building systems limited to buildings with a height of 160 feet (50 m) or less.

Table 2-1 (Continued) Replacement For ASCE 7-05 Table 12.2-1
Design Coefficients And Factors For Basic Seismic Force-Resisting Systems

BASIC SEISMIC FORCE-RESISTING SYSTEM	DETAILING REFERENCE SECTION	RESPONSE MODIFICATION COEFFICIENT R^a	SYSTEM OVERSTRENGTH FACTOR, Ω_0^g	DEFLECTION AMPLIFICATION FACTOR, C_d^b	SYSTEM LIMITATIONS AND BUILDING HEIGHT LIMITATIONS (FEET) BY SEISMIC DESIGN CATEGORY[c]				
					B	C	D[d]	E[d]	F[e]

f. Ordinary moment frame is permitted to be used in lieu of intermediate moment frame for Seismic Design Category B or C.

g. ***Where the tabulated value of the overstrength factor, Ω_0, is greater than or equal to 2½, Ω_0 is permitted to be reduced by subtracting the value of ½ for structures with flexible diaphragms.***

h. ***Single-story steel OMFs and intermediate moment frames in structures assigned to SDC D or E shall be permitted up to a height of 65 ft (20 m), where the dead load supported by and tributary to the roof does not exceed 20 psf (1.0 kN/m^2). In addition, the dead loads of exterior walls tributary to the moment frame more than 35 ft (11 m) above the base shall not exceed 20 psf (1.0 kN/m^2). Steel OMFs in structures assigned to SDC D or E, but not meeting the single story limitations, shall be permitted in light frame construction up to a height of 35 ft (11 m), where neither the roof nor the floor dead load supported by and tributary to the moment frame exceeds 35 psf (1.68 kN/m^2), and the dead load of the exterior walls tributary to the moment frame shall not exceed 20 psf (1.0 kN/m^2). Steel intermediate moment frames in Seismic Design Category D that do not meet the single story limitations shall be permitted to a height of 35 ft (10.6m). Steel intermediate moment frames in SDC E that do not meet the single story limitations shall be permitted to a height of 35 ft (11 m), provided neither the roof nor the floor dead load supported by and tributary to the moment frame exceeds 35 psf (1.68 kN/m^2), and the dead load of the exterior walls tributary to the moment frame does not exceed 20 psf (1.0 kN/m^2).***

i. ***Single story steel OMFs and intermediate moment frames in structures assigned to SDC F shall be permitted up to a height of 65 ft (20 m), where the dead load supported by and tributary to the roof does not exceed 20 psf (1.0 kN/m^2), and the dead loads of the exterior walls tributary to the moment frame does not exceed 20 psf (1.0 kN/m^2). Steel intermediate moment frames in structures assigned to Seismic Design Category F shall be permitted in light frame construction, so long as the limitations for light frame construction in SDC E (footnote h) are met.***

j. ***AISC 341-05 Part I section number***

k. ***AISC 341-05 Part II section number***

l. ***ACI 318-08, Section 21.1.1.7 cites appropriate sections in ACI 318-08***

m. Steel ordinary concentrically braced frames (OCBFs) are permitted in single-story buildings up to a height of 60 ft (18 m) and in penthouse structures, when the dead load of the roof does not exceed 20 psf (1.0 kN/m^2).

n. ***TMS 402-08/ACI 530-08/ASCE 5-08 section number.***

o. A height increase to 45 ft (14 m) is permitted for single story warehouse facilities.

p. ***2009 IBC section numbers.***

q. ***Chapter 2 of this UFC.***

r. ***OMFs are permitted to be used as part of the structural system that transfers forces between isolator units.***

Table 2-1 (Continued) Replacement For ASCE 7-05 Table 12.2-1
Design Coefficients And Factors For Basic Seismic Force-Resisting Systems

BASIC SEISMIC FORCE-RESISTING SYSTEM	DETAILING REFERENCE SECTION	RESPONSE MODIFICATION COEFFICIENT R^a	SYSTEM OVERSTRENGTH FACTOR, $\Omega_0{}^g$	DEFLECTION AMPLIFICATION FACTOR, $C_d{}^b$	SYSTEM LIMITATIONS AND BUILDING HEIGHT LIMITATIONS (FEET) BY SEISMIC DESIGN CATEGORY[c]				
					B	C	D[d]	E[d]	F[e]

s. ***Cold-formed steel – special bolted moment frames shall be limited to one-story in height in accordance with AISI S110.***

t. ***Alternately, the seismic load effect with overstrength, E_{mh}, is permitted to be based on the expected strength determined in accordance with AISI S110.***

Table 2-2 Replacement for ASCE 7-05 Table 12.6-1 Permitted Analytical Procedures

Seismic Design Category	Structural characteristics	Equivalent Lateral Force Analysis, Section 12.8	Modal Response Spectrum Analysis, Section 12.9	Linear Response History Procedure, Section 16.1	Nonlinear Response History Procedure, Section 16.2
B[a], C[a]	All structures	P	P	P	P
D[a], E[a], F[a]	OC I or II buildings not exceeding 2 stories above the base	P	P	P	P
	Structures of light frame construction	P	P	P	P
	Structures with no structural irregularities and not exceeding 160 ft in structural height	P	P	P	P
	Structures exceeding 160 ft in structural height with no structural irregularities and with $T < 3.5T_s$	P	P	P	P
	Structures not exceeding 160 ft in structural height and having only horizontal irregularities of Type 2, 3, 4, or 5 in Table 12.3-1 or vertical irregularities of Type 4, 5a, or 5b in Table 12.3-2	P	P	P	P
	All other structures	NP	P	P	P
Occupancy Category V	All structures	NP	P	P	NP[b]

P: Permitted; NP: Not Permitted. $T_s = S_{D1}/S_{DS}$.

[a] For OC IV structures designed using the alternate procedure of Chapter 3, only the Nonlinear Response History Procedure is permitted

[b] For structures using seismic isolation and/or supplemental damping, nonlinear dynamic analysis is required (see Section D-12.6.2)

Table 2-3 Required Verification and Inspection of Mechanical and Electrical Components*

VERIFICATION & INSPECTION	Continuous	Periodic	Standard Reference	IBC Reference
1. Equipment Verification				
a. Verify model number and serial number are in conformance with project specific seismic qualification (PSSQ).		x		
b. Verify Tag ID is correct and installed per specifications.		x		
2. Equipment Mounting				
a. Verify that Anchor Base Bolting is installed per PSSQ		x		
b. Verify that Equipment Bracing is Installed per PSSQ		x		
c. Verify that Bracing Attachments are installed per PSSQ		x		
3. Utility Conduit/Piping				
a. Verify that Conduit/Piping is connected to the equipment per PSSQ (flex or rigid)		x		
b. Verify that Conduit/Piping is seismically supported independently of equipment and in accordance with PSSQ support requirements.		x		
4. Clearance				
a. Adjacent Equipment – Verify that there is adequate gap to eliminate possibility of pounding.		x		
b. Conduit/Piping - Verify that there is adequate gap to eliminate possibility of pounding.		x		

*All required inspections and verifications shall be carried out for each piece of equipment constituting part of the Designated Seismic Systems.

Table 2-4 Replacement for ASCE 31-03 Table 3-1, Benchmark Buildings

Building Type[1,2]	Model Building Seismic Design Provisions					Evaluation				*Tri-Services Criteria*[9]		
									CBC^{IO}	*Design*		*Evaluation*
	NBC^{LS}	SBC^{LS}	UBC^{LS}	IBC^{LS}	NEHRP^{LS}	FEMA 178^{LS}	FEMA 310$^{LS, IO}$	FEMA 356 ^{LS}		*LS*	*IO*	*LS, IO*
Wood Frame, Wood Shear Panels (Types W1 & W2)	1993	1994	1976	2000	1985	*	1998	2000	1973	***1982***	***1986***	***1999***
Wood Frame, Wood Shear Panels, Multi-Story (Type W1A)	*	*	1997	2000	1997	*	1998	2000	1973	***1998***	***1998***	***1999***
Steel Moment-Resisting Frame (Types S1 & S1A)	*	*	1994[4]	2000	**	*	1998	2000	1995	***1998***	***1998***	***1999***
Steel Braced Frame (Types S2 & S2A)	1993	1994	1988	2000	1991	1992	1998	2006	1973	***1992***	***1992***	***1999***
Steel Light Frame (Type S3)	*	*	*	2000	*	1992	1998	2000	1973	***1992***[7]	***1998***[7]	***1999***
Steel Frame w/Concrete Shear Walls (Type S4)	1993	1994	1976	2000	1985	1992	1998	2000	1973	***1982***	***1986***	***1999***
Reinforced Concrete Moment-Resisting Frame (Type C1)[3]	1993	1994	1976	2000	1985	*	1998	2000	1973	***1982***	***1986***	***1999***
Reinforced Concrete Shear Walls (Types C2 & C2A)	1993	1994	1976	2000	1985	*	1998	2000	1973	***1982***	***1986***	***1999***
Steel Frame with Masonry Infill Walls (Types S5 & S5A)	*	*	*	2000	*	*	1998	2000	*	***	***NP***	***1999***
Concrete Frame with Masonry Infill Walls (Types C3 & C3A)	*	*	*	2000	*	*	1998	2000	*	***	***NP***	***1999***

Table 2-4 (Continued) Replacement for ASCE 31-03 Table 3-1, Benchmark Buildings

Building Type[1,2]	Model Building Seismic Design Provisions					Evaluation				*Tri-Services Criteria*[9]		
	NBC[LS]	SBC[LS]	UBC[LS]	IBC[LS]	NEHRP[LS]	FEMA 178[LS]	FEMA 310[LS, IO]	FEMA 356 [LS]	CBC[IO]	*Design*		*Evaluation*
										LS	*IO*	*LS, IO*
Precast/Tilt-up Concrete Shear Walls (Types PC1 & PC1A)	*	*	1997	2000	*	*	1998	2000	*	***1998***	***1998***	***1999***
Precast Concrete Frame (Types PC2 & PC2A)	*	*	*	2000	*	1992	1998	2000	1973	***1998***	***1998***	***1999***
Reinforced Masonry Bearing Walls w/Flexible Diaphragms (Type RM1)	*	*	1997	2000	*	*	1998	2000	*	***1998***	***1998***	***1999***
Reinforced Masonry Bearing Walls w/Stiff Diaphragms (Type RM2)	1993	1994	1976	2000	1985	*	1998	2006	*	***1982***	***1986***	***1999***
Unreinforced Masonry Bearing Walls w/Flexible Diaphragms (Type URM)[5]	*	*	1991[6]	2000	*	1992	*	2000	*	***	***NP***	***1999 (LS only)***
Unreinforced Masonry Bearing Walls w/Stiff Diaphragms (Type URMA)	*	*	*	2000	*	*	1998	2000	*	***	***NP***	***1999***
Load-Bearing Cold-Formed Steel Framing (Not listed in ASCE 31-03)	***N/A***	***N/A***	***N/A***	***N/A***	***N/A***	***N/A***	***N/A***	2000	***N/A***	***1998***[8]	***1998***[8]	***1999***

Notes:

[1] Building Type refers to one of the Common Building Types defined in ***ASCE 31-03*** Table 2-2.

[2] Buildings on hillside sites shall not be considered Benchmark Buildings.

Table 2-4 (Continued) Replacement for ASCE 31-03 Table 3-1, Benchmark Buildings

Building Type[1,2]	Model Building Seismic Design Provisions					Evaluation			CBC[IO]	*Tri-Services Criteria*[9]		
	NBC[LS]	SBC[LS]	UBC[LS]	IBC[LS]	NEHRP[LS]	FEMA 178[LS]	FEMA 310[LS, IO]	FEMA 356[LS]		*Design*		*Evaluation*
										LS	*IO*	*LS, IO*

[3] Flat Slab Buildings 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 GSREB or its predecessor, the UCBC (Uniform Code of Building Conservation).

[7] ***Pre-engineered metal buildings designed in accordance with 1992 criteria using ASCE 7 loading may be considered as Benchmark Buildings for Life Safety Performance Objective, only if all other applicable restrictions are met. Pre-engineered metal buildings designed in accordance with 1998 criteria, including TI 809-30, Metal Building Systems, may be considered as Benchmark Buildings for both the Life Safety and Immediate Occupancy Performance Objectives, only if all other applicable restrictions are met.***

[8] ***This benchmark year is based in the initial publication of TI 809-07, Design of Cold-Formed Load-Bearing Steel System and Masonry Veneer Steel Stud Walls, 1998.***

[9] ***The Tri-Services Criteria Benchmark Year provisions apply only to the structural aspects of the evaluation. Nonstructural and foundation elements shall require a minimum Tier 1 evaluation, in accordance with ASCE 31-03, except under the following circumstances:***

a. The building was designed and constructed in accordance with TI 809-04 or later Tri-Services criteria; or,

b. The building was evaluated in accordance with TI 809-05 or later Tri-Services criteria, and the building evaluation and rehabilitation included structural, nonstructural, geotechnical, and foundation measures.

[LS] Only buildings designed and constructed or evaluated in accordance with these documents and being evaluated to the Life-Safety Performance Level may be considered Benchmark Buildings.

[IO] Only buildings designed and constructed or evaluated in accordance with these documents and being evaluated to either the Life-Safety or Immediate Occupancy Performance Level may be considered Benchmark Buildings.

[*] No benchmark year established. Buildings shall be evaluated using ***ASCE 31-03***.

** Local provisions shall be compared with the UBC.

Table 2-4 (Continued) Replacement for ASCE 31-03 Table 3-1, Benchmark Buildings

Building Type[1,2]	Model Building Seismic Design Provisions					Evaluation			CBC[IO]	*Tri-Services Criteria*[9]		
	NBC[LS]	SBC[LS]	UBC[LS]	IBC[LS]	NEHRP[LS]	FEMA 178[LS]	FEMA 310[LS, IO]	FEMA 356[LS]		*Design*		*Evaluation*
										LS	*IO*	*LS, IO*

N/A – Not Applicable. This building Type is not listed as a FEMA Model Building type, so no benchmark years have been established in non-Tri-Service documents.

NP – Not Permitted. Tri-Services guidance does not permit the use of URM.

NBC – Building Code Officials and Code Administrators (BOCA), *National Building Code*, 1993.

SBC – Southern Building Code Congress (SBCC), *Standard Building Code*, 1994.

UBC – International Conference of Building Officials (ICBO), *Uniform Building Code*, ***year as shown in table***.

GSREB – ICBO, *Guidelines for Seismic Retrofit of Existing Buildings*, 2001.

IBC – International Code Council, *International Building Code*, 2000.

NEHRP – Federal Emergency Management Agency (FEMA), *NEHRP Recommended Provisions for the Development of Seismic Regulations for New Buildings*. ***Years shown in table refer to editions of document.***

FEMA 178 – FEMA, *NEHRP Handbook for the Seismic Evaluation of Existing Buildings*, 1992.

FEMA 310 – FEMA, *Handbook for the Seismic Evaluation of Buildings – A Prestandard*, 1998. ***FEMA 310 has been superseded by ASCE 31-03.***

CBC – California Building Standards Commission, *California Building Code, California Code of Regulations*, *Title 24*, ***1995 or earlier. CBC shall not be used without proper supporting documentation showing specific provisions cited.***

FEMA 356 - FEMA, *Prestandard and Commentary for the Seismic Rehabilation of Existing Buildings* - ***FEMA 356 has been superseded by ASCE 41-06.***

<u>Tri-Services Criteria:</u>

1982 – TM 5-809-10; NAVFAC P-355; AFM 88-3, Ch 13, Seismic Design for Buildings, 1982.

1986 – TM 5-809-10-1; NAVFAC P-355.1; AFM 88-3, Ch 13, Sec A, Seismic Design Guidelines for Essential Buildings, 1986.

Table 2-4 (Continued) Replacement for ASCE 31-03 Table 3-1, Benchmark Buildings

Building Type[1,2]	Model Building Seismic Design Provisions					Evaluation			CBC[IO]	*Tri-Services Criteria[9]*		
	NBC[LS]	SBC[LS]	UBC[LS]	IBC[LS]	NEHRP[LS]	FEMA 178[LS]	FEMA 310[LS, IO]	FEMA 356[LS]		*Design*		*Evaluation*
										LS	*IO*	*LS, IO*

1988 – TM 5-809-10-2; NAVFAC P-355.2; AFM 88-3, Ch 13, Sec B, Seismic Design Guidelines for Upgrading Existing Buildings, 1988.

1992 – TM 5-809-10; NAVFAC P-355; AFM 88-3, Ch 13, Seismic Design for Buildings, 1992.

CHAPTER 3 ALTERNATE DESIGN PROCEDURE FOR OC IV STRUCTURES

3-1 GENERAL

3-1.1 Overview.

This Chapter shall be used for the alternate design of buildings and other structures in OC IV.

Buildings in OC IV are either unit/installation-essential or post-disaster essential (UFC 3-301-01 Table 2-2). This Chapter provides optional nonlinear analysis procedures for OC IV buildings and other structures that may be used as an alternative to the procedures found in the 2009 *International Building Code* (2009 IBC). Nonlinear analysis procedures may provide more economical or better-performing structural designs than the 2009 IBC procedures. The analysis procedures outlined in this Chapter shall be used only with the approval of the Authority having Jurisdiction.

The nonlinear procedures outlined in this Chapter require that an OC IV building meet two general performance objectives:

1. A Life Safety (LS) performance objective for the Maximum Considered Earthquake (MCE) ground motions, nominally an earthquake with a 2% probability of exceedance in 50 years (2%/50-yr); and,

2. An Immediate Occupancy (IO) performance objective for earthquake ground motions with a 10% probability of exceedance in 50 years (10%/50-yr). The 10%/50-yr earthquake is termed herein as the BSE-1 earthquake, adopting the terminology used in ASCE/SEI 41-06, *Seismic Rehabilitation of Existing Buildings*.

Performance criteria based on tolerable levels of damage are defined to ensure that these performance objectives are met. Nonlinear strength and deformation demands are determined by performing nonlinear static or nonlinear dynamic analyses and the results compared with acceptance criteria contained in authoritative documents, such as ASCE 41 or FEMA P-750, or developed based on laboratory data or rational analysis.

To ensure that satisfactory nonlinear behavior is achieved, restrictions on the types of seismic force-resisting systems that can be used in conjunction with this Chapter are imposed.

This Chapter replaces the provisions of Chapter 16 of the 2009 IBC, as modified by Chapter 2, for use in performing the alternative analysis of OC IV buildings and other structures. All other chapters of the 2009 IBC shall apply as modified by Chapter 2.

3-1.2 Design Review Panel.

A design review of the seismic force-resisting system design and structural analysis shall be performed by an independent team of Registered Design Professionals in the appropriate disciplines and others experienced in seismic analysis methods and the theory and application of nonlinear seismic analysis and structural behavior under extreme cyclic loads. Membership on the Design Review Panel shall be subject to the approval of the Authority having Jurisdiction. The design review shall include, but not necessarily be limited to, the following:

1. Any site-specific seismic criteria used in the analysis, including the development of site-specific spectra and ground motion time-histories;

2. Any acceptance criteria used to demonstrate the adequacy of structural elements and systems to withstand the calculated force and deformation demands, together with any laboratory or other data used to substantiate the criteria;

3. The preliminary design, including the selection of the structural system and the configuration of structural elements; and,

4. The final design of the entire structural system and all supporting analyses.

3-2 DEFINITIONS

3-2.1 General.

2009 IBC Sections 1602 and 1613.2 and ASCE 7-05 Section 11.2 shall apply. In addition, the definitions listed in Section X.1 of Resource Paper 2 of FEMA P-750, *NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures*, 2009 Edition, shall apply.

3-3 CONSTRUCTION DOCUMENTS

3-3.1 General.

2009 IBC Section 1603, as modified by Chapter 2 Section 1603, shall apply.

Exception:

For buildings designed using this Chapter, the Seismic Importance Factor, *I*, the design base shear, seismic response coefficient, C_s, and the Response Modification Factor, *R*, do not apply and shall not be listed in construction documents.

3-4 GENERAL DESIGN REQUIREMENTS

3-4.1 General.

2009 IBC Section 1604 shall apply, except as modified herein. UFC 3-301-01 Table 2-2 shall replace 2009 IBC Table 1604.5. The Occupancy Importance Factor for seismic loading defined in UFC 3-301-01 Table 2-2 shall not apply. Occupancy Importance Factors for seismic design of nonstructural components shall be determined in accordance with the criteria of ASCE7-05 Chapter 13. Occupancy Importance Factors for wind, snow and ice loads shall apply as listed in UFC 3-301-01 Table 2-2.

3-5 LOAD COMBINATIONS

3-5.1 General.

OC IV buildings and other structures, and portions thereof, shall be designed to resist the load combinations specified in this section. For all load combinations where earthquake-generated forces are not considered, 2009 IBC Section 1605.2 shall apply. In addition, where atmospheric ice and wind-on-ice loads are considered, ASCE 7-05 Section 2.3.4 shall apply. Where earthquake-generated forces are considered, 2009 IBC Equations 16-5 and 16-7 shall be replaced by Equations 3-1 and 3-2. 2009 IBC Section 1605.3 shall not apply; allowable stress design shall not be permitted for use in this Chapter. ASCE 7-05 Section 12.4.3.2 shall not apply; for any design situation requiring the use of load combinations with over strength factor, Equations 3-1 and 3-2 shall apply, subject to the exceptions noted in Section 3-17.1.

3-5.2 Seismic Load Combinations.

When the effects of earthquake-generated forces are considered, structures shall resist the most critical effects from the following combinations of factored loads:

When the effects of gravity and seismic loads are additive:

$$1.1(D + 0.25\,L + 0.2\,S) + E$$ **(Equation 3-1)**

When the effects of gravity and seismic loads are counteractive:

$$0.9\,D + E$$ **(Equation 3-2)**

where

D = Effect of dead load

L = Effect of unreduced design live load

S = Effect of design flat roof snow load calculated in accordance with ASCE 7-05

E = The maximum effect of horizontal and vertical earthquake forces at the BSE-1 displacement (Δ_S) or MCE displacement (Δ_M), determined in the nonlinear analysis, as set forth in Section 3-17.1

Exception: Where the design flat-roof snow load calculated in accordance with ASCE 7-05 is less than 30 psf, the effective snow load shall be permitted to be taken as zero.

3-6 DEAD LOADS

3-6.1 General.

2009 IBC Section 1606 shall apply.

3-7 LIVE LOADS

3-7.1 General.

2009 IBC Section 1607 shall apply.

3-8 SNOW LOADS

3-8.1 General.

2009 IBC Section 1608 shall apply.

3-9 WIND LOADS

3-9.1 General.

2009 IBC Section 1609 shall apply.

3-10 SOIL LATERAL LOAD

3-10.1 General.

2009 IBC Section 1610 shall apply, without the exception that is noted there.

3-11 RAIN LOADS

3-11.1 General.

2009 IBC Section 1611 shall apply.

3-12 FLOOD LOADS

3-12.1 General.

2009 IBC Section 1612 shall apply.

3-13 ICE LOADS—ATMOSPHERIC ICING

3-13.1 General.

ASCE 7-05 Chapter 10 shall apply.

3-14 EARTHQUAKE LOADS – GENERAL

3-14.1 Scope.

Every structure, and portion thereof, shall as a minimum be designed and constructed to resist the effects of earthquake motions and assigned an SDC as set forth in 2009 IBC Section 1613.5.6/ASCE 7-05 Section 11.6. The use of nonlinear analysis procedures in this Chapter minimizes the need for SDC use, but the SDC is required for establishing detailing requirements.

3-14.1.1 Additions to Existing Buildings.

2009 IBC section 3403, as modified by Chapter 2 Section 3403 shall apply.

3-14.2 Change of Occupancy.

2009 IBC Section 3408 shall apply (see comment in Chapter 2 Section 3408).

3-14.3 Alterations.

2009 IBC Section 3404, as modified by Chapter 2 Section 3404, shall apply.

3-14.4 Quality Assurance.

2009 IBC Chapter 17, as modified by Chapter 2 Sections 1701-1710, shall apply.

3-14.5 Seismic and Wind.

2009 IBC Section 1604.10 shall apply.

3-15 EARTHQUAKE LOADS – SITE GROUND MOTION

3-15.1 General Procedure for Determining Design Spectral Response Accelerations.

Ground motion accelerations, represented by response spectra and coefficients derived from these spectra, shall be determined in accordance with the general procedure of this Section, or the site-specific response analysis procedure of Section 3-15.2.

Procedures prescribed in this Chapter use both the MCE (2%/50-yr) ground motions and the BSE-1 ground motions. BSE-1 ground motions have a 10% probability of exceedance in 50 years (10%/50-yr).

Mapped MCE spectral response accelerations at short periods, S_S, and at 1- second period, S_1, shall be determined as prescribed in Sections 2-1.6.1 and 2-1.6.2 of UFC 3-301-01. MCE spectral accelerations at short periods and a 1-second period, adjusted for site class effects, shall be determined in accordance with Section 3-15.1.2. The general response spectrum for MCE ground shaking shall be determined in accordance with ASCE 7-05 Section 11.4.5, except that S_{MS} and S_{M1} shall be used respectively in lieu of S_{DS} and S_{D1} (see Section 3-15.1.2).

Mapped 10%/50-yr spectral response accelerations at short periods, $S_{S\text{-}BSE\text{-}1}$, and at a 1-second period, $S_{1\text{-}BSE\text{-}1}$, shall be determined for installations within the United States from Table E-2 of UFC 3-301-01. Alternatively, with the permission of the Authority having Jurisdiction, $S_{S\text{-}BSE\text{-}1}$ and $S_{1\text{-}BSE\text{-}1}$ may be determined using the web-based United States Geological Survey (USGS) Earthquake Ground Motion Parameters Calculator. When using the USGS calculator, the 2002 edition of the ground motion data, and the latitude and longitude of the site shall be used. It is also permissible to determine these accelerations using the *National Seismic Hazard Maps*, published in 2002 and *Seismic Hazard Maps for Puerto Rico and U.S. Virgin Islands*, published in 2003 by the USGS for the NEHRP.

Any discrepancy between the $S_{S\text{-}BSE\text{-}1}$ and $S_{1\text{-}BSE\text{-}1}$ values found in Table E-2 of UFC 3-301-01 and those found in either the USGS software or the maps shall be brought to the attention of the Authority having Jurisdiction.

For installations that lie outside the United States, $S_{S\text{-}BSE\text{-}1}$ and $S_{1\text{-}BSE\text{-}1}$ shall be determined from Tables F-2 and G-1 of UFC 3-301-01. The values listed in UFC 3-301-01 have been derived by USGS. Where site-specific installation data are available, they may be used in lieu of the data from UFC 3-301-01, with the approval of the Authority having Jurisdiction.

The BSE-1 spectral accelerations at short periods and at a 1-second period, adjusted for site class effects, shall be determined in accordance with Section 3-15.1.2. The design response spectrum for BSE-1 ground shaking shall be constructed in accordance with ASCE 7-05 Section 11.4.5, except that the quantities S_{SS} and S_{S1} shall be used respectively in place of S_{DS} and S_{D1}.

3-15.1.1 Site Class Definition.

ASCE 7-05 Section 20.3 shall apply as written.

3-15.1.2 Site Coefficients and Adjusted Earthquake Spectral Response Acceleration Parameters.

The spectral response accelerations for short periods and at a 1-second period, adjusted for site class effects, shall be determined by Equations 3-3 through 3-6:

$$S_{MS} = F_a S_{S\text{-}MCE} \qquad \textbf{(Equation 3-3)}$$

$$S_{SS} = F_a S_{S\text{-}BSE\text{-}1} \qquad \textbf{(Equation 3-4)}$$

$$S_{M1} = F_v S_{1\text{-}MCE} \qquad \textbf{(Equation 3-5)}$$

$$S_{S1} = F_v S_{1\text{-}BSE\text{-}1} \qquad \textbf{(Equation 3-6)}$$

where

F_a = Site coefficient defined in 2009 IBC Table 1613.5.3(1)

F_v = Site coefficient defined in 2009 IBC Table 1613.5.3(2)

$S_{S\text{-}MCE}$ = Mapped 5% damped spectral acceleration for short periods as determined in Section 3-15.1, for the MCE; this value is the same as S_S in the 2009 IBC

$S_{S\text{-}BSE\text{-}1}$ = Mapped 5% damped spectral acceleration for short periods as determined in Section 3-15.1, for the 10%/50-yr earthquake

$S_{1\text{-}MCE}$ = Mapped 5% damped spectral acceleration for a 1-second period as determined in Section 3-15.1, for the MCE; this value is the same as S_1 in the 2009 IBC

$S_{1\text{-}BSE\text{-}1}$ = Mapped 5% damped spectral acceleration for a 1-second period as determined in Section 3-15.1, for the 10%/50-yr earthquake

S_{MS} = MCE spectral response accelerations for short periods; this value is the same as S_{MS} in the 2009 IBC

S_{M1} = MCE spectral response accelerations for a 1-second period; this value is the same as S_{M1} in the 2009 IBC

S_{SS} = The BSE-1 spectral response accelerations for short periods

S_{S1} = The BSE-1 spectral response accelerations for a 1-second period

3-15.2 Site-specific Response Analysis for Determining Ground Motion Accelerations.

ASCE 7-05 Section 21.1 shall apply, except that the procedures outlined for determining MCE parameters shall also be applied to determining BSE-1 parameters.

3-15.3 Ground Motion Hazard Analysis.

ASCE 7-05 Section 21.2 shall apply.

3-16 EARTHQUAKE LOADS – CRITERIA SECTION

3-16.1 Structural Design Criteria.

Each structure shall be assigned a Seismic Design Category in accordance with 2009 IBC Section 1613.5.6/ASCE 7-05 Section 11.6, for use with required structural design and construction provisions. Each structure shall be provided with complete lateral and vertical force-resisting systems capable of providing adequate strength, stiffness, and energy dissipation capacity to withstand the design earthquake ground motions determined in accordance with Section 3-15 within the prescribed performance objectives of Section 3-17. In addition, each structure shall be designed to accommodate the architectural, mechanical, and electrical component requirements of Section 3-21. Design ground motions shall be assumed to occur along any horizontal direction of a structure. A continuous load path, or paths, with adequate strength and stiffness to transfer forces induced by the design earthquake ground motions from the points of application to the final point of resistance shall be provided.

3-16.2 Occupancy Importance Factors.

The structural occupancy importance factor, I, is not used. The component importance factor, I_p, used in Section 3-21, shall be the value specified in Sections 3-21.4.4

3-16.3 Site Limitations.

A structure assigned to OC IV shall not be sited where there is a known potential for an active fault to cause rupture of the ground surface at the structure. An *active fault* is defined as a fault for which there is an average historic slip rate of 1 mm or more per year and for which there is geographic evidence of seismic activity in Holocene times (the most recent 11,000 years).

3-16.4 Building Configuration.

The requirements of ASCE 7-05 Sections 12.3.1, 12.3.2, and 12.3.3 shall not apply to facilities designed using the provisions of this Chapter.

3-16.5 Analysis Procedures.

3-16.5.1 Nonlinear Analysis.

The Alternate OC IV analysis procedure of this Chapter may be used in lieu of the Equivalent Lateral Force or Modal Response Spectrum Analysis procedures that would generally be used to comply with the 2009 IBC and Chapter 2. For this alternate procedure, a nonlinear structural analysis shall be performed. The analysis may use either the Nonlinear Static Procedure (NSP) or the Nonlinear Dynamic Procedure (NDP).

3-16.5.1.1 Nonlinear Static Procedure.

The NSP shall be permitted for structures not exceeding 6 stories in height and having a fundamental period, T, not greater than $3.5T_S$, where T_S is determined in accordance with ASCE 7-05 Section 11.4.5. Application of the NSP shall comply with the requirements of *Resource Paper 2 of FEMA P-750, NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures, 2009 Edition, Part 3, Resource Papers (RP) on Special Topics in Seismic Design.* In applying the NSP, the user may employ the references cited in Resource Paper 2 of FEMA P-750. Further information on NSP may be found in *FEMA P-750, NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures, 2009 Edition, Part 2, Commentary* and in NEHRP Seismic Design Technical Brief No. 4, *Nonlinear Structural Analysis for Seismic Design*, NIST GCR 10-917-5. The following should be noted:

1. To apply the FEMA P-750 NSP, the design earthquake ground motions and associated spectral accelerations shall be as specified herein, and not the design ground motions defined in FEMA P-750.

2. A target displacement shall be separately determined for each of the MCE and BSE-1 spectra.

3. The structure as a whole and each of the elements of the lateral force- resisting system and its connections shall be evaluated for their adequacy to provide Immediate Occupancy Performance at the BSE-1 target displacement and to provide Life Safety Performance at the MCE target displacement.

4. P Delta effects are to be included in the development of the backbone curves (see Section 2.4 NEHRP SDTB No 4).

5. Multidirectional and concurrent seismic effects shall be included as defined in Sections 3.2.7 and 3.2.8 of ASCE-41.

3-16.5.1.2 Nonlinear Dynamic Procedure.

Application of the NDP shall comply with the requirements of ASCE 7-05 Section 16.2.

3-16.5.2 Site Ground Motions.

Two characteristic ground motions shall be required for the design of facilities using this procedure:

1. For the LS performance objective, the MCE ground motion shall be used. For the NSP, spectral response accelerations shall be determined using the procedures of Section 3-15.1 or Section 3-15.2. For the NDP, MCE ground motions shall be determined using procedures prescribed in ASCE 7-05 Section 16.2.3.

2. For the IO performance objective, the BSE-1 ground motion shall be used. For the NSP, spectral response accelerations shall be determined using the procedures of Section 3-15.1 or Section 3-15.2. For the NDP, BSE-1 ground motions shall be determined using procedures prescribed in ASCE 7-05 Section 16.2.3.

3-17 EARTHQUAKE LOADS – MINIMUM DESIGN LATERAL FORCE AND RELATED EFFECTS

3-17.1 Seismic Load Effect, E.

When the NSP is used, the seismic load effect, E, for use in the load combinations of Section 3-5.2 shall be determined from ASCE 7-05 Section 12.4. In the application of ASCE 7-05 Section 12.4, the term S_{DS} shall be interpreted as S_{MS} for the LS performance objective and as S_{SS} for the Immediate Occupancy performance objective. See Section 3-15.1.2. When the NDP is used, the seismic load effect, E, shall simply be the response determined from the dynamic analysis. The redundancy coefficient, ρ, shall be taken as 1.0.

Exceptions:

1. Where these provisions require consideration of structural overstrength (see ASCE 7-05 Section 12.4.3), the values of member forces, Q_E, obtained from NSP analysis at the peak (maximum base shear) of the NSP pushover curve shall be used in place of the quantity $\Omega_0 Q_E$.

2. Where these provisions require consideration of structural overstrength (see ASCE 7-05 Section 12.4.3), the values of member forces, Q_E, obtained from NDP analysis at the maximum base shear found in the analysis using any of the ground motion records shall be used in place of the quantity $\Omega_0 Q_E$.

3-17.2 Redundancy.

ASCE 7-05 Section 12.3.4 shall not apply to facilities designed using the provisions of this Chapter.

3-17.3 Deflection and Drift Limits.

3-17.3.1 Allowable Story Drift.

Because the Alternate Design Procedure is a nonlinear performance-based design approach, specific target drift limits are not set for designs.

3-17.3.1.1 Life Safety Performance Objective.

The LS performance objective shall be achieved for MCE ground shaking. At the LS performance level, structural components may be damaged, but they retain a margin of safety of at least 1.5 against the onset of loss of gravity load carrying capacity. Some residual global structural strength and stiffness remain at the maximum lateral displacement in all stories. No out-of-plane wall failures occur. Partitions may be damaged, and the building may be beyond economical repair. Some permanent (inelastic) drift may occur. While inelastic behavior is permitted, member strength degradation shall be limited in primary structural members (residual strength shall not be less than 80% of nominal yield strength). Primary structural elements are those that are required to provide the building with an ability to resist collapse when ground motion-induced seismic forces are generated. For secondary structural elements (those that are not primary elements), strength degradation to levels below the nominal yield strength shall be permitted. Not more than 20% of the total strength or initial stiffness of a structure shall be assumed to be provided by secondary elements. The LS performance objective shall be verified by analysis - either the NSP or the NDP. LS acceptance criteria contained in ASCE/SEI 41-06 *Seismic Rehabilitation of Existing Buildings* shall be used to demonstrate acceptable performance. Alternatively, acceptance criteria can be developed by the designer and approved by the design review panel (see Section 3-1.2)

3-17.3.1.2 Immediate Occupancy Performance Objective.

The IO performance objective shall be achieved for BSE-1 ground shaking. At the IO performance level, a building remains safe to occupy, essentially retaining pre-earthquake design strength and stiffness. Minor cracking of facades, ceilings, and structural elements may occur. Significant permanent (inelastic) drift does not occur. The structural system for the building remains "essentially" elastic. Any inelastic behavior does not change the basic structural response and does not present any risk of local failures. Member deformations shall not exceed 125% of deformations at nominal member yield strengths. No member strength degradation shall be permitted, regardless of deformation. The IO performance objective shall be verified by analysis, either the NSP or the NDP. The IO acceptance criteria contained in ASCE/SEI 41-06 *Seismic Rehabilitation of Existing Buildings* shall be used to demonstrate acceptable performance. Alternatively, appropriate acceptance criteria can be developed by the designer and approved by the design review panel (see Section 3-1.2)

3-17.3.2 Drift Determination and P-Delta Effects.

3-17.3.2.1 Drift and Deflection Determination for Nonlinear Static Procedure.

The design story drifts, Δ_S *and* Δ_M shall be taken as the values obtained for each story at the target displacements for the BSE-1 and MCE, respectively.

3-17.3.2.2 Drift and Deflection Determination for Nonlinear Dynamic Procedure.

Story drifts shall be determined directly from the nonlinear analysis performed in accordance with the provisions of ASCE 7-05 Section 16.2.

3-17.3.2.3 P-Delta Effects for Nonlinear Static Procedure and Nonlinear Dynamic Procedure.

Static P-Delta (P-Δ) effects shall be incorporated in all lateral load analyses.

3-17.4 Seismic Force-resisting Systems.

3-17.4.1 Permitted Seismic Force-resisting Systems.

Table 3-1, System Limitations for OC IV Buildings Designed Using Alternate Analysis Procedure, shall replace ASCE 7-05 Table 12.2-1 and Table 2-1 of this UFC. Table 3-1 shall be used to determine whether a seismic force-resisting system is permitted. Table 3-1 also lists building height limitations for the permitted systems. Seismic force-resisting systems that are not listed in Table 3-1 may be permitted if analytical and test data are submitted that establish the dynamic characteristics and demonstrate the lateral force resistance and energy dissipation capacity to be equivalent to the structural systems listed in the table. Such exceptions may be authorized when permission is granted by the design review panel (see Section 3-1.2).

3-17.4.2 Structural Design Requirements.

3-17.4.2.1 Dual Systems.

ASCE 7-05 Section 12.2.5.1 shall apply.

3-17.4.2.2 Combinations of Framing Systems.

Different seismic force-resisting systems are permitted along the two orthogonal axes of a building structure, so long as both systems comply with the provisions of this Chapter.

3-17.4.2.3 Interaction Effects.

Moment-resisting frames that are enclosed or adjoined by more rigid elements that are not considered to be part of the seismic force-resisting system shall be designed so that the action or failure of those elements will not impair the vertical load-carrying and seismic force-resisting capability of the frame. The design shall provide for the effect of these rigid elements on the structural system at structural deformations corresponding to the design story drift at the target displacement, as determined by analysis.

3-17.4.2.4 Deformational Compatibility.

For components that are not included in seismic force resisting system ensure that ductile detailing requirements are provided such that the vertical load-carrying capacity of these components is not compromised by induced moments and shears resulting from the design story drift.

Reinforced concrete frame members not designed as part of the seismic force-resisting system shall comply with ACI 318-08 *Building Code Requirements for Structural Concrete,* Section 21.13.

3-17.4.3 Response Modification (R), System Overstrength (Ω_0), Deflection Amplification (C_d) Factors.

Because only the NDP or the NSP are permitted for the alternate design of OC IV structures the factors R, C_d, and Ω_0 are not required.

3-17.4.4 Member Strength.

The load combination requirements of Sections 3-5.1 and 3-5.2 shall be satisfied. Seismic load effects shall be determined in accordance with Section 3-17.1.

3-18 DYNAMIC ANALYSIS PROCEDURES FOR THE SEISMIC DESIGN OF BUILDINGS

3-18.1 General.

The procedures outlined in Section 3-16.6 shall be followed for dynamic analysis of buildings and other structures that are designed in accordance with the provisions of this Chapter.

3-19 EARTHQUAKE LOADS, SOIL-STRUCTURE INTERACTION EFFECTS

3-19.1 Analysis Procedure.

When these effects are considered, the provisions of ASCE 7-05 Chapter 19 shall apply.

3-20 SEISMIC DESIGN, DETAILING, AND STRUCTURAL COMPONENT LOAD EFFECTS

3-20.1 Structural Component Design and Detailing.

The provisions of ASCE 7-05 Chapter 12, as modified by Chapter 2 of this UFC, shall apply.

3-20.2 Structural Integrity.

The provisions of 2009 IBC Section 1614 shall apply.

3-20.3 Soils and Foundations.

The provisions of 2009 IBC Chapter 18 shall apply.

3-21 SEISMIC DESIGN REQUIREMENTS FOR NONSTRUCTURAL COMPONENTS

3-21.1 Component Design.

The provisions of ASCE 7-05 Chapter 13, as modified by Chapter 2, shall apply, except as noted in the following paragraphs. Appendix B provides supplementary guidance on design and analysis of some architectural, mechanical, and electrical components.

3-21.2 Performance Objectives.

The design procedure presented in this Chapter includes two overall performance objectives that influence the requirements for architectural, mechanical, and electrical components. First, the design must provide LS performance for the MCE. Second, the design must provide IO performance for BSE-1 ground motions.

3-21.2.1 Life Safety Performance Objective for Nonstructural Components.

This performance level seeks to mitigate falling hazards, but many architectural, mechanical, and electrical systems may be damaged and become non-functional.

3-21.2.2 Immediate Occupancy Performance Objective for Nonstructural Components.

This performance level ensures that installed equipment and contents remain mounted to their supporting system and remain functional, but the equipment may not be operational due to loss of utilities.

3-21.3 Modification of ASCE 7-05 for Life Safety Design.

3-21.3.1 Ground Motion Parameters for Determination of Life Safety Seismic Forces

In the application of ASCE 7-05 Section 13.3.1, seismic forces shall be determined for the MCE ground motion parameters.

3-21.3.2 Nonlinear Static Procedure.

In the application of ASCE 7-05 Section 13.3.1, seismic forces on components based on the NSP shall be based on ASCE 7-05 Equations 13.3-1 through 13.3-3. The quantity S_{MS} shall be substituted for the term S_{DS} found in the equations. In the application of ASCE 7-05 Section 13.3.2, the response of the building to the MCE ground motion shall be used.

3-21.3.3 Nonlinear Dynamic Procedure.

In the application of ASCE 7-05 Section 13.3.1, seismic forces on components based on the NDP shall be based on ASCE 7-05 Equation 13.3-4. The term a_i shall be the maximum acceleration at the level of the component under consideration, as determined from the dynamic analysis. In the application of ASCE 7-05 Section 13.3.2, the response of the building to the MCE ground motion shall be used.

3-21.3.4 Component Importance Factors.

The component importance factor, I_p, is required for force calculations in ASCE 7-05 Section 13.3.1. I_p shall be 1.0, in lieu of the importance factors listed in ASCE 7-05 Section 13.1.3.

3-21.4 Modification of ASCE 7-05 for Immediate Occupancy Design.

3-21.4.1 Ground Motion Parameters for Determination of IO Seismic Forces.

In the application of ASCE 7-05 Section 13.3.1, seismic forces shall be determined for the BSE-1 ground motion parameters.

3-21.4.2 Nonlinear Static Procedure.

In the application of ASCE 7-05 Section 13.3.1, seismic forces on components based on the NSP shall be based on ASCE 7-05 Equations 13.3-1 through 13.3-3. The quantity S_{SS} shall be substituted for the term S_{DS} found in the equations. In the application of ASCE 7-05 Section 13.3.2, the response of the building to the BSE-1 ground motion shall be used.

3-21.4.3 Nonlinear Dynamic Procedure.

In the application of ASCE 7-05 Section 13.3.1, seismic forces on components based on the NDP shall be based on ASCE 7-05 Equation 13.3-4. The term a_i shall be the maximum acceleration at the level of the component under consideration, as determined from the dynamic analysis. In the application of ASCE 7-05 Section 13.3.2, the response of the building to the BSE-1 ground motion shall be used.

3-21.4.4 Component Importance Factors.

The component importance factor, I_p, is required for force calculations in ASCE 7-05 Section 13.3.1. I_p shall be as given in ASCE 7-05 Section 13.1.3.

Table 3-1
System Limitations for Occupancy Category IV Buildings Designed Using Alternate Procedure of Chapter C

Basic Seismic Force-Resisting System[2]	System and Building Height (ft) Limitations[1] Seismic Design Category				
	B	C	D	E	F
Bearing Wall Systems					
Ordinary steel braced frames in light-frame construction	NL	NL	65	65	65
Special reinforced concrete shear walls	NL	NL	160	160	100
Ordinary reinforced concrete shear walls	NL	NL	NP	NP	NP
Special reinforced masonry shear walls	NL	NL	160	160	100
Light-framed walls with shear panels - wood structural panels/sheet steel panels	NL	NL	65	65	65
Light-framed walls with shear panels - all other materials	NL	NL	35	NP	NP
Light-framed walls with shear panels - using flat strap bracing	NL	NL	65	65	65
Building Frame Systems					
Steel eccentrically braced frames, moment-resisting, connections at columns away from links	NL	NL	160	160	100
Steel eccentrically braced frames, nonmoment-resisting, connections at columns away from links	NL	NL	160	160	100
Special steel concentrically braced frames	NL	NL	160	160	100
Ordinary steel concentrically braced frames	NL	NL	35[3]	35[3]	NP[3]
Special reinforced concrete shear walls	NL	NL	160	160	160
Ordinary reinforced concrete shear walls	NL	NL	NP	NP	NP
Composite eccentrically braced frames	NL	NL	160	160	100
Composite concentrically braced frames	NL	NL	160	160	100
Ordinary composite braced frames	NL	NL	NP	NP	NP
Composite steel plate shear walls	NL	NL	160	160	100
Special composite reinforced concrete shear walls with steel elements	NL	NL	160	160	100
Special reinforced masonry shear walls	NL	NL	160	160	100
Light-framed walls with shear panels - wood structural panels/sheet steel panels	NL	NL	65	65	65
Light-framed walls with shear panels - all other materials	NL	NL	35	NP	NP
Moment-Resisting Frame Systems					
Special steel moment frames	NL	NL	NL	NL	NL
Special steel truss moment frames	NL	NL	160	100	NP
Intermediate steel moment frames	NL	NL	35[5]	NP[5]	NP[6]
Ordinary steel moment frames	NL	NL	NP[5]	NP[5]	NP[6]
Special reinforced concrete moment frames	NL	NL	NL	NL	NL

TABLE 3-1 (CONTINUED)
SYSTEM LIMITATIONS FOR OCCUPANCY CATEGORY IV BUILDINGS DESIGNED USING ALTERNATE PROCEDURE OF CHAPTER C

Basic Seismic Force-Resisting System[2]	System and Building Height (ft) Limitations[1]				
	Seismic Design Category				
	B	C	D	E	F
Intermediate reinforced concrete moment frames	NL	NL	NP	NP	NP
Special composite moment frames	NL	NL	NL	NL	NL
Intermediate composite moment frames	NL	NL	NP	NP	NP
Composite partially restrained moment frames	160	160	100	NP	NP
Special masonry moment frames	NL	NL	160	160	100
Dual Systems with Special Moment Frames capable of resisting at least 25% of prescribed seismic forces					
Steel eccentrically braced frames	NL	NL	NL	NL	NL
Special steel concentrically braced frames	NL	NL	NL	NL	NL
Special reinforced concrete shear walls	NL	NL	NL	NL	NL
Ordinary reinforced concrete shear walls	NL	NL	NP	NP	NP
Composite eccentrically braced frames	NL	NL	NL	NL	NL
Composite concentrically braced frames	NL	NL	NL	NL	NL
Composite steel plate shear walls	NL	NL	NL	NL	NL
Special composite reinforced concrete shear walls with steel elements	NL	NL	NL	NL	NL
Ordinary composite reinforced concrete shear walls with steel elements	NL	NL	NP	NP	NP
Special reinforced masonry shear walls	NL	NL	NL	NL	NL
Dual Systems with Intermediate Moment Frames capable of resisting at least 25% of prescribed seismic forces					
Special steel concentrically braced frames[4]	NL	NL	NP	NP	NP
Special reinforced concrete shear walls	NL	NL	160	100	100
Ordinary reinforced concrete shear walls	NL	NL	NP	NP	NP
Composite concentrically braced frames	NL	NL	160	100	NP
Ordinary composite braced frames	NL	NL	NP	NP	NP
Ordinary composite reinforced concrete shear walls with steel elements	NL	NL	NP	NP	NP
Cantilevered Column Systems detailed to conform to the requirements for:					
Special steel moment frames	35	35	35	35	35
Special reinforced concrete moment frames	35	35	35	35	35

NP - indicates not permitted, NL – indicates not limited.

[1] Any system that is restricted by this table may be permitted if it is approved by the design review panel

TABLE 3-1 (CONTINUED)
SYSTEM LIMITATIONS FOR OCCUPANCY CATEGORY IV BUILDINGS DESIGNED USING ALTERNATE PROCEDURE OF CHAPTER C

Basic Seismic Force-Resisting System[2]	System and Building Height (ft) Limitations[1]				
	Seismic Design Category				
	B	C	D	E	F

(see Section 3-1.2).

[2] See Table 2-1 for detailing references for seismic force-resisting systems.

[3] Steel ordinary concentrically braced frames are permitted in single-story buildings, up to a height of 60 ft, where the dead load of the roof does not exceed 20 psf, and in penthouse structures.

[4] Ordinary moment frames may be used in lieu of intermediate moment frames for Seismic Design Categories B or C.

[5] Limitations for steel ordinary moment frames (OMFs) and intermediate moment frames (IMFs) in structures assigned to Seismic Design Categories D and E:

a. Single story steel OMFs and IMFs shall be permitted up to a height of 65 ft, where the dead load supported by and tributary to the roof does not exceed 20 psf. In addition, the dead loads of exterior walls tributary to such moment frames, for walls more than 35 ft above the base shall not exceed 20 psf.

b. Steel OMFs not meeting the limitations of note 5a shall be permitted in light-framed construction up to a height of 35 ft, where neither the roof nor the floor dead load supported by and tributary to the moment frames exceeds 35 psf. In addition, the dead loads of exterior walls tributary to such moment frames shall not exceed 20 psf.

c. Steel IMFs not meeting the limitations of note 5a shall be permitted up to a height of 35 ft in SDC D. Steel IMFs not meeting the limitations of note 5a shall be permitted up to a height of 35 ft in SDC E, provided neither the roof nor the floor dead load supported by and tributary to the moment frames exceeds 35 psf, and the dead loads of the exterior walls tributary to the moment frames does not exceed 20 psf.

[6] Limitations for steel OMFs and IMFs in structures assigned to Seismic Design Category F:

a. Single-story OMFs and IMFs shall be permitted up to a height of 65 ft, where the dead load supported by and tributary to the roof does not exceed 20 psf, and the dead loads of the exterior walls tributary to the moment frames does not exceed 20 psf.

b. Steel IMFs not meeting the limitations of note 5a shall be permitted in light-framed construction up to a height of 35 ft in SDC F, provided neither the roof nor the floor dead load supported by and tributary to the moment frames exceeds 35 psf, and the dead loads of the exterior walls tributary to the moment frames does not exceed 20 psf.

CHAPTER 4 DESIGN FOR ENHANCED PERFORMANCE OBJECTIVES: OC V

4-1601 GENERAL

4-1601.1 Overview.

This Chapter shall be used for the design and analysis of buildings and other structures in OC V.

OC V encompasses facilities that are considered to be national strategic military assets (UFC 3-301-01 Table 2-2). Special design and analysis procedures apply to OC V buildings and other structures. OC V structures shall be designed to ensure that their foundations, superstructures and installed mission-essential nonstructural elements remain elastic, and their installed equipment remains operational, for the MCE ground motions.

This Chapter modifies provisions of 2009 IBC and ASCE 7-05 for use in analyzing OC V buildings and other structures. In case a provision in 2009 IBC Chapter 16, 17, or 18 or ASCE 7-05 Chapter 11, 12, or 13 is modified by Chapter 4 and also by Chapter 2 of this UFC, the Chapter 4 modification controls. Any provision in those chapters not modified by Chapter 4 of this UFC shall apply to OC V facilities, as modified by Chapter 2 of this UFC. All 2009 IBC structural chapters other than 16, 17, and 18 and all ASCE 7-05 chapters other than 11, 12, and 13 (such as Chapter 15) shall apply to OC V facilities as modified by Chapter 2 of this UFC. There are some redundancies, such as Sections 4-1602.1, 4-1606.1, 4-1607.1, and 4-1611.1.

4-1601.2 Design Review Panels.

4-1601.2.1 Structural Design Review Panel.

A design review of the seismic force-resisting system design and structural analysis shall be performed by an independent team of Registered Design Professionals in the appropriate disciplines and others experienced in seismic analysis methods and the theory and application of nonlinear seismic analysis and structural behavior under extreme cyclic loads. Membership on the Structural Design Review Panel shall be subject to the approval of the Authority having Jurisdiction. The design review shall include, but not necessarily be limited to, the following:

1. Any site-specific seismic criteria used in the analysis, including the development of site-specific spectra and ground motion time-histories.

2. Any acceptance criteria used to demonstrate the adequacy of structural elements and systems to withstand the calculated force and deformation demands, together with any laboratory or other data used to substantiate the criteria.

3. The preliminary design, including the selection of the structural system; the configuration of structural elements; and supports for all architectural, mechanical, and electrical components.

4. The final design of the entire structural system and supports for all architectural, mechanical, and electrical components, and all supporting analyses.

5. All procurement documents (statements of work, specifications, etc.) that are developed for seismic qualification of equipment that must remain operable following the design earthquake. Post-earthquake operability shall be verified by shake table testing, experience data, or analysis.

6. All documentation that is developed for seismic qualification of equipment that must remain operable following the design earthquake.

4-1601.2.2 Nonstructural Component Design Review Panel.

A design review of the nonstructural component design (including anchorage) shall be performed by an independent team of Registered Design Professionals in the appropriate disciplines and others experienced in the qualification of nonstructural components using time histories and in-structure response. Membership on the Nonstructural Component Design Review Panel shall be subject to the approval of the Authority having Jurisdiction. The design review shall occur prior to commissioning and shall include, but not necessarily be limited to, the following:

1. Review in-structure response data and confirm that any recommendations made by the Structural Design Review Panel have been incorporated into the in-structure response.

2. Review component qualifications to confirm proper in-structure response was utilized.

3. Upon completion of design review of all documentation, the review panel shall perform a walk-down of the project and confirm the following:

    a. Component installations are in their submitted and approved location.

    b. Identification nameplates are installed as specified in Section 4-13.9

    c. Component qualification documentation has been incorporated into the Operations & Maintenance Manual as specified in Section 4-13.8.

4-1602 DEFINITIONS AND NOTATIONS

4-1602.1 General.

2009 IBC Section 1602 shall apply.

4-1603 CONSTRUCTION DOCUMENTS

4-1603.1 General.

2009 IBC Section 1603, as modified by Section 2-1603 of this UFC, shall apply.

Exceptions:

1. The Seismic Importance Factor, *I*, the seismic response coefficient, C_S, the Response Modification Factor, *R*, and the Seismic Design Category do not apply and shall not be listed in construction documents.

2. The classification of the building in OC V, that it is designed in accordance with the provisions of this UFC, and the date of this UFC, shall be listed in construction documents.

4-1604 GENERAL DESIGN REQUIREMENTS

4-1604.1 General.

2009 IBC Section 1604 shall apply.

Exception: UFC 3-301-01 Table 2-2, shall replace 2009 IBC Table 1604.5.

4-1604.10 Wind and seismic detailing.

2009 IBC Section 1604.10 shall not apply to OC V facilities.

4-1605 LOAD COMBINATIONS

4-1605.1 General.

2009 IBC Section 1605 shall apply.

Exceptions:

1. For all load combinations, structural elements shall be designed to remain linear (elastic).

2. In applying 2009 IBC Equations 16-5 and 16-7, the combined effect of earthquake forces, *E*, shall be computed using the procedures outlined in this Chapter.

3. 2009 IBC Section 1605.3 shall not apply.

4-1606 DEAD LOADS

4-1606.1 General.

2009 IBC Section 1606 shall apply.

4-1607 LIVE LOADS

4-1607.1 General.

2009 IBC Section 1607 shall apply.

4-1608 SNOW AND ICE LOADS

4-1608.1 General.

Design snow loads shall be determined in accordance with 2009 IBC Section 1608. Design atmospheric ice loads on ice-sensitive structures shall be determined in accordance with ASCE 7-05 Chapter 10.

Exceptions:

1. In the determination of design snow loads for OC V structures using 2009 IBC Section 1608, the importance factor, I_s, shall be the value listed in UFC 3-301-01 Table 2-2. This importance factor shall be used unless a site-specific study for snow loads is conducted and subjected to review by the Structural Design Review Panel (see Section 4-1601.2.1). For a site-specific study, the site-specific probability shall be consistent with Performance Category 3 of DoE STD 1020-2002.

2. In the determination of design atmospheric ice loads for OC V structures using ASCE 7-05, the importance factor on ice thickness, I_i, shall be the value listed in UFC 3-301-01 Table 2-2. This importance factor shall be used unless a site-specific study for ice loads is conducted and subjected to review by the Structural Design Review Panel (see Section 4-1601.2.1). For a site-specific study, the site-specific probability shall be consistent with Performance Category 3 of DoE STD 1020-2002. The importance factor for wind on ice, I_w, and the concurrent wind speed for OC V structures subject to wind on ice loads shall be the same as for OC IV structures as outlined in ASCE 7-05 Chapter 10.

4-1609 WIND LOADS

4-1609.1 General.

Design wind loads shall be determined in accordance with 2009 IBC Section 1609.

Exception: In the determination of design wind loads for OC V structures using 2009 IBC Section 1609, the importance factor, I_w, shall be the value listed in UFC 3-301-01 Table 2-2. This importance factor shall be used unless a site-specific study for wind loads is conducted and subjected to review by the Structural Design Review Panel (see Section 4-1601.2.1). For a site-specific study, the site-specific probability shall be consistent with Performance Category 3 of DoE STD 1020-2002.

4-1610 SOIL LATERAL LOADS

4-1610.1 General.

2009 IBC Section 1610 shall apply, without the exception that is noted there.

4-1611 RAIN LOADS

4-1611.1 General.

2009 IBC Section 1611 shall apply.

4-1612 FLOOD LOADS

4-1612.1 General.

2009 IBC Section 1612 shall apply.

Exceptions:

1. The **DESIGN FLOOD** shall be defined as the flood associated with the area within a flood plain subject to a 0.2 percent or greater chance of flooding in any given year.

2. The **FLOOD HAZARD AREA** shall be defined as the area within a flood plain subject to a 0.2 percent or greater chance of flooding in any given year.

4-1612.2 Tsunami.

The effects of tsunami shall be considered for facilities located in known tsunami hazard areas or within 300 feet of mean sea level elevation within 10 miles of the sea coast. Inundation elevations at the site shall be determined for an event with a 2% probability of exceedance in 50 years. Potential tsunami sources shall include distant earthquakes, local earthquakes, landslides, and storms and tides. Occupancy Category V facilities shall be designed to mitigate the effects of an event with a 2% probability of exceedance in 50 years, including debris impact effects.

4-1613 EARTHQUAKE LOADS

4-1613.3.1 Additions to Existing Buildings.

2009 IBC Section 3403 Additions, as modified by Sections 2-3403.1.1 and 2-3403.4 of this UFC, shall apply to OC V facilities.

4-1613.3.2 Change of Occupancy.

2009 IBC Section 3408 Change of Occupancy shall apply to OC V facilities.

4-1613.3.3 Alterations.

2009 IBC Section 3404 Alterations, as modified by Section 2-3404 of this UFC, shall apply to OC V facilities.

4-1613.3.4 Repairs.

2009 IBC Section 3405 Repairs, as modified by Section 2-3405 of this UFC, shall apply to OC V facilities.

NOTE: Numbering system changes to reflect ASCE 7-05 organization. For example, Section 4-11 will cover topics

from Chapter 11 of ASCE 7-05.

4-11 SEISMIC DESIGN CRITERIA

4-11.1 Structural Design Criteria.

Each OC V structure shall be designed in accordance with the provisions of this Chapter. Permissible structural systems are listed in Table 4-1. The components of a structure that must be designed for seismic resistance and the types of lateral force analysis that must be performed are prescribed in this Chapter. Each structure shall be provided with complete lateral and vertical force-resisting systems capable of providing adequate strength and stiffness to withstand the design earthquake ground motions determined in accordance with Section 4-11.4, within the prescribed deformation limits of Section 4-12.12. The design ground motions shall be assumed to occur along any horizontal direction of a structure, as well as in the vertical direction. A continuous load path, or paths, with adequate strength and stiffness to transfer forces induced by the design earthquake ground motions from the points of application to the final point of resistance shall be provided.

Table 4-1
Systems Permitted for Occupancy Category V Buildings

Basic Seismic Force-Resisting System	Detailing Requirements
Bearing Wall Systems	
Ordinary reinforced concrete shear walls	ACI 318, excluding Ch. 21
Ordinary reinforced masonry shear walls	ACI 530
Building Frame Systems	
Steel eccentrically braced frames, moment-resisting connections at columns away from links	AISC 360
Steel eccentrically braced frames, non-moment-resisting connections at columns away from links	
Ordinary steel concentrically braced frames	
Ordinary reinforced concrete shear walls	ACI 318, excluding Ch. 21
Composite steel and concrete eccentrically braced frames	AISC 360 (LRFD) and ACI 318, excluding Ch. 21
Composite steel and concrete concentrically braced frames	
Ordinary composite steel and concrete braced frames	
Composite steel plate shear walls	
Ordinary composite reinforced concrete shear walls with steel elements	
Ordinary reinforced masonry shear walls	ACI 530
Moment-Resisting Frame Systems	
Ordinary steel moment frames	AISC 360
Ordinary reinforced concrete moment frames	ACI 318, excluding Ch. 21
Ordinary composite moment frames	AISC 360 (LRFD) and ACI 318, excluding Ch. 21
Composite partially restrained moment frames	
Cantilevered Column Systems Detailed to Conform to the Requirements for:	
Ordinary steel moment frames	AISC 360
Ordinary reinforced concrete moment frames	ACI 318, excluding Ch. 21

Note: Any system prohibited here may be permitted if approved by the Structural Design Review Panel (Section 4-1601.2.1).

4-11.4 SEISMIC GROUND MOTION VALUES

4-11.4.1 Development of MCE Spectral Response Accelerations and Response History Criteria.

The Site Specific Ground Motion Procedures outlined in ASCE 7-05 Section 11.4.7 shall be used to develop MCE ground motion acceleration time histories for OC V structures. The MCE shall generally be characterized by a 5-percent-damped acceleration response spectrum. A lower value of damping may be more appropriate and the value should be as approved by the Structural Design Review Panel (see Section 4-1601.2.1).

A primary purpose of seismic response history analysis is to determine the in-structure demand for the design and/or qualification of nonstructural equipment and distributed systems. The ASCE 43-05, Section 2.4 Criteria for Developing Synthetic or Modified Recorded Time Histories shall be used to develop the seismic response histories for OC V facilities.

At least seven 3-component ground motions shall be selected and scaled from individual recorded events for in-structure response analysis. The histories shall be selected from events having magnitudes, fault distances, and source mechanisms that are consistent with those that control the MCE for the OC V structure. Ground motion records shall be sourced from stations with similar soil profiles, defined in terms of Site Class, to that at the site of the OC V structure. The shape of the spectra of the recorded motions shall be similar to that of the target spectra.

4-11.4.5 Design Response Spectrum

4-11.4.5.1 Design Horizontal Response Spectrum.

The unreduced MCE ground motions determined from the Site Specific Ground Motion Procedure shall be used.

4-11.4.5.2 Design Vertical Response Spectrum.

The unreduced MCE ground motions determined from the Site Specific Ground Motion Procedure shall be used. The vertical spectrum values, S_{av}, shall not be lower than the minimum ordinates determined in FEMA P-750 NEHRP Recommended Seismic Provisions, Chapter 23, Vertical Ground Motions for Seismic Design (Section 23.1) adjusted to produce MCE values (Section 23.2). Ground motions for calculating the minimum ordinates shall be the site specific MCE ground motions determined in D-11.4.5.1, not the MCE_R ground motions that FEMA P-750 is based on.

4-11.5 IMPORTANCE FACTOR AND OCCUPANCY CATEGORY

4-11.5-1 Importance Factor.

A seismic importance factor is not required for OC V buildings and other structures (see UFC 3-301-01 Table 2-2). However, some referenced sections of ASCE 7-05 require the use of ***I***. In these cases, ***I*** shall be taken as 1.0.

4-11.6 SEISMIC DESIGN CATEGORY.

The requirements of ASCE 7-05 Section 11.6 shall not apply to OC V structures.

4-11.7 DESIGN REQUIREMENTS FOR SEISMIC DESIGN CATEGORY A.

The requirements of ASCE 7-05 Section 11.7 shall not apply to OC V structures.

4-11.8 GEOLOGICAL HAZARDS AND GEOTECHNICAL INVESTIGATION

4-11.8.1 Site Limitations for Occupancy Category V.

A structure assigned to OC V shall not be sited where there is a known potential for an active fault to cause rupture of the ground surface at the structure. The term *active fault* is defined in Section 11.2 of ASCE 7-05.

4-12 SEISIMIC DESIGN REQUIREMENTS FOR BUILDING STRUCTURES

4-12.2 STRUCTURAL SYSTEM SELECTION

4-12.2.1 Selections and Limitations.

Table 4-1, *Systems Permitted for Occupancy Category V Buildings*, shall be used to determine whether a seismic force-resisting system is permitted for use in OC V. Exceptions may be authorized when permission is granted by the Structural Design Review Panel (see Section 4-1601.2.1).

Once a permitted structural system has been selected, no specific building height limitations shall apply. The requirement to ensure elastic behavior at the design level earthquake mitigates the need for height limitations.

4-12.2.2 and 4-12.2.3 Combinations of Framing Systems.

Combinations of permitted structural systems (see Table 4-1) may be used to resist seismic forces, both along the same axis of a building and along the orthogonal axes of the building. For systems combined along the same axis of a building, total seismic force resistance shall be provided by the combination of the different systems in proportion to their stiffnesses. Displacements of parallel framing systems shall be shown by analysis to be compatible.

4-12.2.3.1 and 4-12.2.3.2 R, Cd, and Ω0 Values for Vertical and Horizontal Combinations.

The design of OC V structures shall use a linear elastic Modal Response Spectrum Analysis (MRSA) procedure. Structural response shall be restricted to elastic behavior. No yielding shall be permitted for the MCE ground motions. The factors R, C_d, and Ω_0 shall be set to 1.0.

4-12.3 DIAPHRAGM FLEXIBILITY, CONFIGURATION IRREGULARITIES, AND REDUNDANCY

4-12.3.2 Irregular or Regular Classification and 4-12.3.3 Limitations and Additional Requirements for Systems with Structural Irregularities.

Because buildings in OC V are designed to respond to MCE ground shaking in an elastic manner, and they are required to be analyzed by procedures that adequately account for any structural irregularity, it shall not be necessary to classify OC V buildings as regular or irregular. Therefore, 2009 IBC design procedures that are intended to account for irregularities do not need to be applied to OC V buildings.

4-12.3.4 Redundancy.

ASCE 7-05 Section 12.3.4 shall apply. Structural systems with a redundancy factor, ρ, equal to 1.3 shall not be permitted for buildings in OC V.

4-12.4.4 Minimum Upward force for Horizontal Cantilevers.

Vertical seismic forces shall be computed from the vertical spectral accelerations specified in this Chapter.

4-12.5 DIRECTION OF LOADING

4-12.5.1 Direction of Loading Criteria.

When effects from the three earthquake ground motion components with respect to the principal axes of the building are calculated separately, the combined earthquake-induced response for each principal axis of the building shall consist of the sum of 100% of the maximum value resulting from loading applied parallel to that axis and 40% of both maximum values that result from loading components orthogonal to that axis. Absolute values of all loading components shall be used, so that all values are additive. If the three quantities are designated E_x, E_y, and E_z, they shall be combined in accordance with Equations 4-1, 4-2, and 4-3, and the maximum response, $E_{T\text{-}max}$, shall be the most severe effects of Equations 4-1, 4-2, or 4-3, for each individual structural element:

$$E_T = \pm [1.0\, E_x + 0.4\, E_y + 0.4\, E_z] \qquad \textbf{(Equation 4-1)}$$

$$E_T = \pm [0.4\, E_x + 1.0\, E_y + 0.4\, E_z] \qquad \textbf{(Equation 4-2)}$$

$$E_T = \pm [0.4\, E_x + 0.4\, E_y + 1.0\, E_z] \qquad \textbf{(Equation 4-3)}$$

where

E_x, E_y = Maximum horizontal components of response

E_z = Maximum vertical component of response

E_T = Maximum combined response from three orthogonal components

4-12.6 ANALYSIS PROCEDURE SELECTION

4-12.6.1 General Requirements.

Structures in OC V shall be designed to ensure that their superstructures and installed mission-critical nonstructural elements remain elastic, when subjected to MCE ground motions, and that mission-essential equipment remains operable immediately following the MCE ground motions. MCE spectral acceleration parameters shall be based on the procedures outlined in Section 4-11.4. In all analyses performed using the provisions of this Chapter, the variables R, C_d, ρ and Ω_0 shall all be set to 1.0, as indicated in Section 4-12.3.3 of this UFC.

4-12.6.2 Horizontal and Vertical Force Determination.

Except for seismically isolated structures and structures using supplemental damping, structural analysis for horizontal and vertical force determination shall be accomplished using a combined three-dimensional linear elastic Modal Response Spectrum Analysis (MRSA) in accordance with the provisions of ASCE 7-05 Sections 12.7.3 and 12.9. Refer to Section 4-11.5-1 for application of the Importance Factor, *I*, in ASCE 7-05 Section 12.9. Modal values shall be combined in accordance with the provisions of ASCE 7-05 Section 12.9.4. Further information on the use of the MRSA can be found in ASCE 4-98, *Seismic Analysis of Safety-Related Nuclear Structures and Commentary*. For the ground motion component associated with each horizontal plan dimension of the structure, applied forces shall be determined using 5-percent-damped linear horizontal response spectra that are developed in accordance with the provisions of Section 4-11.4.1 The response spectra developed in Section 4-11.4.5.1 shall be used to calculate forces for both horizontal directions.

For the ground motion component associated with the vertical axis of the structure, applied forces shall be determined using 5-percent-damped linear vertical response spectra that are developed in accordance with the provisions of Section 4-11.4.5.2. Provisions of ASCE 7-05 Section 16.2 shall not be applied.

> **Exception:** For structures using seismic isolation and/or supplemental damping, horizontal and vertical seismic forces shall be determined using nonlinear dynamic analysis, in which the seismic isolators and/or dampers are modeled with nonlinear properties consistent with test results, and the remaining structural system is modeled as linearly elastic. The nonlinear response history analysis procedures of ASCE 7-05 Section 17.6 shall be used for the nonlinear analyses, except that vertical ground motions shall be included in the analyses.

4-12.6.3 Member Forces.

Response in structural elements and nonstructural elements that directly support critical functions shall remain linear for the MCE ground motions, at anticipated drift demands. The requirement for linear response may be met through any combination of elastic member design, added damping or energy dissipation, or base isolation. The designer should consider the economics of these options, as well as the performance of critical installed equipment, in the structural design process.

4-12.6.3.1 Low Seismicity Applications.

In areas of low seismic activity ($S_{MS} < 0.25$ and $S_{M1} < 0.10$), it is anticipated that linear response may be achieved through proper design of all structural elements in both the lateral load and gravity load systems, using one or more of the seismic force-resisting systems listed in Table 4-1. Alternatives may be used, if they are verified adequately through analysis and are approved by the Structural Design Review Panel (see Section 4-1601.2.1).

4-12.6.3.2 Moderate Seismicity Applications

In areas of moderate seismic activity ($0.25 \leq S_{MS} \leq 0.75$, $0.10 \leq S_{M1} \leq 0.30$), it is anticipated that linear response in the gravity load system and critical nonstructural elements may be achieved using supplemental energy dissipation (added damping) systems, in conjunction with one or more of the seismic force-resisting systems listed in Table 4-1. Where *damping systems* are used, they shall be designed, tested, and constructed in accordance with the requirements of ASCE 7-05 Chapter 18. Analysis shall conform to the requirements of ASCE 7-05 Section 18.4, Response Spectrum Procedure. It is recognized that damping systems generally have inherent nonlinear behavior. It is not the intent of these provisions to require linear behavior in damping or isolation systems. Alternatives may be used, if they are verified adequately through analysis and are approved by the Structural Design Review Panel (see Section 4-1601.2.1).

4-12.6.3.3 High to Very High Seismicity Applications.

In areas of high to very high seismic activity ($S_{MS} > 0.75$ or $S_{M1} > 0.30$), it is anticipated that linear response in the gravity load system and critical nonstructural elements may be achieved using seismic isolation systems, in conjunction with one or more of the seismic force-resisting systems listed in Table 4-1. In such situations, ASCE 7-05 Chapter 17 shall be applied. It is recognized that isolation systems generally have inherent nonlinear behavior. It is not the intent of these provisions to require linear behavior in damping or isolation systems. Alternatives may be used, if they are verified adequately through analysis and are approved by the Structural Design Review Panel (see Section 4-1601.2.1).

> **Exception:** ASCE 7-05 Chapter 17 requires the use of the factor R_i for scaling the forces for structural elements above the isolation system. For OC V structures, the R_i factor shall be taken as 1.0. Table 4-1 shall be used for selecting the structural system.

4-12.8 EQUIVALENT LATERAL FORCE PROCEDURE.

The provisions of ASCE 7-05 Section 12.8 shall not be permitted for OC V structures.

4-12.9 MODAL RESPONSE SPECTRUM ANALYSIS

4-12.9.2 Modal Response Parameters.

Story drifts shall be computed using a linear elastic MRSA procedure (see Section 4-12.6.2). Story drifts and P-Delta effects shall be determined using the procedures outlined in ASCE 7-05 Section 12.9.2. Refer to Section 4-11.5-1 for application of Importance Factor, *I*, in this section.

4-12.10 DIAPHRAGMS, CHORDS, AND COLLECTORS

4-12.10.1.1 Diaphragm Design Forces.

ASCE 7-05 Section 12.10.1.1, shall be modified to delete the maximum force limit ($0.4S_{DS}Iw_{px}$) that is placed on Equation 12.10-1.

4-12.11 STRUCTURAL WALLS AND THEIR ANCHORAGE.

4-12.11.1 Design for Out-of-Plane Forces and 4-12.11.2 Anchorage of Concrete or Masonry Structural Walls.

Unless otherwise specified in this Chapter, computations involving transmitted seismic force, F_p, shall use the maximum of the computed force using the equations for F_p in this section and the actual forces computed using the procedures of this Chapter. The value of S_{MS} shall be used in lieu of S_{DS} wherever referenced in equations for F_p. Refer to Section 4-11.5-1 for application of Importance Factor, *I*, in this section.

4-12.12 DRIFT AND DEFORMATION

4-12.12.1 Story Drift Limit.

The design story drift (Δ) shall not exceed the allowable story drift (Δ_a) for OC IV structures in ASCE 7-05 Table 12.12-1.

> **Exception:** Where performance requirements for installed equipment or other nonstructural features require smaller allowable drifts than those permitted by this Section, the smaller drifts shall govern.

4-12.12.4 Deformational Compatibility.

ASCE 7-05 Section 12.12.4 shall apply.

> **Exception:** Reinforced concrete frame members not designed as part of the seismic force-resisting system shall comply with ACI 318-08 Section 21.13.

4-13 SEISMIC DESIGN REQUIREMENTS FOR NONSTRUCTURAL COMPONENTS

4-13.1 GENERAL

4-13.1 Scope.

The provisions of ASCE 7-05 Chapter 13, as modified by Chapter 2 of this UFC, shall apply, except as noted in the following paragraphs. Appendices B and C provide supplementary guidance on design and analysis of architectural, mechanical, and electrical components.

4-13.2 General Design Requirements

4-13.2.1.1 General Requirements.

All architectural, mechanical, and electrical components shall be designed for the in-structure horizontal and vertical response spectra developed in Section 4-13.7.4. Designs shall include bracing, anchorage, isolation, and energy dissipation, as appropriate, for all components, in addition to the components themselves. Motion amplifications through component supports shall be determined and accommodated through design. Installed architectural, mechanical, and electrical components shall be classified as Mission-Critical Level 1 (MC-1), Mission-Critical Level 2 (MC-2), or Non-mission-critical (NMC). The structural engineer shall classify all architectural, mechanical, and electrical components, in consultation with functional occupancy representatives designated by the Authority having Jurisdiction.

4-13.2.1.2 Mission-Critical Level 1 Components.

MC-1 components are those architectural, mechanical, and electrical components that are critical to the mission of the facility and must be operational immediately following the MCE ground shaking. MC-1 components shall be certified as operable immediately following the MCE ground shaking in accordance with the provisions of ASCE 7-05 Section 13.2.2 as modified by Chapter 2 of this UFC.

4-13.2.1.3 Mission-Critical Level 2 Components.

MC-2 components are those architectural, mechanical, and electrical components that may incur minor damage that would be reparable with parts stocked at or near the facility within a 3-day period, by on-site personnel, following the MCE ground shaking. If the failure of an MC-2 component can cause the failure of an MC-1 component, then the MC-2 component shall be considered as an MC-1 component. Typical MC-2 components may be suspended ceiling system components, lights, overhead cranes, etc. MC-2 components shall be attached, anchored, and supported to resist the MCE-induced building motions. All supporting structures for MC-2 components shall remain elastic during the MCE-induced building motions. MC-2 component performance shall be shown through analysis.

4-13.2.1.4 Non-Mission-Critical Components.

NMC components are those architectural, mechanical, and electrical components that may incur damage in the MCE ground shaking. If the failure of an NMC component can cause the failure of an MC-1 or MC-2 component, then the NMC component shall be classified the same as the corresponding MC-1 or MC-2 component. NMC components shall be designed so they will not cause falling hazards or impede facility egress. Typical NMC components may include bathroom vent fans, space heaters, etc. NMC component performance shall be shown through analysis.

4-13.2.2.1 Component Qualification Documentation.

The seismic qualification documentation for each piece of equipment shall contain the following as a minimum:

1. The engineering submittal, which shall contain the following:

   a. Design calculations and/or complete description of the equipment/ component with cut sheets and/or photographs containing all germane data including fastening requirements, welds, post-installed anchors, etc.

   b. Development of the in-structure demand response for vertical and horizontal shaking.

   c. Development of the capacity response (fragility curve) for vertical and horizontal shaking.

   d. Design of the anchorage including anchor qualifications, calculations indicating forces predicated on the seismic loads, and capacity of the anchors.

   e. A drawing indicating the equipment/component and location in the facility sufficient to be used for the installation.

   All of the above elements shall be checked and signed by the designer and checker.

   The designer shall affix his Professional Engineer seal on the cover page.

   The cover page shall identify the equipment/component and the performance category (MC-1 or MC-2).

2. Documentation of an independent design review of Item 1.

3. The Department of Energy (DOE) Screening Evaluation Worksheet (SEWS) of the installed equipment/component and accompanying Special Inspection of any post-installed anchorages or Special Inspection of components identifying the Special Inspector. Consideration shall be given to the installed condition and proximity to adjacent structures and components to avoid pounding effect.

   The appropriate DOE SEWS can be obtained from the DOE web site at: http://www.hss.energy.gov/seismic/. Other evaluation worksheets can be used upon approval by the Authority Having Jurisdiction.

4. Documentation of the independent "walk-down" inspection of the equipment in the final installed condition.

4-13.3 SEISMIC DEMANDS ON NONSTRUCTURAL COMPONENTS

4-13.3.1 Seismic Design Force.

In the application of ASCE 7-05 Section 13.3.1, seismic forces shall be analyzed for the MCE ground motion parameters. The force calculations found in ASCE 7-05 Equations 13.3-1 through 13.3-3 shall not apply. The following procedures shall be used.

4-13.3.1.1 MC-1 Components.

Forces for MC-1 components shall be determined by response spectrum analysis or equivalent static analysis, using as input the in-structure response spectra determined in accordance with Section 4-13.7.4. MC-1 components and their supports shall remain elastic. MC-1 component forces shall be determined using Equation 4-4, with R_p for both components and supports set to 1.0.

$$F_p = \frac{a_{ip} W_p}{R_p} \qquad \text{(Equation 4-4)}$$

where

F_p = seismic design force centered at the component's center of gravity and distributed relative to the component's mass distribution

a_{ip} = component spectral acceleration in a given direction, at the fundamental period of the component

W_p = component operating weight

R_p = component response modification factor

4-13.3.1.2 MC-2 Components.

Forces for MC-2 components shall be determined by response spectra analysis or equivalent static analysis, using as input the in-structure response spectra developed in accordance with Section 4-13.7.4. MC-2 component supports shall remain elastic, while limited inelastic component response is permitted. MC-2 component forces shall be determined using Equation 4-4, with R_p for supports set to 1.0, and R_p for components as specified in ASCE 7-05 Table 13.5-1.

4-13.3.1.3 NMC Components.

ASCE 7-05 Equation 13.3-4 shall be used for NMC component force calculations. The peak in-structure floor acceleration determined in accordance with Section 4-13.7.4 shall be substituted for the term a_i, the acceleration at level *i*. Inelastic deformations are permitted in both component and support response. In applying ASCE 7-05 Equation 13.3-4, the values of a_p and R_p specified in ASCE 7-05 Table 13.5-1 shall be used. The component importance factor, I_p, is required for force calculations in ASCE 7-05 Equation 13.3-4. I_p shall be 1.0, in lieu of the importance factors listed in ASCE 7-05 Sections 13.1.3.

4-13.7 Response Analysis Procedures for Architectural, Mechanical, and Electrical Components.

4-13.7.1 General.

ASCE 4-98, Seismic Analysis of Safety-Related Nuclear Structures and Commentary, shall serve as a reference in response analysis.

4-13.7.2 Dynamic Coupling Effects.

It is anticipated that installed mechanical and electrical systems may require significant secondary structural systems in OC V buildings. The provisions of ASCE 4-98 Section 3.1.7, *Dynamic coupling criteria*, shall apply.

4-13.7.3 Modeling Flooring Systems.

Structures with rigid flooring systems shall be modeled in accordance with the provisions of ASCE 4-98 Section 3.1.8.1.1, *Structures with rigid floors*. Structures with flexible flooring systems shall be modeled in accordance with the provisions of ASCE 4-98 Section 3.1.8.1.2, *Structures with flexible floors*.

4-13.7.4 In-structure Response Spectra.

Provisions of ASCE 4-98 Section 3.4, *Input for subsystem seismic analysis*, shall apply for the construction of in-structure response spectra needed for the analysis of acceleration and displacement environments for installed architectural, mechanical, and electrical components. In-structure response spectra shall be developed from models of primary structures subjected to MCE ground motions. The suggested frequencies in Table 2.3-2 in ASCE 4-98 shall be utilized in developing the spectra. However, the frequency range in the table shall be expanded to range from 0.1 Hz to 50 Hz. Increments above 34 Hz shall be at 3 Hz and increments below 0.5 Hz shall be at 0.10 Hz.

> **Exception:** In the application of ASCE 4-98 Section 3.4, those provisions that relate to spectra-to-spectra analysis in Section 3.4.2.1.2 shall not apply.

4-13.8 Component Qualification Documentation and O&M Manual.

All MC-1 and MC-2 equipment qualification documentation as outlined in Section 4-13.2.2.1 shall be maintained in a file identified as “Mission Critical Components and Equipment Qualifications Manual” that shall be a part of the Operations & Maintenance Manual that is turned over to the Authority having Jurisdiction. The project specifications should require the Operations & Maintenance Manual state that replaced or modified components need to be qualified per the original qualification criteria.

4-13.9 Component Identification Nameplate.

All MC-1 and MC-2 equipment shall bear permanent marking or nameplates constructed of a durable heat and water resistant material. Nameplates shall be mechanically attached to all nonstructural components and placed on the component for clear identification. The nameplate shall not be less than 5" x 7" with red letters 1" in height on a white background stating MC-1 or MC-2 as appropriate. The following statement shall be on nameplate: "This equipment/component is Mission Critical. No modifications are allowed unless authorized in advance and documented in the Mission Critical Equipment Qualifications Manual." The nameplate shall also contain the component identification number in accordance with the drawings/specifications and the O&M manuals. Continuous piping, and conduits shall be similarly marked as specified in the contract documents.

NOTE: Numbering system changes to reflect 2009 IBC organization.

4-1701 GENERAL

4-1701.1 Scope.

2009 IBC Chapter 17, as modified by Chapter 2 of this UFC, shall apply to OC V buildings.

4-1801 SOILS AND FOUNDATIONS.

The provisions of 2009 IBC Chapter 18 shall apply to OC V buildings, except the minimum Chapter 18 provisions applied shall be those required for SDC D structures. In addition, the requirement in the following paragraph shall apply.

4-1801.1 Foundation Uplift and Rocking.

The requirement for linear response of these structures may lead to the existence of significant overturning forces in the structural system, and accompanying foundation element uplift forces or rocking. The Registered Design Professional shall be responsible for evaluating foundation overturning and rocking in the design analysis, and this evaluation shall be reviewed by the Structural Design Review Panel (see Section 4-1601.2.1).

APPENDIX A REFERENCES

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Washington, DC
http://dod.wbdg.org/

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P.O. Box 9005
Champaign, IL 61826-9005
http://www.arl.army.mil

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Washington, DC 20472
http://www.fema.gov

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Building and Fire Research Laboratory
100 Bureau Drive, Stop 8600
Gaithersburg, MD 20899-8600
http://www.nist.gov/index.html

ICSSC RP 8 /NIST GCR 11-917-12, *Standards of Seismic Safety for Existing Federally Owned and Leased Buildings*, December 2011

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Washington, DC 20585
http://energy.gov/

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DOE-STD -1020-2002, *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities*, January 2002

Volume 4 of DOE Binders: SAND92-0140 Part I, UC-523, *Use of Seismic Experience Data to Show Ruggedness of Equipment in Nuclear Power Plants*, Revision 4, Senior Seismic Review and Advisory Panel, Sandia National Laboratories, Feb 1991

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California Office of Statewide Health Planning and Development
400 R Street
Sacramento, CA 95811-6213
http://www.oshpd.ca.gov

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NON-GOVERNMENT PUBLICATIONS:

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P.O. Box 9094
Farmington Hills, MI 48333
http://www.concrete.org/

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ACI 355.2-07, *Qualification of Post-Installed Mechanical Anchors in Concrete*, 2007 Edition

ACI 355.4-10, *Acceptance Criteria for Qualification of Post-Installed Adhesive Anchors in Concrete*, 2010 Edition

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One East Wacker Drive, Suite 3100
Chicago, IL 60601-2001
http://www.aisc.org/

ANSI/AISC 341-05, *Seismic Provisions for Structural Steel Buildings*, 2005

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1140 Connecticut Ave., NW
Suite 705
Washington, D.C. 20036
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Reston, VA 20191-4400
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Three Park Avenue
New York, NY 10016-5990
http://www.asme.org/kb/standards

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ASME B31.4-02, *Liquid Transportation Systems for Hydrocarbons, Liquid Petroleum Gas, Anhydrous Ammonia, and Alcohols*

ASME B31.5-01, *Refrigeration Piping*

ASME B31.8-99, *Gas Transmission and Distribution Piping Systems*

ASME B31.9-96, *Building Services Piping*

6. ASTM International
100 Barr Harbor Drive
PO Box C700
West Conshohocken
PA 19428-2959
http://www.astm.org/

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ASTM A500/A500M-10a, *Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes*

ASTM F1554-07ae1, *Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi*

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Quincy, MA 02169-7471
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200 West Adams Street, #2100
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http://www.smacna.org/

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18 Telecommunications Industry Association (TIA)
2500 Wilson Boulevard, Suite 300
Arlington, VA 22201
http://www.tiaonline.org/

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19. The Masonry Society
3970 Broadway, Suite 201-D
Boulder, CO USA 80304-1135
http://www.masonrysociety.org

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38 West Trenton Boulevard,
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APPENDIX B GUIDANCE FOR SEISMIC DESIGN OF NONSTRUCTURAL COMPONENTS

B-1 INTRODUCTION

This Appendix defines architectural, mechanical, and electrical components, discusses their participation and importance in relation to the seismic design of the structural system, and provides guidance for their design to resist damage from earthquake-induced forces and displacements. The fundamental principles and underlying requirements of this Appendix are that the design of these components for buildings in Occupancy Categories (OCs) I, II, and III should be such that they will not collapse and cause personal injury due to the accelerations and displacements caused by severe earthquakes, and that they should withstand more frequent but less severe earthquakes without excessive damage and economic loss. In contrast, components in OC V buildings, and designated components in OC IV, are required to remain operational following a design earthquake.

B-1.1 Design Criteria.

2009 IBC Section 1613, as modified by Chapter 2 Section 1613 of this UFC, governs the seismic design of architectural, mechanical, and electrical components. 2009 IBC Section 1613 references Chapter 13 of SEI/ASCE 7-05, *Minimum Design Loads for Buildings and Other Structures* (ASCE 7-05). Because ASCE 7-05 is the primary source of design requirements for these components, this Appendix cites ASCE 7-05 provisions and amplifies them as appropriate.

B-1.2 Walk-down Inspections and Seismic Mitigation for Buildings in Occupancy Categories IV and V.

B-1.2.1 General Guidance.

Chapter 2 Section 1707.7 requires that an initial *walk-down* inspection of new OC IV and V buildings be performed. A walk-down inspection is a visual inspection of a building to identify possible seismic vulnerabilities of its architectural, mechanical, and electrical components. Inspections should include investigating adequacy of component load paths, anchorage and bracing, and components' abilities to accommodate differential motions with respect to supporting building structure. The walk-down inspector should become familiar with the design earthquake motions for the site, structural configuration of the building, building drawings, and documentation of all previous walk-down inspections. Inspectors should document all observations with photographs, schematic drawings, and narrative discussions of apparent vulnerabilities. Inspection reports normally do not include detailed assessments of component vulnerabilities, but they may recommend further detailed assessments. Inspectors should also define mitigation recommendations in inspection reports. Prior to building commissioning, the Authority having Jurisdiction should ensure seismic mitigation recommendations are fully implemented. An example of a walk-down inspection of Madigan Army Medical Center at Fort Lewis, WA, may be found in USACERL Technical Report 98/34, *Seismic Mitigation for Equipment at Army Medical Centers*.

B-1.2.2 Periodic Post-commissioning Walk-down Inspections.

In addition to initial walk-down inspections performed at building commissioning, periodic post- construction walk-down inspections should be conducted in OC IV and V buildings by installation personnel, as part of routine operations and maintenance. For OC IV buildings, such inspections should be conducted at least every second year following building commissioning, or, for affected systems, when any change to architectural, mechanical, or electrical systems occurs. For OC V buildings, such inspections should be conducted every year following building commissioning, or, for affected systems, when any change to architectural, mechanical, or electrical systems occurs. System changes also include those associated with any equipment placed in the facility that is considered to be mission-critical. For example, the addition of a new portable piece of critical communications equipment, computer equipment, or medical diagnostics equipment should be included.

B-2 ARCHITECTURAL COMPONENTS

B-2.1 Reference.

ASCE 7-05 Section 13.5, Architectural Components.

B-2.2 General.

Architectural components addressed in ASCE 7-05 Chapter 13 are listed in ASCE 7-05 Table 13.5-1. These components are called "architectural" because they are not part of the vertical or lateral load-carrying systems of a building, or part of the mechanical or electrical systems. Although they are usually shown on architectural drawings, they often have a structural aspect and can affect the response of a building to earthquake ground motions. Architects should consult with structural, mechanical, and electrical engineers, as appropriate, when dealing with these elements. The structural engineer must review architectural (as well as mechanical and electrical) component anchorage details, to ensure compliance with anchorage requirements. During this review, the structural engineer must also identify installed architectural (as well as mechanical and electrical) components that may adversely affect the performance of the structural system.

B-2.3 Typical Architectural Components.

Examples of architectural components that have a structural aspect <u>requiring special attention</u> follow.

B-2.3.1 Nonstructural Walls.

A wall is considered architectural or nonstructural when it is not designed to participate in resisting lateral forces. To ensure that nonstructural walls do not resist lateral forces, they should either be disconnected from the building structure (i.e., isolated) at the top and the ends of the wall or be very flexible (in-plane) relative to the structural walls and frames resisting lateral forces. An isolated wall must be capable of acting as a cantilever from the floor, or be braced to resist its own out-of-plane motions and loads, without interacting with the lateral force-resisting system. Such interaction may be detrimental to the wall or the lateral force-resisting system or both.

B-2.3.2 Curtain Walls and Filler Walls.

A curtain wall is an exterior wall, often constructed of masonry that lies outside of and usually conceals the structural frame of a building. A filler wall is an infill, usually constructed of masonry, within the structural members of a frame. These walls are often considered architectural in nature if they are designed and detailed by the architect. However, they can act as structural shear walls. If they are connected to the frame, they will be subjected to the deflections of the frame and will participate with the frame in resisting lateral forces. Curtain walls and infill walls in buildings governed by this document should be designed so they do not restrict the deformations of the structural framing under lateral loads (i.e., so they are isolated from building lateral deformations). Lateral supports and bracing for these walls should be provided as prescribed in this Appendix.

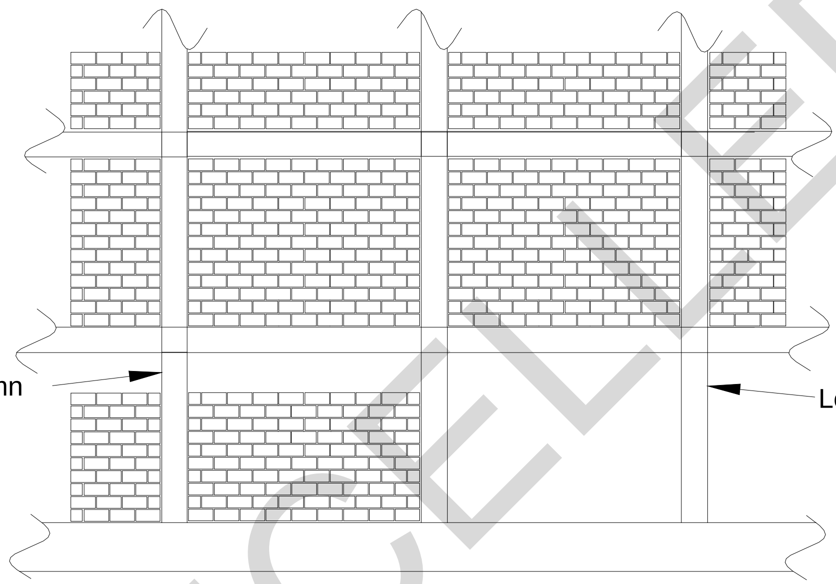
B-2.3.3 Partial Infill Walls.

A partial infill wall is one that has a strip of windows between the top of the solid infill and the bottom of the floor above, or has a vertical strip of window between one or both ends of the infill and a column. Such walls require special treatment. If they are not properly isolated from the structural system, they will act as shear walls. The wall with windows along the top is of particular concern because of its potential effect on the adjacent columns. The columns are fully braced where there is an adjacent infill, but are unbraced in the zone between the windows. The upper, unbraced part of the column is a “short column,” and its greater rigidity (compared with the other, longer unbraced columns in the system) must be considered in structural design. Short columns are very susceptible to shear failure in earthquakes. Figure B-1 shows a partial infill wall, with short columns on either side of the infill, which should be avoided. All infills in buildings governed by this document should be considered to be nonstructural components, and should be designed so they do not restrict the deformation of the structural framing under lateral loads. In this instance, the partial infill should be sufficiently isolated from the adjacent frame elements to permit those elements to deform in flexure as designed.

B-2.3.4 Precast Panels.

Exterior walls that consist of precast panels attached to the building frame are addressed uniquely. The general design of wall panels is usually shown on architectural drawings, while structural details of the panels are usually shown on structural drawings. Often, structural design is assigned to the General Contractor, to allow maximum use of the special expertise of the selected panel subcontractor. In such cases, structural drawings should include design criteria and representative details in order to show what is expected. The design criteria should include the required design forces and frame deflections that must be accommodated by the panels and their connections. Particular attention should be given to the effects of deflections of the frame members supporting precast panels, to assure that appropriate reaction forces and deflections are considered. Panels with more than two attachment points between their bottom edge and the supporting frame should be avoided. Further guidance can be found in *Architectural Precast Concrete,* 3rd Edition (MNL-122-07), published by the Precast/Prestressed Concrete Institute (PCI).

Figure B-1. Partial Infill Masonry Wall between Two Concrete Columns, Causing Adverse "Short Column" Effect



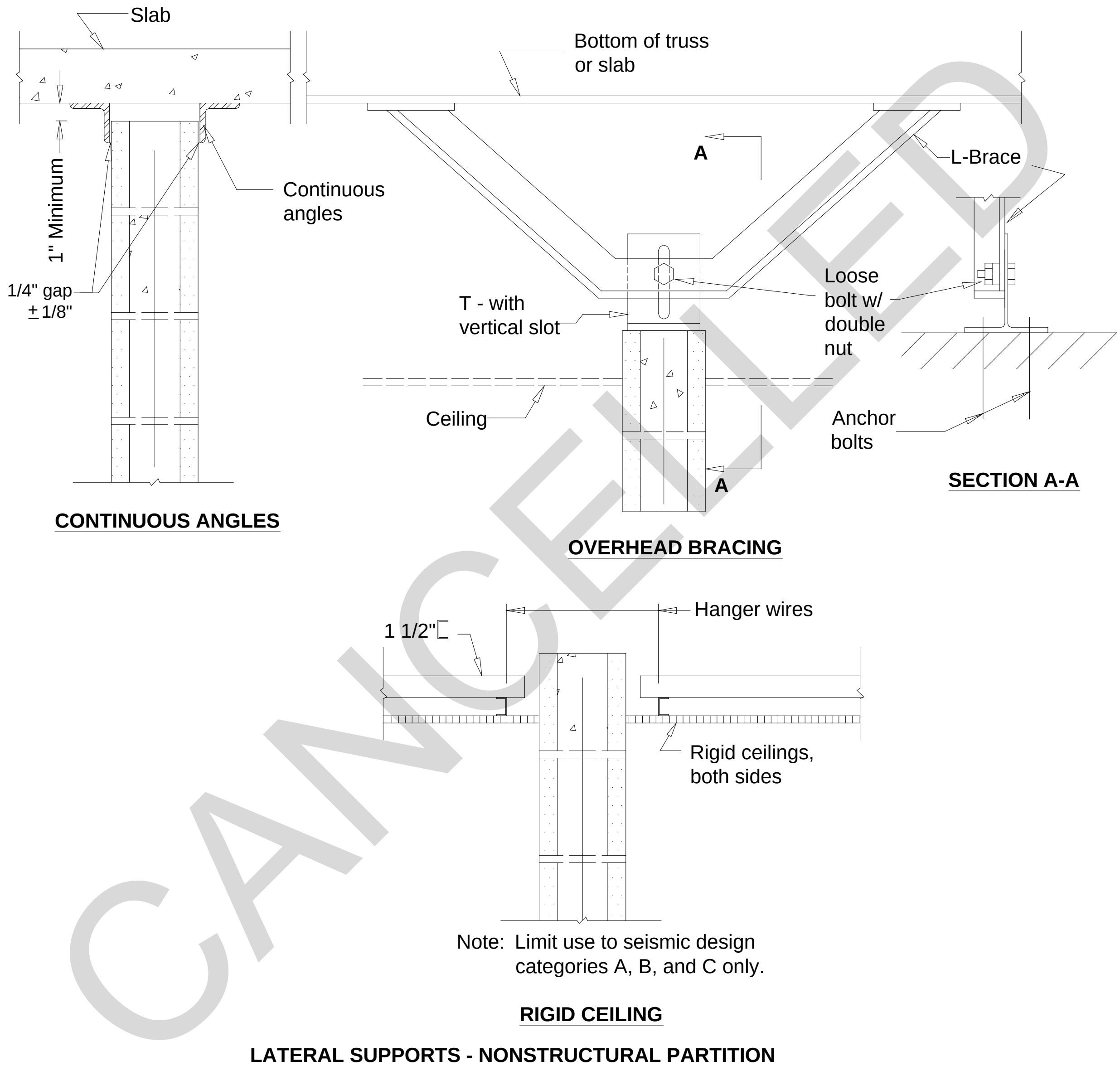
B-2.3.5 Masonry Veneer.

Reference should be made to *Building Code Requirements for Masonry Structures* (TMS 402-08/ACI 530-08/ASCE 5-08), commonly referred to as the MSJC (Masonry Standards Joint Committee) Code. A masonry veneer is defined as a masonry wythe that provides the exterior finish of a wall system and transfers out-of-plane load directly to a backing, but is not considered to add load-resisting capacity to the wall system. A masonry veneer may be anchored or adhered. An anchored veneer is defined as a masonry veneer secured to and supported laterally by the backing through anchors and supported vertically by the foundation or other structural elements. An adhered veneer is defined as a masonry veneer secured to and supported by the backing through adhesion. Chapter 6 of the MSJC Code provides requirements for design and detailing of anchored masonry veneer and adhered masonry veneer. The design of anchored veneer is addressed in Section 6.1.2 of the MSJC Code, while the design of adhered veneer is addressed in Section 6.1.3 of the same document.

B-2.3.6 Rigid Partition Walls.

Rigid partition walls are generally nonstructural masonry walls. Such walls should be isolated, so they are unable to resist in-plane lateral forces to which they are subjected, based on relative rigidities. Typical details for isolating these walls are shown in Figure B-2. These walls should be designed for the prescribed forces normal to their plane.

Figure B-2. Typical Details for Isolation of Rigid Partition Walls



B-2.3.7 Nonrigid Partition Walls.

Nonrigid partition walls are generally nonstructural partitions, such as stud and drywall, stud and plaster, and movable partitions. When these partitions are constructed according to standard recommended practice, they are assumed to be able to withstand design in-plane drift of only 0.005 times the story height (1/16 in./ft [5 mm/m] of story height) without damage. This is much less than the most restrictive allowable story drift in ASCE 7-05 Table 12.12-1. Therefore, damage to these partitions should be expected in the design earthquake if they are anchored to the structure in the in-plane direction. For OC IV and V buildings, these partition walls should be isolated from in-plane building motions at the tops and sides of partitions if drifts exceeding 0.005 times the story height are anticipated in the design earthquake. Partition walls should be designed for the prescribed seismic force acting normal to flat surfaces. However, the wind or the usual 5 pounds per square foot partition load (2009 IBC Section 1607.13) will usually govern. Bracing the tops of the walls to the structure will normally resist these out-of-plane forces applied to the partition walls.

Economic comparison between potential damage and costs of isolation should be considered. For partitions that are not isolated, a decision has to be made for each project as to the contribution, if any, such partitions will make to damping and response of the structure, and the effect of seismic forces parallel to (in-plane with) the partition resulting from the structural system as a whole. Usually, it may be assumed that this type of a partition is subject to future changes in floor layout location. The structural role of partitions may be controlled by limiting the height of partitions and by varying the method of support.

B-2.3.8 Suspended Ceilings.

Requirements for suspended ceilings are provided in ASCE 7-05 Section 13.5.6, as modified by Chapter 2. The Ceilings & Interior Systems Construction Association (CISCA) *Guidelines for Seismic Restraint for Direct Hung Suspended Ceiling Assemblies, Seismic Zones 3 and 4* (May 2004) provides detailing recommendations for suspended ceiling assemblies. Useful guidance is also available in AC 368 *Acceptance Criteria for Suspended Ceiling Framing Systems*, issued by the International Code Council Evaluation Service (ICC-ES) in February 2007.

B-3 MECHANICAL AND ELECTRICAL COMPONENTS

B-3.2 Component Support.

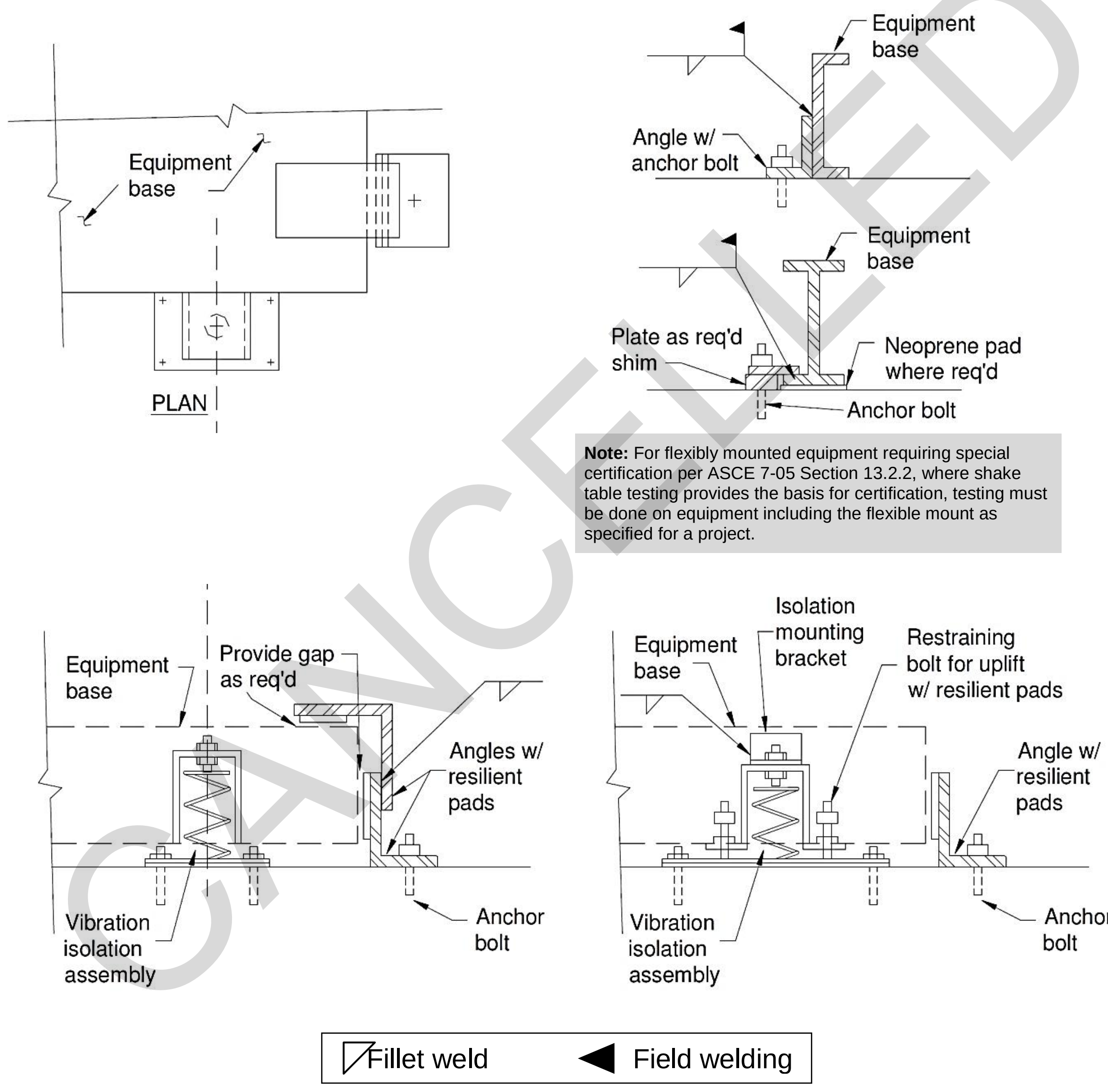
B-3.2.1 References.

ASCE 7-05 Section 13.6.5 Component Supports, as modified by Chapter 2 Section 13.6.5.5.

B-3.2.2 Base-mounted Equipment in OCs IV and V.

Floor or pad-mounted mission-critical equipment installed in OC V buildings and OC IV buildings assigned to SDC D, E, or F should use cast-in-place anchor bolts to anchor them. Alternatively, post-installed anchors shall be permitted to be used provided they are qualified for earthquake loading in accordance with ACI 355.2, *Qualification of Post-Installed Mechanical Anchors in Concrete*, and ACI 355.4, *Acceptance Criteria for Qualification of Post-Installed Adhesive Anchors in Concrete*, as applicable. For this equipment, two nuts should be provided on each bolt, and anchor bolts should conform to ASTM F1554-07a, *Standard Specification for Anchor Bolts, Steel, 36, 55, and 105-ksi Yield Strength*. Cast-in-place anchor bolts should have an embedded straight length equal to at least 12 times the nominal bolt diameter. Anchor bolts that exceed the normal depth of equipment foundation piers or pads should either extend into the concrete floor, or the foundation should be increased in depth to accommodate the bolt lengths. Figure B-3 illustrates typical base anchorage and restraint for equipment.

Figure B-3. Typical Seismic Restraints for Floor-mounted Equipment

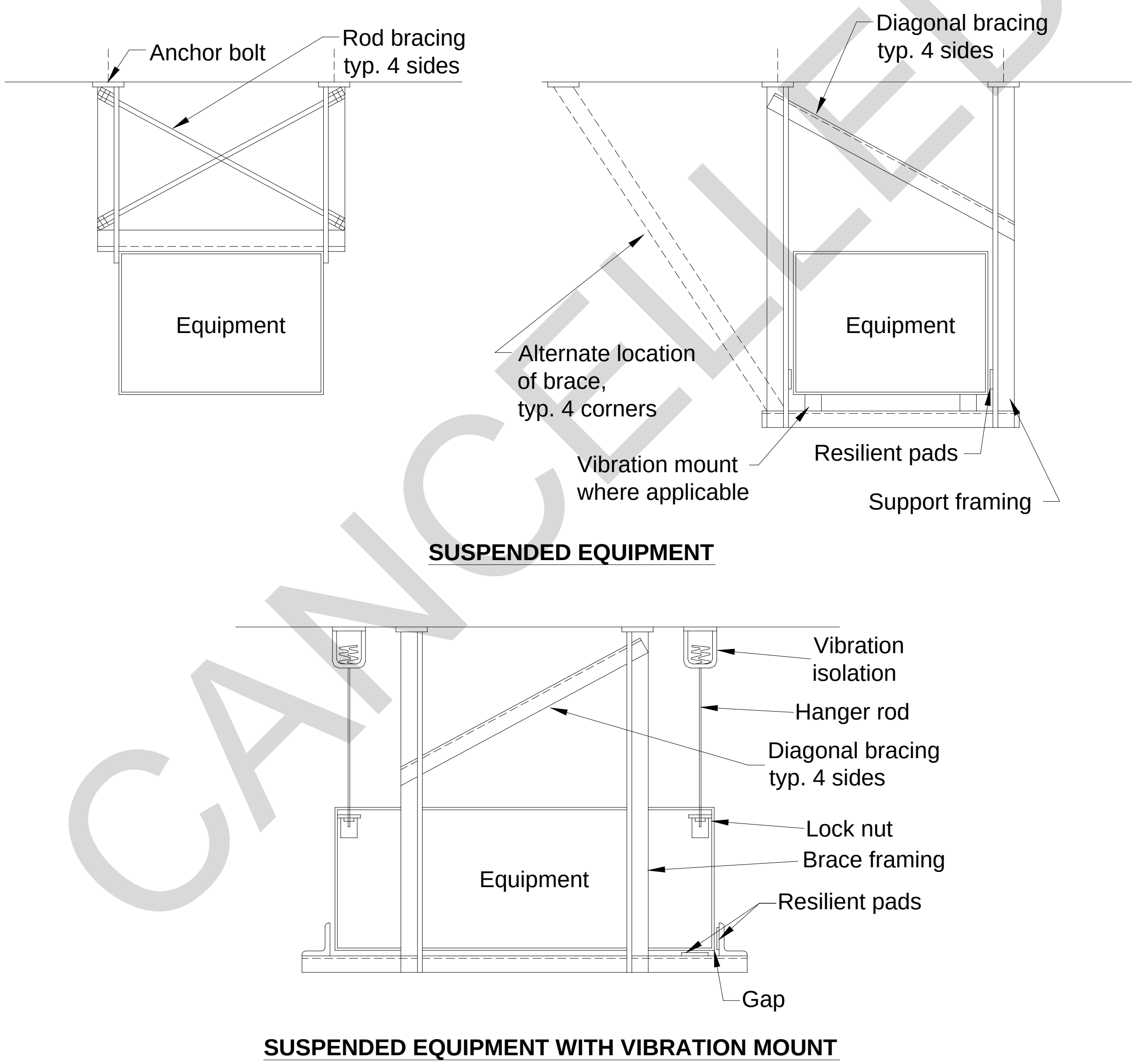


B-3.2.3 Suspended Equipment.

Seismic bracing for suspended equipment may use the bracing recommendations and details in ANSI/SMACNA 001-2008, *Seismic Restraint Manual: Guidelines for Mechanical Systems*, 3rd Edition, or the International Seismic Application Technology

(ISAT), *Engineered Seismic Bracing of Suspended Utilities*, 3rd Edition, November 2002. The ISAT recommendations may be used for suspended plumbing and process piping, mechanical piping and equipment, HVAC ducts, cable trays and bus ducts, electrical conduits, conduit racks, and vibration isolation. The ISAT guidelines require the calculation of a Total Design Lateral Force (TDLF). This force should be calculated in accordance with seismic force calculations for F_p in ASCE 7-05 Section 13.3.1. Trapeze-type hangers should be secured with not less than two bolts. Figure B-4 shows typical seismic restraints for suspended equipment.

Figure B-4. Typical Seismic Restraints for Suspended Equipment



B-3.2.4 Supports and Attachments for Piping.

Seismic supports required in accordance with ASCE 7-05 Section 13.6.8.4, Other Piping Systems, should be designed in accordance with the following guidance. This piping is not constructed in accordance with ASME B31 or NFPA 13.

B-3.2.4.1 General.

The provisions of this section apply to all risers and riser connections; all horizontal pipes and attached valves; all connections and brackets for pipes; flexible couplings and expansion joints; and spreaders. The following general guidance applies to these elements:

1. For seismic analysis of horizontal pipes, the equivalent static force should be considered to act concurrently with the full dead load of the pipe, including contents.

2. All connections and brackets for pipe should be designed to resist concurrent dead and equivalent static forces. Seismic forces should be determined from ASCE 7-05 Section 13.3.1. Supports should be provided at all pipe joints unless continuity is maintained. Figure B-5 provides acceptable sway bracing details.

3. Flexible couplings should be provided at the bottoms of risers for pipes larger than 3.5 in. (89 mm) in diameter. Flexible couplings and expansion joints should be braced laterally and longitudinally unless such bracing would interfere with the action of the couplings or joints. When pipes enter buildings, flexible couplings should be provided to allow for relative movement between the soil and building.

4. Spreaders should be provided at appropriate intervals to separate adjacent pipelines unless pipe spans and clear distances between pipes are sufficient to prevent contact between the pipes during an earthquake.

B-3.2.4.2 Rigid versus Flexible Piping Systems.

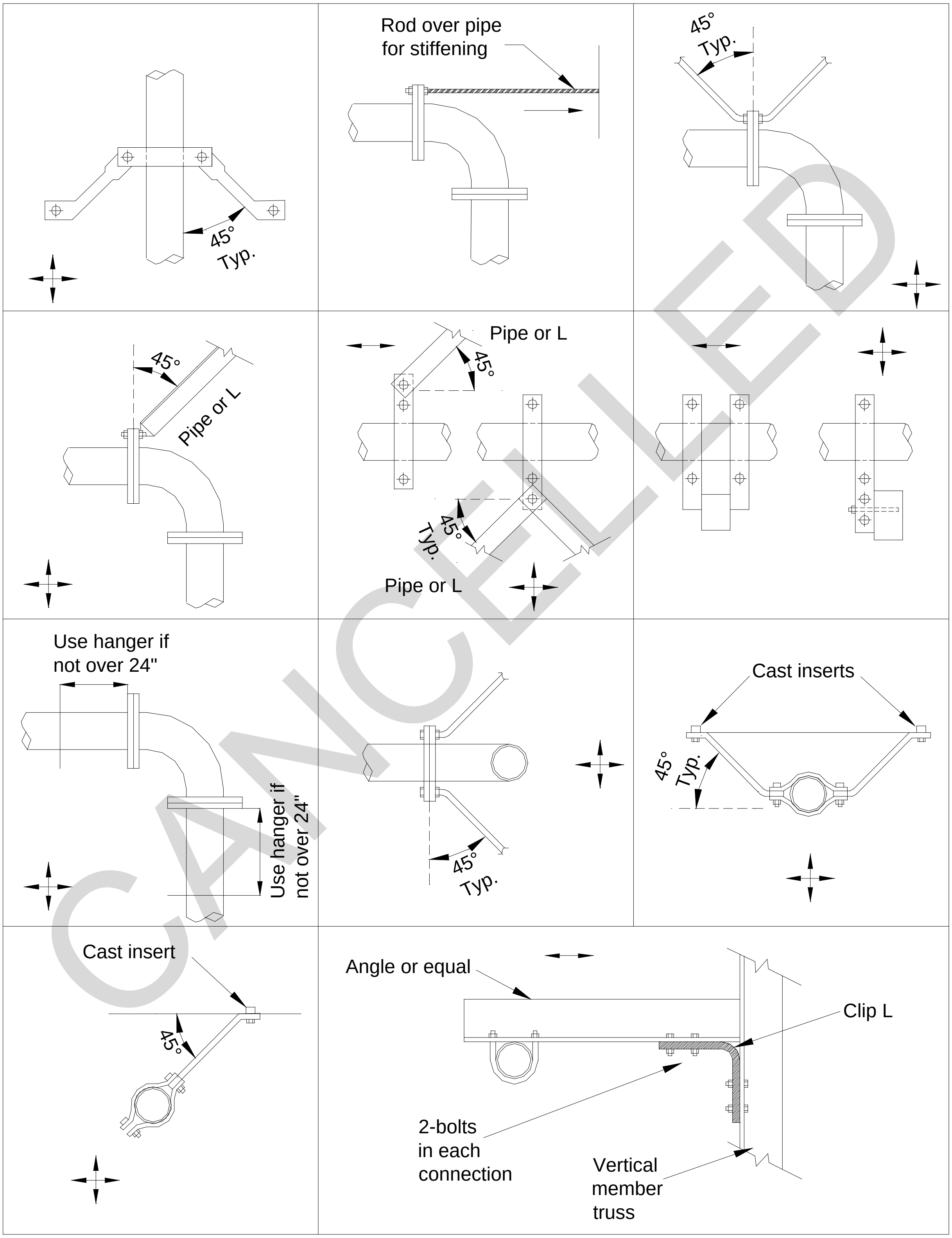
Piping systems should be considered either rigid or flexible. Rigid pipes are stiffer than flexible pipes. Their dynamic response is assumed to be decoupled from the building amplified response, so that the component amplification factor, a_p, is set to 1.0 (see ASCE 7-05 Table 13.6-1, note a). Flexible pipes are more flexible, and it is assumed that they may couple with and further amplify building motion, so a_p is set to 2.5. This suggests that pipe system forces, F_p, would be less for rigid pipes, however, that is not necessarily the case because R_p values are larger for flexible pipes than rigid pipes. Therefore, designers are encouraged to use high- deformability pipe systems that may permit longer pipe support spacing in accordance with this guidance. It should be noted that when high deformability pipe systems, which have the larger R_p values, are used (e.g., welded steel pipe systems), F_p, may be limited by the minimum value set forth by ASCE 7-05 Equation 13.3-3. Forces based on ASCE 7-05 Equation 13.3-3 may also govern for pipes installed in lower levels of a building.

B-3.2.4.2.1 Rigid Piping System.

A piping system is assumed rigid if its maximum period of vibration is no more than 0.06 second (ASCE 7-05 Section 11.2 definition for Component, rigid). ASCE 7-05 Table

13.6-1 shows that a_p equals 1.0 for rigid pipes, where the support motions are not amplified. Rigid and rigidly attached pipes should be designed in accordance with ASCE 7-05 Equation 13.3-1, where W_p is the weight of the pipes, their contents, and attachments. Forces should be distributed in proportion to the total weight of pipes, contents, and attachments.

Figure B-5. Acceptable Seismic Details for Pipe Sway Bracing



Tables B-1, B-2, and B-3 may be used to determine allowable span-diameter relationships for rigid pipes; standard (40S) pipe; extra strong (80S) pipe; types K, L, and M copper tubing; and 85 red brass or SPS copper pipe in OC IV and V buildings. These tables are based on water-filled pipes with periods equal to 0.06 seconds. Figures B-6, B-7, and B-8 display support conditions for Tables B-1, B-2, and B-3, respectively. The relationship used to determine maximum pipe lengths, *L*, shown in the tables, that will result in rigid pipes having a maximum period of vibration of 0.06 seconds, is given in Equation B-1 (which is excerpted from the *Shock and Vibration Handbook*):

$$L = \sqrt{C \pi T_a \sqrt{\frac{EI_g}{w}}} \text{, in. or mm} \qquad \textbf{(Equation B-1)}$$

where

C = period constant, equal to 0.50 for pinned-pinned pipes; 0.78 for fixed- pinned pipes; and 1.125 for fixed-fixed pipes

T_a = natural period of pipe in its fundamental mode, set equal to 0.06 second

E = modulus of elasticity of pipe, psi or MPa

I = moment of inertia of pipe, in^4 or mm^4

w = weight of pipe and contents per unit length, lb/in. or N/mm

Table B-1
Maximum Span for Rigid Pipe with Pinned-Pinned Conditions, L

Diameter Inches	Std. Wt. Steel Pipe 40S	Ex. Strong Steel Pipe 80S	Copper Tube Type K	Copper Tube Type L	Copper Tube Type M	85 Red Brass & SPS Copper Pipe
1	7'- 0"	7'- 0"	5'- 5"	5'- 4"	4'- 11"	5'- 11"
1 1/2	8'- 5"	8'- 6"	6'- 5"	6'- 3"	5'- 12"	7'- 1"
2	9'- 4"	9'- 5"	7'- 3"	7'- 1"	6'- 10"	7'- 10"
2 1/2	10'- 3"	10'- 5"	7'- 11"	7'- 10"	7'- 5"	8'- 8"
3	11'- 3"	11'- 5"	8'- 8"	8'- 6"	8'- 1"	9'- 6"
3 1/2	11'- 12"	12'- 2"	9'- 3"	9'- 1"	8'- 8"	10'- 2"
4	12'- 8"	12'- 11"	9'- 10"	9'- 9"	9'- 5"	10'- 9"
5	13'- 11"	14'- 3"	10'- 11"	10'- 8"	10'- 4"	11'- 8"
6	15'- 1"	15'- 7"	11'- 12"	11'- 6"	11'- 2"	12'- 7"
8	16'- 12"	17'- 8"				
10	18'- 9"	19'- 4"				
12	20'- 1"	20'- 9"				

Figure B-6. Pinned-pinned Support Condition for Table B-1

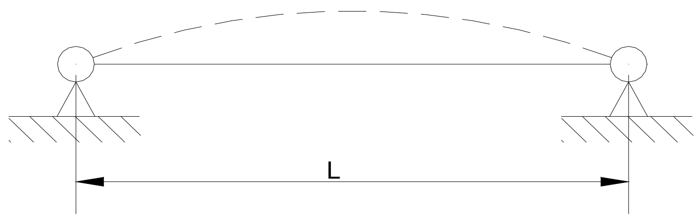


Table B-2
Maximum Span for Rigid Pipe with Fixed-Pinned Condition, L

Diameter Inches	Std. Wt. Steel Pipe 40S	Ex. Strong Steel Pipe 80S	Copper Tube Type K	Copper Tube Type L	Copper Tube Type M	85 Red Brass & SPS Copper Pipe
1	8'- 9"	8'- 10"	6'- 9"	6'- 8"	6'- 1"	7'- 5"
1 1/2	10'- 6"	10'- 7"	7'- 12"	7'- 10"	7'- 6"	8'- 10"
2	11'- 7"	11'- 9"	9'- "	8'- 10"	8'- 6"	9'- 9"
2 1/2	12'- 10"	12'- 12"	9'- 11"	9'- 9"	9'- 4"	10'- 9"
3	14'- 1"	14'- 3"	10'- 10"	10'- 7"	10'- 1"	11'- 10"
3 1/2	14'- 11"	15'- 3"	11'- 7"	11'- 4"	10'- 10"	12'- 8"
4	15'- 9"	16'- 1"	12'- 4"	12'- 2"	11'- 9"	13'- 5"
5	17'- 5"	17'- 10"	13'- 8"	13'- 3"	12'- 10"	14'- 7"
6	18'- 10"	19'- 5"	14'- 11"	14'- 5"	13'- 11"	15'- 8"
8	21'- 2"	22'- 0"				
10	23'- 5"	24'- 2"				
12	25'- 1"	25'- 11"				

Figure B-7. Fixed-pinned Support Condition for Table B-2

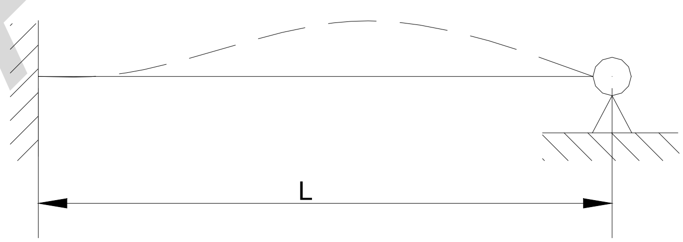
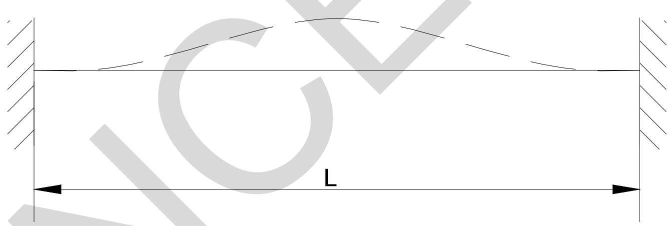


Table B-3
Maximum Span for Rigid Pipe with Fixed-Fixed Condition, L

Diameter Inches	Std. Wt. Steel Pipe 40S	Ex. Strong Steel Pipe 80S	Copper Tube Type K	Copper Tube Type L	Copper Tube Type M	85 Red Brass & SPS Copper Pipe
1	10'- 7"	10'- 7"	8'- 1"	7'- 12"	7'- 4"	8'- 11"
1 1/2	12'- 7"	12'- 8"	9'- 7"	9'- 5"	8'- 12"	10'- 8"
2	13'- 11"	14'- 2"	10'- 10"	10'- 8"	10'- 2"	11'- 9"
2 1/2	15'- 5"	15'- 7"	11'- 11"	11'- 9"	11'- 2"	12'- 11"
3	16'- 11"	17'- 2"	12'- 12"	12'- 9"	12'- 1"	14'- 3"
3 1/2	17'- 12"	18'- 4"	13'- 11"	13'- 8"	13'- 1"	15'- 3"
4	18'- 11"	19'- 4"	14'- 9"	14'- 8"	14'- 2"	16'- 1"
5	20'- 11"	21'- 5"	16'- 5"	15'- 11"	15'- 5"	17'- 7"
6	22'- 7"	23'- 4"	17'- 12"	17'- 4"	16'- 9"	18'- 10"
8	25'- 6"	26'- 5"				
10	28'- 2"	29'- 0"				
12	30'- 2"	31'- 1"				

Figure B-8. Fixed-fixed Support Condition for Table B-3



B-3.2.4.2.2 Flexible Piping Systems.

Piping systems that do not comply with the rigidity requirements of Section B-3.2.4.1.1 (i.e., period less than or equal to 0.06 seconds) should be considered flexible (i.e., period greater than 0.06 second). Flexible piping systems should be designed for seismic forces with consideration given to both the dynamic properties of the piping system and the building or structure in which it is placed. In lieu of a more detailed analysis, equivalent static lateral force may be computed using ASCE 7-05 Equation 13.3-1, with $a_p = 2.5$. The forces should be distributed in proportion to the total weight of pipes, contents, and attachments. If the weight of attachments is greater than 10% of pipe weight, attachments should be separately braced, or substantiating calculations should be required. If temperature stresses are appreciable, substantiating calculations should be required. The following guidance should also be followed for flexible pipe systems:

1. Separation between pipes should be a minimum of four times the calculated maximum displacement due to F_p, but not less than 4 in. (102 mm) clearance between parallel pipes, unless spreaders are provided.

2. Clearance from walls or rigid elements should be a minimum of three times the calculated displacement due to F_p, but not less than 3 in. (76 mm) clearance from rigid elements.

3. If the provisions of the above paragraphs appear to be too severe for an economical design, alternative methods based on rational and substantial analysis may be applied to flexible piping systems.

4. Acceptable seismic details for sway bracing are shown in Figure B-5.

B-3.3 Stacks (Exhaust) Associated with Buildings.

B-3.3.1 References.

ASCE 7-05 Section 13.5 and Chapter 15, and Chapter 2 Section 13.6.1.

B-3.3.2 General.

Stacks are actually vertical beams with distributed mass and, as such, cannot be modeled accurately by single-mass systems. This design guidance applies to either cantilever or singly-guyed stacks attached to buildings. When a stack foundation is in contact with the ground and the adjacent building does not support the stack, it should be considered to be a nonbuilding structure (see ASCE 7-05 Chapter 15). This guidance is intended for stacks with a constant moment of inertia. Stacks having a slightly varying moment of inertia should be treated as having a uniform moment of inertia with a value equal to the average moment of inertia.

Stacks that extend more than 15 ft (4.6 m) above a rigid attachment to adjacent buildings should be designed according to the guidance for cantilever stacks presented in Section B-3.3.3. Stacks that extend less than 15 ft (4.6 m) should be designed for the equivalent static lateral force defined in ASCE 7-05 Section 13.3.1 using the a_p and R_p values in ASCE 7-05 Table 13.5-1.

Stacks should be anchored to adjacent buildings using long anchor bolts (where bolt length is at least 12 bolt diameters). Much more strain energy can be absorbed with long anchor bolts than with short ones. The use of long anchor bolts has been demonstrated to give stacks better seismic performance. A bond-breaker material should be used on the upper portion of the anchor bolt to ensure a length of unbonded bolt for strain energy absorption. Two nuts should be used on anchor bolts to provide an additional factor of safety.

B-3.3.3 Cantilever Stacks.

The fundamental period of a cantilever stack should be determined from the period coefficient (e.g., C = 0.0909) provided in Figure B-9, unless actually computed. The equation and the period coefficients, C, shown in Figure B-9 were derived from the *Shock and Vibration Handbook* (6th Edition, 2009). Dynamic response of ground-supported stacks may be calculated from the appropriate base shear equations for the Equivalent Lateral Force Procedure defined in ASCE 7-05 Section 12.8.

B-3.3.4 Guyed Stacks.

Analysis of guyed stacks depends on the relative rigidities of cantilever resistance and guy cable support systems. If a cable is relatively flexible compared to the cantilevered stack stiffness, the stack should respond in a manner similar to the higher modes of vibration of a cantilever, with periods and mode shapes similar to those shown in Figure B-9. The fundamental period of vibration of the guyed system should be somewhere between the values for the fundamental and the appropriate higher mode of a similar cantilever stack. An illustration for a single guyed stack is shown in Figure B-10. Guyed stacks should be designed with rigid cables so that the true deflected shape is closer to that shown on the right side of Figure B-10. This requires pretensioning of guy cables to a minimum of 10 percent of stack seismic forces, F_p. Design for guyed stacks is beyond the scope of this document. However, some guidance may be found in TIA-222-G, *Structural Standards for Antenna Supporting Structures and Antennas,* 2005, including Addendum 2, 2009.

B-3.4 Elevators.

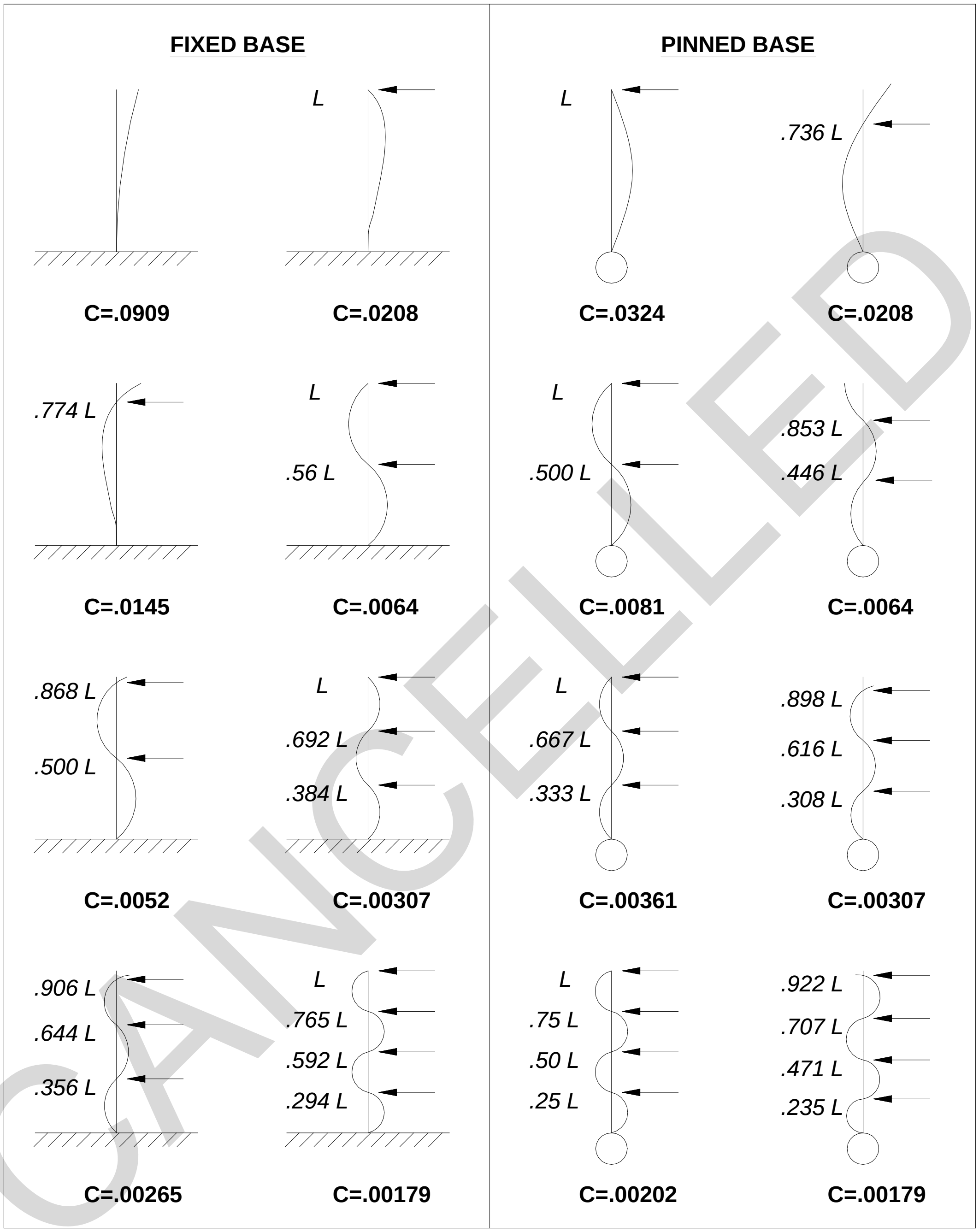
B-3.4.1 References.

ASCE 7-05 Section 13.6.10, "Elevator and Escalator Design Requirements," as modified by Chapter 2 Section 13.6.10.3.

B-3.4.2 General.
Elevator car and counterweight frames, roller guide assemblies, retainer plates, guide rails, and supporting brackets and framing (Figure B-11) should be designed in accordance with ASCE 7-05 Section 13.6.10. Lateral forces acting on guide rails should be assumed to be distributed one-third to top guide rollers and two- thirds to

bottom guide rollers of elevator cars and counterweights. An elevator car and/or counterweight should be assumed to be located at its most adverse position in relation to its guide rails and support brackets. Horizontal deflections of guide rails should not exceed 1/2 in. (12.7 mm) between supports, and horizontal deflections of the brackets should not exceed 1/4 in. (6.4 mm).

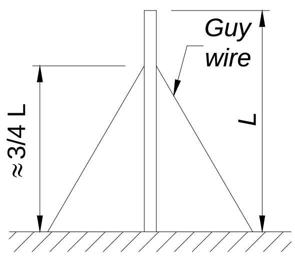
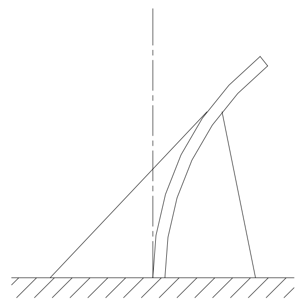
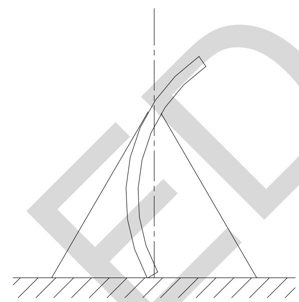
Figure B-9. Period Coefficients for Uniform Beams



$$T_a = C\sqrt{\frac{wL^4}{EI}}$$

T_a = Fundamental period (sec)
w = Weight per unit length of beam (lb/in) (N/mm)
L= Total beam length (in) (mm)
I = Moment of inertia (in^4) (mm^4)
E = Modulus of elasticity (psi) (MPa)
C = Period constant

Figure B-10. Single Guyed Stacks.

DESCRIPTION	DEFLECTED SHAPE	
	FLEXIBLE WIRE	RIGID WIRE
		

B-3.4.3 Retainer Plates.

In structures assigned to SDC D, E, and F, clearances between the machined faces of rail and retainer plates should not be more than 3/16 in. (4.8 mm), and the engagement of a rail should not be less than the dimension of its machined side face. When a car safety device attached to lower members of a car frame complies with lateral restraint requirements, a retainer plate is not required for the bottom of the car.

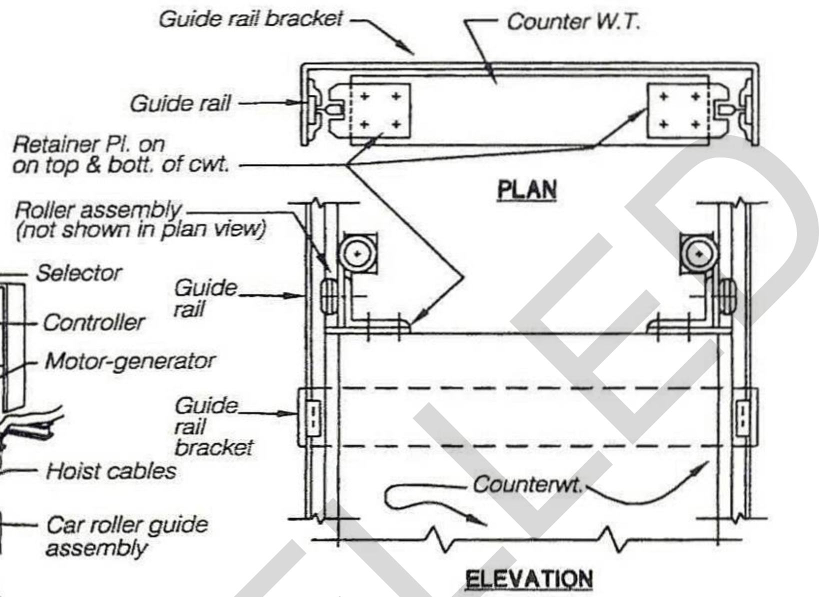
B-3.4.4 Counterweight Tie Brackets.

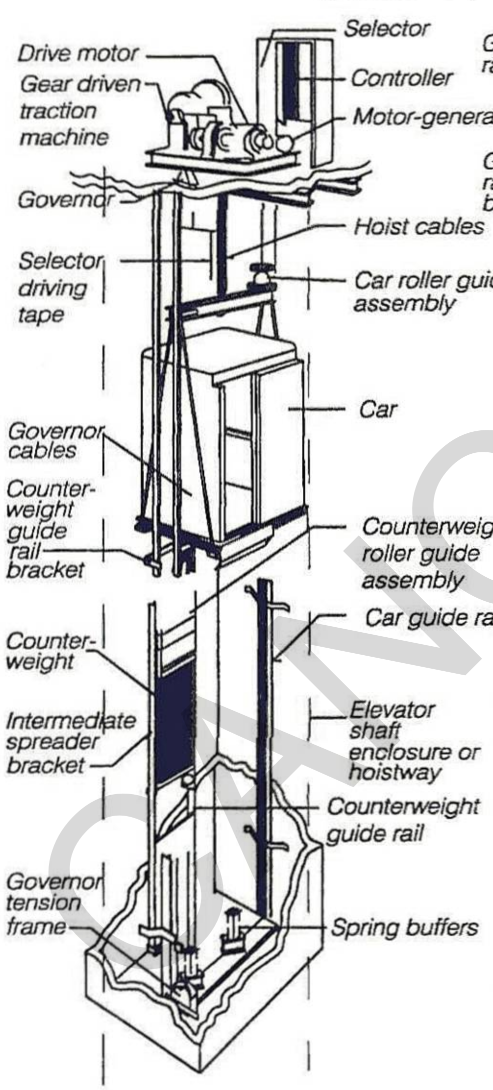
In structures assigned to SDC D, E, and F, the maximum spacing of counterweight rail tie brackets tied to a building structure should not exceed 16 ft (4.9 m). An intermediate spreader bracket, which is not required to be tied to a building structure, should be provided for tie brackets spaced greater than 10 ft (3.0 m), and two intermediate spreader brackets are required for tie brackets spaced greater than 14 ft (4.3 m).

B-3.4.5 Force Calculation.

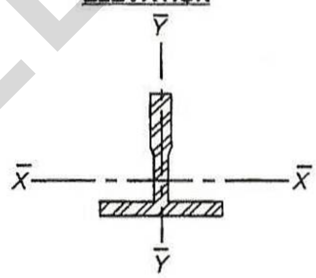
Elevator machinery and equipment should be designed for a_p = 1.0 in ASCE 7-05 Equation 13.3-1, when rigid and rigidly attached. Non-rigid or flexibly mounted equipment (i.e., which has a period greater than 0.06 second) should be designed with a_p = 2.5.

Figure B-11. Elevator Details





TRACTION TYPE ELEVATOR



Section Properties of Elevator Guide Rails

Nom. Wt. per Foot	A	$\bar{y}$	I_x	S_x	r_x	I_y	S_y	r_y
8	2.40	0.81	1.40	0.86	0.78	1.28	0.73	0.74
11	3.24	1.12	4.29	1.80	1.15	2.67	1.19	0.90
12	3.51	1.08	4.49	1.85	1.13	3.61	1.45	1.01
15	4.41	0.97	4.78	1.89	1.04	5.51	2.21	1.12
18.5	5.44	1.26	9.67	3.23	1.33	7.45	2.71	1.17
22.5	6.73	1.38	11.17	4.20	1.28	8.64	3.10	1.13
30	8.93	1.74	24.00	7.37	1.64	11.08	4.03	1.11

A = Area (in.^{2})
$\bar{y}$ = Distance from back of rail to axis x-x (in.)
I_x = Moment of inertia about axis x-x (in.^{4})
S_x = Section modulus about axis x-x (in.^{3})
r_x = Radius of gyration about axis x-x (in.)
I_y = Moment of inertia about axis y-y (in.^{4})
S_y = Section modulus about axis y-y (in.^{3})
r_y = Radius of gyration about axis y-y (in.)

B-3.5 Lighting Fixtures in Buildings.

B-3.5.1 Reference.

ASCE 7-05 Sections 13.2.5 Testing Alternative for Seismic Capacity Determination, 13.5.6 Suspended Ceilings, 13.6.1, 13.6.2, 13.6.4 and 13.6.5 Mechanical and Electrical Components, as modified by this UFC's Chapter 2 Sections 13.5.6 and 13.6.5.5.

B-3.5.2 General.

Lighting fixtures, including their attachments and supports, in SDC C, D, E, and F should conform to the following materials and construction requirements:

1. Fixture supports should use materials that are suitable for this purpose. Cast metal parts, other than those of malleable iron, and cast or rolled threads, should be subject to special investigation to ensure structural adequacy.

2. Loop and hook or swivel hanger assemblies for pendant fixtures should be fitted with restraining devices to hold their stems in the support position during earthquake motions. Pendant-supported fluorescent fixtures should also be provided with flexible hanger devices at their attachments to the fixture channel to preclude breaking of the support. Motions of swivels or hinged joints should not cause sharp bends in conductors or damage to insulation.

3. A supporting assembly that is intended to be mounted on an outlet box should be designed to accommodate mounting features on 4 in. (102 mm) boxes, 3 in. (76 mm) plaster rings, and fixture studs.

4. Each surface-mounted individual or continuous row of fluorescent fixtures should be attached to a seismic-resisting ceiling support system. Support devices for attaching fixtures to suspended ceilings should be locking-type scissor clamps or full loop bands that will securely attach to the ceiling support. Fixtures attached to the underside of a structural slab should be properly anchored to the slab at each of their corners.

5. Each wall-mounted emergency light unit should be secured in a manner that will hold the unit in place during a seismic disturbance.

B-3.6 Bridges, Cranes, and Monorails.

B-3.6.1 References.

ASCE 7-05 Section 13.6 Mechanical and Electrical Component, as modified by Chapter 2 Sections 13.6.13 and 13.6.14, and 2009 IBC Section 1607.12.

B-3.6.2 General.

2009 IBC Section 1607.12 provides live load design guidance for cranes. Vertical restraints should be provided to resist crane uplift. Experience has shown that vertical ground motions can be amplified significantly in either crane bridges or crane rail support brackets that are cantilevered from columns. Analysis of cranes should consider their amplified response in the vertical direction, in addition to horizontal response. The criteria for this section specify a component amplification factor, a_p, of 2.5 in the direction parallel to crane rails, because a crane bridge would almost certainly be flexible enough in its weak axis to have a natural period greater than 0.06 seconds. This factor is greater than 1.0 because, at large natural periods, a crane bridge can be expected to amplify ground and building motions. This factor has a value of 1.0 perpendicular to crane rails because the bridge would be loaded axially in this direction, resulting in a natural period that is less than 0.06 second. The crane bridge is considered to be rigid when loaded axially, so that it will not amplify ground or building motions. When a crane is not in the locked position, it is reasonable to assume that upper bound forces in the direction parallel to crane rails, between the wheels and rails, cannot exceed a conservative estimate of the force that could be transmitted by friction between the brake wheels and rails.

APPENDIX C MECHANICAL AND ELECTRICAL COMPONENT CERTIFICATION

C-1 COMPONENT CERTIFICATION

C-1.1 General.

The background to mechanical and electrical component certification is explained in *Special Seismic certification of Nonstructural Components* (Tobloski, M. Structural Engineering and Design, 2011).

ASCE 7-05 Section 13.2 states that certification shall be by analysis, testing or experience data. Mechanical and electrical equipment that must remain operable following the design earthquake must be certified based on shake table testing or experience data (section 13.2.2). ASCE 7-05 Section 13.2.2b states that "Components with hazardous contents shall be certified by the supplier as maintaining containment following the design earthquake by (1) analysis, (2) approved shake table testing in accordance with Section 13.2.5, or (3) experience data in accordance with Section 13.2.6."

The California Office of Statewide Health Planning and Development (OSHPD) has published Code Application Notice (CAN) 2-1708A.5, which explicitly explains OSHPD's expectations as they relate to special seismic certification. The main focus of the CAN is to emphasize items requiring physical shake table testing. OSHPD has also created a Special Seismic Certification Preapproval (OSP) program. This program offers a means to obtain prequalification of product lines for special seismic certification. From http://www.oshpd.ca.gov/FDD/Pre-Approval/index.html one can scroll down to the list of equipment that is pre-approved by OSHPD.

C-1.1.1 References.

ASCE 7-05 Section 13.2, General Design Requirements, and Chapter 2 Section 13.2.2.

C-1.1.2 Analytical Certification.

Certification based on analysis, as noted in ASCE 7-05 Section 13.2.2b, requires a reliable and conservative understanding of the equipment configuration, including the mass distribution, strength, and stiffness of the various subcomponents. From this information, an analytical model may be developed that reliably and conservatively predicts the equipment dynamic response and potential controlling modes of failure. If such detailed information on the equipment or a basis for conservative estimates of these properties is not available, then methods other than analysis must be used. The use of analysis for active or energized components is not permitted (see ASCE 7-10 Section 13.2.2). Any analytical qualification of equipment should be peer-reviewed independently by qualified, Registered Design Professionals.

C-1.1.3 Certification Based on Testing.

Shake table tests conducted in accordance with either ICC-ES AC156, *Acceptance Criteria for Seismic Qualification by Shake-Table Testing of Nonstructural Components,* or a site-specific study, should first use uniaxial motions in each of the three principal axes of the equipment that is being tested. The measured response recorded with vibration response monitoring instrumentation should be reviewed to determine if out-of-plane response (in terms of peak amplitude) at a given location of instrumentation exceeds 20% of the in-plane response. The in-plane direction is the direction of horizontal test motions, while the out-of-plane direction is at a horizontal angle of 90 degrees with respect to the in-plane axis. An out-of-plane response (equipment relative acceleration or equipment deformation) that exceeds 20% of the in-plane response, for either horizontal test, indicates that significant cross-coupling is occurring. In that case, the final qualification test should be triaxial, with simultaneous phase-incoherent motions in all three principal axes. If out-of-plane response is less than 20% of the in-plane response for both horizontal tests, at each critical location instrumented, then the final qualification tests can be biaxial with motions in one horizontal and the vertical directions. After post-test inspection and functional compliance verification, the Unit Under Test (UUT) may be rotated 90 degrees about the vertical axis and biaxial testing for the other horizontal direction and vertical direction can be conducted. Normally, two biaxial tests, rather than a single triaxial test, would be conducted when a triaxial shake table is not available or the displacement capacity of a triaxial shake table in one direction is too small.

The development of ICC-ES AC156 is documented in Background on the Development of the NEHRP Seismic Provisions for Non-Structural Components and their Application to Performance Based Seismic Engineering (Gillengerten, J.D., and Bachman, R.E., ASCE Structures Congress, 2003). For OC V facilities the site- specific seismic site response analysis will result in a set of site-specific ground motions that define the seismic hazard. The building model could be analyzed with these motions to define predicted time-history motions at each location where critical equipment is to be installed. From these building response motions, response spectra could be developed, using 5% of critical damping. If the equipment will be placed at several locations in the same building or in multiple buildings, a required response spectrum (RRS) could be developed that envelopes all the spectra generated from each building response record. As an alternative to the ICC-ES AC156 procedure, the equipment could be qualified with triaxial motions fit to the RRS, but generated according to ICC-ES AC156. A second alternative approach would be to test with the predicted time history motions that have the greatest response spectra amplitude at the measured natural frequency of the equipment in each of the principal directions. Using worst-case records would require that resonance search shake table tests be conducted in each of the three principal directions as defined in ICC-ES AC156. All alternatives to ICC-ES AC156 equipment qualification testing require peer review of the development of test records and test plans by qualified, Registered Design Professionals. Post-test inspection and functional compliance verification would still be required in accordance with ICC-ES AC156.

C-1.1.4 Additional Certification Methods.

Three additional methods are permitted for defining equipment capacity: earthquake experience data, seismic qualification testing data, and the CERL Equipment Fragility and Protection Procedure. The use of these methods requires a peer review by a qualified, Registered Design Professional.

C-1.1.4.1 Earthquake Experience Data.

Earthquake experience data that were obtained by surveying and cataloging the effects of strong ground motion earthquakes on various classes of equipment mounted in conventional power plants and other industrial facilities may be used. Section 4.2.1 of the publication *Generic Implementation Procedure (GIP) for Seismic Verification of Nuclear Plant Equipment* (DOE 1992) provides these data. Based on this work, a Reference Spectrum would be developed to represent the seismic capacity of equipment in the earthquake experience equipment class. DOE/EH-0545, *Seismic Evaluation Procedure for Equipment in U.S. Department of Energy Facilities*, provides guidance on this procedure. A detailed description of the derivation and use of this Reference Spectrum is contained in DoE publication SAND92-0140, *Use of Seismic Experience Data to Show Ruggedness of Equipment in Nuclear Power Plants*. This document should be reviewed before using the Reference Spectrum. The Reference Spectrum and four spectra from which it is derived are shown in Figure 5.3-1 of DOE/EH-0545. The Reference Spectrum and its defining response levels and frequencies are shown in Figure 5.3-2 of the same document. When this approach is used, the Reference Spectrum is used to represent the seismic capacity of equipment, when the equipment is determined to have characteristics similar to the earthquake experience equipment class and meets the intent of the caveats for that class of equipment as defined in Chapter 8 of DOE/EH-0545.

C-1.1.4.2 Qualification Testing Database.

Data collected from seismic qualification testing of nuclear power plant equipment may be used in the certification of equipment. These data were used to develop generic ruggedness levels for various equipment classes in the form of Generic Equipment Ruggedness Spectra (GERS). The development of the GERS and the limitations on their use are documented in Electric Power Research Institute (EPRI) report NP-5223, *Generic Seismic Ruggedness of Power Plant Equipment in Nuclear Power Plants*. The nonrelay GERS and limitations for their use are discussed in Chapter 8 of DOE/EH-0545, while the relay GERS are in Chapter 11 of the same document. The EPRI report should be reviewed by users of the GERS to understand the basis for them. The use of either the Reference Spectrum or the GERS for defining equipment capacity requires careful review of the basis for them to ensure applicability to the equipment being evaluated.

C-1.1.4.3 CERL Equipment Fragility and Protection Procedure.

The CERL Equipment Fragility and Protection Procedure (CEFAPP), defined in USACERL Technical Report 97/58, may be used for defining equipment capacity. Similar to the other methods, CEFAPP defines a response spectrum envelope of the equipment capacity. This method requires a series of shake table tests to develop an actual failure envelope across a frequency range. This experimental approach requires greater effort than the ICC-ES AC156 qualification testing. However, the resulting failure envelope provides a more accurate and complete definition of capacity, rather than simply determining that the equipment survived a defined demand environment. Unlike the AC156 procedure, site-specific testing, or the other two additional methods, CEFAPP defines actual equipment capacity and provides information on modes of failure with respect to response spectra amplitudes and frequency of motion. Definitions of equipment capacity are more accurate with respect to frequency and mode of failure than can be established using the alternative methods. When equipment capacity is compared with the seismic demands at the various locations in which the equipment is to be installed, the equipment vulnerability, if any, can be clearly defined in terms of predicted mode of failure and frequency. The procedure provides information on how to protect the equipment, using isolation, strengthening, or stiffening. The use of CEFAPP requires peer review of proposed test motions, the test plan, and use of the data, by qualified Registered Design Professionals.

C-1.1.4.4 Qualification of Power Substation Equipment.

IEEE Recommended Practices for Seismic Design of Substations (IEEE 693-2005) provides detailed guidance for the qualification of equipment used in power substations. This guidance should be used for the qualification of this equipment even if installed at facilities other than substations (e.g., power plants).