

# UNIFIED FACILITIES CRITERIA (UFC)

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## DESIGN OF RISK CATEGORY V STRUCTURES, NATIONAL STRATEGIC MILITARY ASSETS



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**UNIFIED FACILITIES CRITERIA (UFC)**

**STRUCTURAL ENGINEERING**

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U.S. ARMY CORPS OF ENGINEERS

NAVAL FACILITIES ENGINEERING COMMAND (Preparing Activity)

AIR FORCE CIVIL ENGINEER CENTER

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

<b>Change No.</b>	<b>Date</b>	<b>Location</b>

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**This new UFC supersedes Chapter 4 of UFC 3-310-04, dated 1 June 2013 with change 1 of 20 June 2016.**

## FOREWORD

The Unified Facilities Criteria (UFC) system is prescribed by MIL-STD 3007 including the exemption process 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 Civil Engineer Center (AFCEC) are responsible for administration of the UFC system. Military Departments, the Defense Agencies, and the DoD Field Activities 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](#). 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/>.

Refer to UFC 1-200-01, *DoD Building Code (General Building Requirements)*, for implementation of new issuances on projects.

### AUTHORIZED BY:



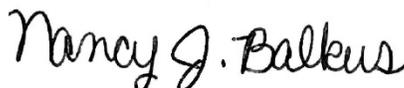
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## UNIFIED FACILITIES CRITERIA (UFC) REVISION SUMMARY SHEET

**Subject:** UFC 3-301-02, *Design of Risk Category V Structures, National Strategic Military Assets*

**Cancels:** UFC 3-310-04, *Seismic Design*, Change 1, 20 June 2016

### Description of Changes:

- This new UFC contains the seismic design provisions for DoD Risk Category V structures previously contained in retired UFC 3-310-04 (seismic design) Change 1, 20 June 2016. It also contains all other environmental loading criteria for DoD Risk Category V structures.
- This UFC adopts the structural design provisions of the 2018 *International Building Code* (2018 IBC) and the 2016 American Society of Civil Engineers Minimum Design Loads and Associated Criteria for Buildings and Other Structures (ASCE 7-16) for the design and renovation of DoD specific Risk Category V structures.

### Reasons for Changes:

- UFC 3-310-04, *Seismic Engineering* and UFC 3-301-01, *Structural Engineering*, have been merged into a single document – UFC 3-301-01, *Structural Engineering*, which contains seismic and nonseismic structural provisions for structures designated as Risk Category I through IV. Enhanced DoD Risk Category V provisions are now to be found solely in this UFC, which is purposed specifically for Risk Category V structures and includes all associated environmental loading in addition to seismicity (e.g. wind or flood).
- The updated UFC is designed to be consistent with and to supplement the guidance contained in 2018 IBC as modified by UFC 1-200-01.

**Impact:** There are negligible cost impacts.

**Non-Unified Items:** This document contains no non-unified items

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## CHAPTER 1 INTRODUCTION

### 1-1 PURPOSE AND SCOPE.

This Unified Facility Criteria (UFC) provides enhanced design requirements for Risk Category V (RC V) structures, national strategic military assets designed and constructed for the Department of Defense (DoD). These technical requirements are based on the 2018 *International Building Code* (2018 IBC) and the structural standard referenced by the 2018 IBC: ASCE/SEI 7-16 *Minimum Design Loads and Associated Criteria for Buildings and Other Structures* (hereafter referred to simply as ASCE 7-16).

This UFC must be used for the design and analysis of buildings and other structures assigned to Risk Category V.

RC V encompasses facilities that are considered to be national strategic military assets (see UFC 3-301-01 Table 2-2). Special design and analysis procedures apply to RC V buildings and other structures. Design RC V structures to ensure that their foundations, superstructures and installed mission-essential nonstructural elements remain elastic, and their installed equipment remains operational when subjected to severe environmental loading.

This UFC modifies provisions of the 2018 IBC and ASCE 7-16 for use in analyzing RC V buildings and structures. In cases where a provision in the 2018 IBC or ASCE 7-16 is not modified by this UFC, first apply UFC 3-301-01 and then apply UFC 1-200-01. If neither of these UFC documents modify the relevant provision then apply the 2018 IBC and ASCE 7-16 directly.

### 1-2 BACKGROUND.

UFC 1-200-01 uses and supplements 2018 IBC as the building code for DoD. UFC 3-301-01 further modifies the structural-specific design requirements of IBC and ASCE 7-16. The last edition of UFC 3-301-01, dated 1 June 2013 Change 3, 12 September 2016, contained only the non-seismic structural requirements, whereas the last edition of UFC 3-310-04, dated 1 June 2013 Change 1, 20 June 2016, contained the seismic requirements for structures. In its current edition, UFC 3-301-01 contains all structural requirements, both seismic and nonseismic, for structures assigned to Risk Category I, II, III, or IV. Only the enhanced seismic requirements for RC V structures are now contained in this UFC. These requirements were found in Chapter 4 of the last edition of UFC 3-310-04. The requirements have been revised to be consistent with the 2018 IBC and ASCE 7-16.

### 1-3 APPLICABILITY.

This UFC applies to all service elements and contractors involved in the planning, design and construction of DoD facilities worldwide that are assigned to Risk Category V.

### 1-4 CONFLICTS AND MODIFICATIONS.

The 2018 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, especially when the structures are national strategic military assets. In addition, the construction of military facilities outside the United States can introduce requirements that are not addressed in national model building codes. The provisions contained in this UFC are intended to fulfill the unique military requirements for RC V structures that are not found in the model building codes. When conflicts between the 2018 IBC or ASCE 7-16 and this UFC arise, the UFC prevails.

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 prevail. Notify the SER of where conflicts are discovered.

#### **1-5 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.

#### **1-6 OTHER CRITERIA.**

Military criteria other than those listed in this document may be applicable to specific types of structures. Such structures must meet the additional requirements of the applicable military criteria.

##### **1-6.1 General Building Requirements.**

Comply with UFC 1-200-01, DoD Building Code (General Building Requirements). UFC 1-200-01 provides applicability of model building codes and government unique criteria for typical design disciplines and building systems, as well as for accessibility, antiterrorism, security, high performance and sustainability requirements, and safety. Use this UFC in addition to UFC 1-200-01 and the UFCs and government criteria referenced therein.

##### **1-6.2 Structural Requirements.**

Comply with UFC 3-301-01, DoD Building Code (Structural Engineering). UFC 3-301-01 modifies certain structural provisions of the model building codes for the purpose of DoD structures. Use this UFC in addition to UFC 3-301-01 and the UFCs and government criteria referenced therein.

##### **1-6.3 Progressive Collapse Analysis and Design.**

Apply UFC 4-023-03, *Design of Buildings to Resist Progressive Collapse*, in the design of DoD buildings, if required by UFC 4-010-01, *DoD Minimum Antiterrorism Standards*

*for Buildings*. This UFC and UFC 4-023-03 both apply in that case. Design in accordance with one does not guarantee compliance with the other.

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## CHAPTER 2 DESIGN FOR ENHANCED RC V PERFORMANCE OBJECTIVES

### 2-1 DESIGN REVIEW.

#### 2-1.1 Structural Design Review.

A design review of the proposed seismic force-resisting system and associated structural analysis (calculations) must be conducted by an independent licensed Structural Engineer or Professional Engineer with at least 15 years of experience in the theory and application of nonlinear seismic analysis and structural behavior under extreme cyclic loads. Previous design experience must be commensurate in complexity to the project being reviewed. Selection of the design reviewer is subject to the review and approval of the AHJ and must be retained by the A/E design firm (DBB) or the General Contractor (DB). The design review must include, but is not necessarily 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; verification of post-earthquake operability 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.

#### **[C] 2-1.1 Structural Design Review**

An independent Structural Design Review is to be conducted at the contractor's expense. The structural design review should be started early in the design process to ensure that the seismic design of the RC V facility is performed to the satisfaction of the Structural Reviewer. The Structural Reviewer should create a comprehensive report documenting the findings for each of the tasks listed in this section. A detailed list of all documents that were evaluated should be included in the report. Each

evaluation should discuss how each topic was assessed, the criteria that were used for evaluation, a quantitative comparison of calculated response to allowable limits, and discussion on whether the criteria were satisfied. Additionally, the report should include discussion of critical element utilization ratios, the extent to which seismic effects govern the design of structural elements and how calculations and finite element (FE) models were evaluated, with a focus on modeling assumptions and boundary conditions.

The comprehensive report is to be signed and wet stamped by the structural reviewer and at a minimum must include:

1. Evaluation of Site Specific Seismic Hazard Analysis
  - a. Evaluation of development of site specific spectra
  - b. Evaluation of development of ground motion response histories
2. Evaluation of Seismic Force-Resisting System Response
  - a. Evaluation of seismic force-resisting system narrative
  - b. Evaluation of acceptance criteria for structural elements, including contributing and non-contributing structural elements
  - c. Evaluation of seismic calculations and analyses demonstrating that structure can withstand seismic force and deformation demands
3. Evaluation of development of in-structure response spectra
4. Evaluation of nonstructural component designation as MC-1, MC-2 and NMC.
  - a. Evaluation of the basis for determination of equipment designations to ensure owner/user intent has been considered and satisfied.
  - b. Provide concurrence with the list and designations
  - c. Review of draft Screening Evaluation Work Sheets (SEWS) for each MC-1 component.
  - d. Evaluation of procurement documents (statements of work, specifications, qualification criteria, etc.) for MC-1 and MC-2 architectural, mechanical, and electrical equipment and systems to ensure proper seismic qualification and labeling of equipment that must remain operable following the design earthquake.

## **2-1.2 Nonstructural Component Design Review.**

A review of the nonstructural component design (including anchorage) must be performed by an independent licensed structural engineer or professional engineer with at least 15 years of experience in the theory and application of nonlinear seismic analysis and structural behavior under extreme cyclic loads. Previous design experience must be commensurate in complexity to the project being reviewed.

Selection of the nonstructural component design reviewer is subject to the review and approval of the AHJ and must be retained by the A/E design firm (DBB) or the General Contractor (DB). The structural and non-structural component design review may be conducted by the same individual subject to the before noted qualifications. The non-structural component design review should occur prior to commissioning and should include, but not necessarily be limited to, the following:

1. Review of in-structure response data and confirmation that any recommendations made by the Structural Design Review have been incorporated into the in-structure response.
2. Review of component qualifications to confirm proper in-structure response was utilized.
3. Upon completion of design review of all documentation, the reviewer must 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 2-17.6
  - c. Component qualification documentation has been incorporated into the Operations & Maintenance Manual as specified in Section 2-17.5.

### **[C] 2-1.2 Nonstructural Component Design Review**

An independent nonstructural component design review is to be convened at the contractor's expense. The nonstructural component design review should be started early in the construction phase of the RC V project to ensure the contractor meets the requirements of the UFC to the satisfaction of the nonstructural reviewer. The nonstructural component reviewer should create a comprehensive report documenting completion of each of the tasks listed in this section. The report should include all required data, including but not limited to, photos, field notes, equipment tags and measurements. The report should also identify any variance to the Structural Design Review report and ultimately state whether criteria for Risk Category V has been satisfied.

The comprehensive report is to be signed and wet stamped by the nonstructural component design reviewer and at a minimum must include:

1. Review of anchorage design for all nonstructural components
2. Review of in-structure response data confirming that comments from the Structural Reviewer have been incorporated
3. Review of component qualification documents to ensure that the proper in-structure seismic demand was used

4. After completion of the design review activities listed above and before commissioning, the reviewer should perform a walk-down of the facility to confirm the following:

- a. Location of installed Mission Critical components
- b. Installation of identification nameplates as specified in Section 4-13.9 of this UFC
- c. Incorporation of component qualification documents into the O&M Manual as specified in Section 4-13.8 of this UFC

## **2-2 DEFINITIONS AND NOTATIONS.**

### **2-2.1 General.**

2018 IBC Section 202, as modified by UFC 3-301-01 and this section applies.

#### **ACTIVE FAULT**

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).

#### **WIND-BORNE DEBRIS REGION**

For locations within the United States and its territories and possessions, areas within hurricane-prone regions located:

1. Within 1 mile (1.61 km) of the coastal mean high water line where the basic design wind speed,  $V$ , is 130 mph (58 m/s) or greater; or
2. In areas where the basic design wind speed is 140 mph (63.6 m/s) or greater.

For locations outside of the United States and its territories and possessions, any region where either of the above two conditions apply.

The wind speeds referenced above are Risk Category V wind speeds.

#### **DESIGNATED SEISMIC SYSTEMS**

Those nonstructural components that require design in accordance with ASCE 7-16 Chapter 13. This designation applies to systems that are required to be operational following the  $MCE_R$  for RC V structures. All systems in RC V facilities designated as MC-1 (see Section 2-16.2) must be considered part of the Designated Seismic Systems.

## **2-3 CONSTRUCTION DOCUMENTS.**

**2-3.1 General.**

2018 IBC Section 1603, as modified by UFC 3-301-01, applies.

Exceptions:

1. The Seismic Importance Factor,  $I_e$ , the seismic response coefficient,  $C_s$ , the Response Modification Factor,  $R$ , and the Seismic Design Category do not apply and must not be listed in construction documents.
2. The classification of the building in RC V, that it is designed in accordance with the provisions of this UFC, and the date of this UFC, must be listed in construction documents.
3. Construction documents for architectural, mechanical, and electrical components must be prepared by a Registered Design Professional for all buildings assigned to RC V.

**2-4 GENERAL DESIGN REQUIREMENTS.**

**2-4.1 General.**

2018 IBC Section 1604, as modified by UFC 3-301-01, applies. UFC 3-301-01 Table 2-2 is to replace 2018 IBC Table 1604.5.

**2-4.2 Wind and Seismic Detailing.**

2018 IBC Section 1604.9 does not apply to RC V facilities.

**2-5 LOAD COMBINATIONS.**

**2-5.1 General.**

2018 IBC Section 1605 applies.

Exceptions:

1. For all load combinations, structural elements must be designed to remain linear (elastic).
2. In applying 2018 IBC Equations 16-5 and 16-7, the combined effect of earthquake forces,  $E$ , needs to be computed using the procedures outlined in this UFC.
3. 2018 IBC Section 1605.3 does not apply.

**2-6 DEAD LOADS.**

**2-6.1 General.**

2018 IBC Section 1606 applies.

## **2-7 LIVE LOADS.**

### **2-7.1 General.**

2018 IBC Section 1607, as modified by UFC 3-301-01, applies. Wherever Table 1607.1 is referenced in the IBC, it is to be replaced by Table G-1 of UFC 3-301-01.

## **2-8 SNOW AND ICE LOADS.**

### **2-8.1 General.**

Design snow loads are to be determined in accordance with 2018 IBC Section 1608, as modified by UFC 3-301-01. Design atmospheric ice loads on ice-sensitive structures are to be determined in accordance with ASCE 7-16 Chapter 10.

Exceptions:

1. In the determination of design snow loads for RC V structures using 2018 IBC Section 1608, the importance factor,  $I_s$ , is to be determined from UFC 3-301-01 Table 2-2
2. In the determination of design atmospheric ice loads for RC V structures using ASCE 7-16, the importance factor on ice thickness,  $I_i$ , is to be determined from UFC 3-301-01 Table 2-2. The importance factor for wind on ice,  $I_w$ , and the concurrent wind speed for RC V structures subject to wind on ice loads are to be the same as for RC IV structures as outlined in ASCE 7-16 Chapter 10.

### **2-8.2 Snow Load Case Studies.**

Snow load case studies may be done to clarify and refine snow loadings at site-specific locations with the approval of the AHJ. A site-specific study must be conducted if the ground snow load is greater than 50 psf (1.4KPa). The methodology used to conduct snow load case studies at site-specific locations is presented in the Cold Regions Research and Engineering Laboratory (CRREL) report "Database and Methodology for Conducting Site Specific Snow Load Case Studies for the United States."

## **2-9 WIND LOADS.**

### **2-9.1 Design Wind Speeds Inside and Outside of the United States.**

Basic design wind speeds for Risk Category V are for a return period of 10,000 years and can be found for specific installations inside and outside of the United States using the structural load data tool hosted on the Whole Building Design Guide website at:

<https://www.wbdg.org/additional-resources/tools/ufcsldt>

At locations where the basic design wind speed is not provided contact the AHJ for further guidance.

## **2-10 SOIL LATERAL LOADS.**

### **2-10.1 General.**

2018 IBC Section 1610 applies except as follows: The noted exception in section 1610.1 to allow the use of active soil pressure under certain conditions is disallowed for RC V structures.

## **2-11 RAIN LOADS.**

### **2-11.1 General.**

2018 IBC Section 1611 applies.

## **2-12 FLOOD LOADS.**

### **2-12.1 General.**

2018 IBC Section 1612 applies.

Exceptions:

1. The **DESIGN FLOOD** is to be defined as a flood with a 2 percent chance of exceedance in 50 years (2500-year mean return interval).
2. The **FLOOD HAZARD AREA** is to be defined as the area within a flood plain subject to a 2 percent chance of flood exceedance in 50 years (2500-year mean return interval). A probabilistic flood hazard analysis must be performed where a facility does not clearly fall outside of said area by inspection.

## **2-13 TSUNAMI LOADS.**

### **2-13.1 General.**

Section 2-4.7 of UFC 3-301-01 applies.

## **2-14 EXISTING BUILDINGS.**

### **2-14.1 Seismic Evaluation and Retrofit.**

RC V structures must be designed to ensure that during the  $MCE_R$  their superstructures and installed mission-essential non-structural elements remain elastic, and following the  $MCE_R$  their installed equipment remains operational. ASCE 41 is not to be used for evaluating existing buildings that are classified as RC V facilities. For any evaluations of existing RC V buildings, the analysis procedures of this UFC apply. All strengthening

of existing buildings and additions to existing buildings that must satisfy RC V performance requirements need to satisfy the requirements of this UFC.

## **2-15 EARTHQUAKE LOADS.**

### **2-15.1 Structural Design Criteria.**

Each RC V structure is to be designed in accordance with the provisions of this Chapter. Permissible structural systems are listed in Table 2-1. 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 is to be provided with complete seismic and vertical force-resisting systems capable of providing adequate strength and stiffness to withstand the design earthquake ground motions determined in accordance with Section 2-15.2, within the prescribed deformation limits of Section 2-16.9. The design ground motions are to 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 must be provided.

### **2-15.2 Seismic Ground Motion Values.**

#### **2-15.2.1 Development of $MCE_R$ Spectral Response Accelerations and Response History Criteria.**

The Site Specific Ground Motion Procedures outlined in ASCE 7-16 Section 11.4.8 is to be used to develop  $MCE_R$  ground motion acceleration time histories for RC V structures. The  $MCE_R$  can 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 Reviewer (see Section 2-1.1). In the application of seismic provisions of the 2018 IBC and ASCE 7-16, the terms  $S_{DS}$  and  $S_{D1}$  are to be replaced by  $S_{MS}$  and  $S_{M1}$ , respectively, obtained from this response spectrum.

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

**Table 1-1 Systems Permitted for Risk Category V Buildings**

<b>Basic Seismic Force-Resisting System</b>	<b>Detailing Requirements</b>
<b>Bearing Wall Systems</b>	
Ordinary reinforced concrete shear walls	ACI 318, excluding Ch. 18
Ordinary reinforced masonry shear walls	TMS 402
<b>Building Frame Systems</b>	
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. 18
Composite steel and concrete eccentrically braced frames	AISC 360 (LRFD) and ACI 318, excluding Ch. 18
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	TMS 402
<b>Moment-Resisting Frame Systems</b>	
Ordinary steel moment frames	AISC 360
Ordinary reinforced concrete moment frames	ACI 318, excluding Ch. 18
Ordinary composite moment frames	AISC 360 (LRFD) and ACI 318, excluding Ch. 18
Composite partially restrained moment frames	
<b>Cantilevered Column Systems Detailed to Conform to the Requirements for:</b>	
Ordinary steel moment frames	AISC 360
Ordinary reinforced concrete moment frames	ACI 318, excluding Ch. 18

Note: Any system prohibited here may be permitted if approved by the Structural Design Reviewer (Section 2-1.1).

At least seven 3-component ground motions must be selected and scaled from individual recorded events for in-structure response analysis. The histories must be selected from events having magnitudes, fault distances, and source mechanisms that are consistent with those that control the  $MCE_R$  for the RC V structure. Ground motion

records are to be sourced from stations with similar soil profiles, defined in terms of Site Class, to that at the site of the RC V structure. The shape of the spectra of the recorded motions must be similar to that of the target spectra.

## **2-15.2.2 Design Response Spectrum.**

### **2-15.2.2.1 Design Horizontal Response Spectrum.**

The unreduced  $MCE_R$  ground motions determined from the Site Specific Ground Motion Procedure are to be used.

### **2-15.2.2.2 Design Vertical Response Spectrum.**

The unreduced  $MCE_R$  ground motions determined from the Site Specific Ground Motion Procedure are to be used. The vertical spectrum values,  $S_{aMv}$ , cannot be lower than the minimum ordinates determined from ASCE 7-16 Section 11.9.2. Ground motions for calculating the minimum ordinates are to be the site-specific  $MCE_R$  ground motions determined in 2-15.2.2.1. The 'Gulerce Abrahamson Method' may also be used for deriving vertical acceleration if conditions for the method are met.

## **2-15.3 Importance Factor and Risk Category.**

### **2-15.3.1 Importance Factor.**

A seismic importance factor is not required for RC V buildings and other structures (see UFC 3-301-01 Table 2-2). However, some referenced sections of ASCE 7-16 require the use of  $I_e$ . In these cases,  $I_e$  is to be taken as 1.0.

#### **[C] 2-15.3.1 Importance Factor**

The provisions of this UFC are for designing RC V structures only. The seismic loads required in this UFC already take into account the critical nature of these structures, and as a result, are set to a very high level, which is reflected in the fact that these structures are designed to remain elastic during an MCE-level event. For this reason, application of an importance factor is not required.

## **2-15.4 Seismic Design Category.**

The requirements of ASCE 7-16 Section 11.6 do not apply to RC V structures.

### **2-15.4.1 Design Requirements for Seismic Design Category A.**

The requirements of ASCE 7-16 Section 11.7 do not apply to RC V structures.

## **2-15.5 Geological Hazards and Geotechnical Investigation.**

### **2-15.5.1 Site Limitations for Risk Category V.**

A structure assigned to RC V must 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 2-2.1 of this UFC.

## **2-16 SEISMIC DESIGN REQUIREMENTS FOR BUILDING STRUCTURES.**

### **2-16.1 Structural System Selection.**

#### **2-16.1.1 Selections and Limitations.**

Table 2-1, *Systems Permitted for Risk Category V Buildings*, is to be used to determine whether a seismic force-resisting system is permitted for use in an RC V structure. Exceptions may be authorized when permission is granted by the Structural Design Reviewer (see Section 2-1.1).

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

#### **2-16.1.2 Combinations of Framing Systems.**

Combinations of permitted structural systems (see Table 2-1) 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 is to be provided by the combination of the different systems in proportion to their stiffness. Displacements of parallel framing systems must be shown by analysis to be compatible.

#### **2-16.1.3 $R$ , $C_d$ , and $\Omega_0$ Values for Vertical and Horizontal Combinations.**

The design of RC V structures must use a linear elastic Modal Response Spectrum Analysis (MRSA) procedure. Structural response is to be restricted to elastic behavior. No yielding is to be permitted for the  $MCE_R$  ground motions. The factors  $R$ ,  $C_d$ , and  $\Omega_0$  are to be set to 1.0.

#### **[C] 2-16.1.3 $R$ , $C_d$ , and $\Omega_0$ Values for Vertical and Horizontal Combinations**

The factors  $R$ ,  $C_d$ , and  $\Omega_0$  are meant to model the inelastic properties of a structure that is designed to resist an MCE-level seismic event through inelastic deformations. In contrast, structures assigned to RC V are designed to remain elastic during an MCE-level event. As a result, these three seismic factors are irrelevant for the design of RC V structures.

### **2-16.2 Diaphragm Flexibility, Configuration Irregularities, and Redundancy.**

#### **2-16.2.1 Irregular or Regular Classification and Limitations and Additional Requirements for Systems with Structural Irregularities.**

ASCE 7-16 Sections 12.3.2 and 12.3.3 do not apply.

**[C] 2-16.2.1 Irregular or Regular Classification and Limitations and Additional Requirements for Systems with Structural Irregularities.**

Because buildings assigned to RC V are designed to respond to  $MCE_R$  ground shaking in an elastic manner, and they are required to be analyzed by procedures that adequately account for any structural irregularity, it is not necessary to classify RC V buildings as regular or irregular. In addition, any design provisions intended to account for structural irregularities need not apply.

**2-16.2.2 Redundancy.**

ASCE 7-16 Section 12.3.4 applies. For the purpose of determining the redundancy factor  $\rho$ , assume the seismic design category to be D; for definition of extreme torsional irregularity, refer to ASCE 7-16 Table 12.3-1. Structural systems with a redundancy factor,  $\rho$ , equal to 1.3 are not permitted.

**2-16.2.3 Upward force for Horizontal Cantilevers.**

Vertical seismic forces are to be computed from the vertical spectral accelerations specified in this Chapter. The minimum vertical force in ASCE 7-16 Section 12.4.4 applies.

**2-16.3 Direction of Loading.**

**2-16.3.1 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 must 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 must be used, so that all values are additive. If the three quantities are designated  $E_x$ ,  $E_y$ , and  $E_z$ , they are to be combined in accordance with Equations 2-1, 2-2, and 2-3, and the maximum response,  $E_{T-max}$ , is to be the most severe effects of Equations 2-1, 2-2, or 2-3, for each individual structural element:

$$E_T = \pm [1.0 E_x + 0.4 E_y + 0.4 E_z] \quad \text{(Equation 2-1)}$$

$$E_T = \pm [0.4 E_x + 1.0 E_y + 0.4 E_z] \quad \text{(Equation 2-2)}$$

$$E_T = \pm [0.4 E_x + 0.4 E_y + 1.0 E_z] \quad \text{(Equation 2-3)}$$

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

## **2-16.4 Analysis Procedure Selection.**

### **2-16.4.1 General Requirements.**

Structures assigned to RC V must be designed to ensure that their superstructures and installed mission-critical nonstructural elements remain elastic, when subjected to  $MCE_R$  ground motions, and that mission-essential equipment remains operable immediately following the  $MCE_R$  ground motions.  $MCE_R$  spectral acceleration parameters must be based on the procedures outlined in Section 2-15.2. In all analyses performed using the provisions of this Chapter, the variables  $R$ ,  $C_d$ ,  $\rho$  and  $\Omega_0$  are all to be set to 1.0, as indicated in Section 2-16.1.3 of this UFC.

### **2-16.4.2 Horizontal and Vertical Force Determination.**

Except for seismically isolated structures and structures using supplemental damping, structural analysis for horizontal and vertical force determination must be accomplished using a combined three-dimensional linear elastic Modal Response Spectrum Analysis (MRSA) in accordance with the provisions of ASCE 7-16 Sections 12.7.3 and 12.9.1. Refer to Section 2-15.3.1 for application of the Importance Factor,  $I_e$ , in ASCE 7-16 Section 12.9.1. Modal values are to be combined in accordance with the provisions of ASCE 7-16 Section 12.9.1.3. Further information on the use of the MRSA can be found in ASCE 4-16, *Seismic Analysis of Safety-Related Nuclear Structures*. For the ground motion component associated with each horizontal plan dimension of the structure, applied forces are to be determined using linear horizontal response spectra that are developed in accordance with the provisions of Sections 2-15.2.1 and 2-15.2.2.1.

For the ground motion component associated with the vertical axis of the structure, applied forces are to be determined using linear vertical response spectra that are developed in accordance with the provisions of Sections 2-15.2.1 and 2-15.2.2.2.

Exception: For structures using seismic isolation and/or supplemental damping, horizontal and vertical seismic forces must 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 7-16 Section 17.6 are to be used for the nonlinear analyses, except that vertical ground motions need to be included in the analyses.

### **2-16.4.3 Member Forces.**

Response in structural elements and nonstructural elements that directly support critical functions must remain linear for the  $MCE_R$  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.

#### **2-16.4.3.1 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 2-1. Alternatives may be used, if they are verified adequately through analysis and are approved by the Structural Design Reviewer (see Section 2-1.1).

#### **2-16.4.3.2 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 2-1. Where *damping systems* are used, they must be designed, tested, and constructed in accordance with the requirements of ASCE 7-16 Chapter 18. Analysis must conform to the requirements of ASCE 7-16 Section 18.7.1, 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 Reviewer (see Section 2-1.1).

#### **2-16.4.3.3 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 2-1. In such situations, ASCE 7-16 Chapter 17 must 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 Reviewer (see Section 2-1.1).

Exception: ASCE 7-16 Chapter 17 requires the use of the factor  $R_I$  for scaling the forces for structural elements above the isolation system. For RC V structures, the  $R_I$  factor is to be taken as 1.0. Table 2-1 must be used for selecting the structural system.

### **2-16.5 Equivalent Lateral Force Procedure.**

The application of ASCE 7-16 Section 12.8 is not permitted for RC V structures.

### **2-16.6 Modal Response Spectrum Analysis.**

#### **2-16.6.1 Modal Response Parameters.**

Story drifts must be computed using a linear elastic MRSA procedure (see Section 2-16.4.2). Story drifts and P-Delta effects are to be determined using the procedures outlined in ASCE 7-16 Section 12.9.1. Refer to Section 2-15.3.1 for application of Importance Factor,  $I_e$ , in this section.

## **2-16.7 Diaphragms, Chords, and Collectors.**

Diaphragm, chords, and collectors must be designed in accordance with ASCE 7-16 Section 12.10.

### **2-16.7.1 Design by ASCE 7-16 Sections 12.10.1 and 12.10.2.**

When diaphragm forces are determined from Section 12.10.1, apply a multiplier of 3 to the force at the uppermost level and design the diaphragm at each floor level for that force. The same adjustment apply to the design of collector elements by ASCE 7-16 Section 12.10.2.

ASCE 7-16 Section 12.10.1.1, is to be modified to delete the maximum force limit ( $0.4S_{DS}/eW_{px}$ ) that is placed on Equation 12.10-1.

#### **[C] 2-16.7.1 Diaphragms, Chords, and Collectors**

The above adjustments are intended to ensure that diaphragm behavior will remain elastic all the way up to the  $MCE_R$ . There are ample indications that the diaphragm design force levels of ASCE 7-16 Section 12.10.1 do not result in elastic diaphragm behavior even in the Design Basis Earthquake (DBE). The suggested modifications are adapted from the manual: Seismic Design of Precast/Prestressed Concrete Structures (PCI MNL-140, 2nd Edition) and the PCI Design Handbook (7th Edition) published by the Precast/Prestressed Concrete Institute (PCI). The multiplier assumes that shear walls or braced frames form part of the seismic force-resisting system, which is typical of RC V structures.

ASCE 7-16 Section 12.10.3 was introduced to address the above problem, which led to the addition of Section 2-16.7.2 of this UFC.

### **2-16.7.2 Design by ASCE 7-16 Sections 12.10.3.**

When the alternative design provisions of ASCE 7-16 Section 12.10.3 are used, the ground motion parameters  $S_{DS}$  and  $S_{D1}$  are to be replaced by  $S_{MS}$  and  $S_{M1}$ , respectively. Diaphragm design force reduction factor,  $R_s$ , is to be taken as 1.0. The collector elements must be designed using ASCE 7-16 Section 12.10.3.4.

## **2-16.8 Structural Walls and Their Anchorage.**

### **2-16.8.1 Design for Out-of-Plane Forces and Anchorage of Structural Walls and Transfer of Design Forces into Diaphragms.**

Unless otherwise specified in this Chapter, transmitted seismic force,  $F_p$ , must be the maximum of  $F_p$  calculated in accordance with the provisions of ASCE 7-16 Section 12.11.2 and the actual forces computed using the procedures of this Chapter. The value of  $S_{MS}$  is to be used in lieu of  $S_{DS}$  in the equation for  $F_p$  in ASCE 7-16 Section 12.11.2. ASCE 7-16 lower-bound value for wall anchorage forces must be revised to  $0.3k_a I_e W_p$ . Refer to Section 2-15.3.1 for application of Importance Factor,  $I_e$ , in this section.

## **2-16.9 Drift and Deformation.**

### **2-16.9.1 Story Drift Limit.**

The design story drift ( $\Delta$ ) must not exceed the allowable story drift ( $\Delta_a$ ) for RC IV structures in ASCE 7-16 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 govern.

### **2-16.9.2 Deformational Compatibility.**

ASCE 7-16 Section 12.12.5 does not apply.

## **2-17 SEISMIC DESIGN REQUIREMENTS FOR NONSTRUCTURAL COMPONENTS.**

### **2-17.1 General.**

#### **2-17.1.1 Scope.**

The provisions of ASCE 7-16 Chapter 13, as modified by UFC 3-301-01, apply, except as noted in the following paragraphs. Appendix D of UFC 3-301-01 provides supplementary guidance on design and analysis of architectural, mechanical, and electrical components. Appendix E of UFC 3-301-01 provides supplementary guidance on certification of mechanical and electrical components.

### **2-17.2 General Design Requirements.**

#### **2-17.2.1 General Requirements.**

All architectural, mechanical, and electrical components must be designed for the in-structure horizontal and vertical response spectra developed in Section 2-17.4.4. Designs must include bracing, anchorage, isolation, and energy dissipation, as appropriate, for all components, in addition to the components themselves. Motion amplifications through component supports must be determined and accommodated through design. Installed architectural, mechanical, and electrical components are to be classified as Mission-Critical Level 1 (MC-1), Mission-Critical Level 2 (MC-2), or Non-mission-critical (NMC). The structural engineer must classify all architectural,

mechanical, and electrical components, in consultation with functional risk representatives designated by the AHJ.

Unless specifically noted otherwise in this UFC, any ASCE 7-16 Chapter 13 provision that is specific to RC IV structures must also be applied to RC V structures. Where ASCE 7-16 Chapter 13 requirements are based on the SDC of a structure, determine SDC assuming RC to be IV.

#### **2-17.2.2 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  $MCE_R$  ground shaking. MC-1 components are part of the Designated Seismic System and as such must be certified as operable immediately following the  $MCE_R$  ground shaking in accordance with the provisions of ASCE 7-16 Section 13.2.2 as modified by UFC 3-301-01.

Exception: When shake table testing is performed, the Required Response Spectra (RRS) is not permitted to be derived using ICC-ES AC156.

#### **2-17.2.3 Mission-Critical Level 2 Components.**

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

#### **2-17.2.4 Non-Mission-Critical Components.**

NMC components are those architectural, mechanical, and electrical components that may incur damage in the  $MCE_R$  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 must be classified the same as the corresponding MC-1 or MC-2 component. NMC components must be designed so they will not cause falling hazards or impede facility egress. Typical NMC components may include bathroom vent fans, space heaters, etc.

#### **2-17.2.5 Component Qualification Documentation.**

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

1. The engineering submittal containing 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. For MC-1 components, 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 must be checked and signed by the designer and checker.

The designer must affix his/her Professional Engineer seal on the cover page.

The cover page must 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 MC-1 equipment/component and accompanying Special Inspection of any post-installed anchorages or Special Inspection of components identifying the Special Inspector. Consideration must 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: <https://ehss.energy.gov/au/seismic/>. Other evaluation worksheets can be used upon approval by the Authority Having Jurisdiction.

4. For MC-1 components, documentation of the independent “walk-down” inspection of the equipment in the final installed condition.

## **2-17.3 Seismic Demands on Nonstructural Components.**

### **2-17.3.1 Seismic Design Force.**

In the application of ASCE 7-16 Section 13.3.1, seismic forces are to be analyzed for the  $MCE_R$  ground motion parameters. The force calculations found in ASCE 7-16 Equations 13.3-1 through 13.3-3 do not apply. The following procedures must be used.

#### **2-17.3.1.1 MC-1 Components.**

Forces for MC-1 components are to be determined by response spectrum analysis or equivalent static analysis, using as input the in-structure response spectra determined in accordance with Section 2-17.4.4. MC-1 components and their supports must remain elastic. MC-1 component forces are to be determined using Equation 2-4, with  $R_p$  for both components and supports set to 1.0.

$$F_p = \frac{a_{ip}W_p}{R_p} \quad \text{(Equation 2-4)}$$

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

### 2-17.3.1.2 MC-2 Components.

Forces for MC-2 components are to be determined by response spectra analysis or equivalent static analysis, using as input the in-structure response spectra developed in accordance with Section 2-17.4.4. MC-2 component supports must remain elastic, while limited inelastic component response is permitted. MC-2 component forces are to be determined using Equation 2-4, with  $R_p$  for supports set to 1.0, and  $R_p$  for components as specified in ASCE 7-16 Tables 13.5-1 and 13.6-1.

### 2-17.3.1.3 NMC Components.

ASCE 7-16 Equation 13.3-4 must be used for NMC component force calculations. The peak in-structure floor acceleration determined in accordance with Section 2-17.4.4 is to 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 7-16 Equation 13.3-4, the values of  $a_p$  and  $R_p$  specified in ASCE 7-16 Tables 13.5-1 and 13.6-1 are to be used. The component importance factor,  $I_p$ , is required for force calculations in ASCE 7-16 Equation 13.3-4.  $I_p$  is to be taken as 1.0, in lieu of the importance factors listed in ASCE 7-16 Sections 13.1.3.

## 2-17.4 Response Analysis Procedures for Architectural, Mechanical, and Electrical Components.

### 2-17.4.1 General.

ASCE 4-16, *Seismic Analysis of Safety-Related Nuclear Structures*, is to serve as a reference in response analysis.

### 2-17.4.2 Dynamic Coupling Effects.

It is anticipated that installed mechanical and electrical systems may require significant secondary structural systems in RC V buildings. The provisions of ASCE 4-16 Section 3.7, *Dynamic Coupling Criteria*, apply.

#### **2-17.4.3 Modeling Flooring Systems.**

Structures with rigid flooring systems are to be modeled in accordance with the provisions of ASCE 4-16 Section 3.8.1.1, *Structures with Rigid Floor Diaphragms*. Structures with flexible flooring systems are to be modeled in accordance with the provisions of ASCE 4-16 Section 3.8.1.2, *Structures with Flexible Floor Diaphragms*.

#### **2-17.4.4 In-structure Response Spectra.**

Provisions of ASCE 4-16 Section 6, *Input for Subsystem Analysis*, 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 must be developed from models of primary structures subjected to  $MCE_R$  ground motions. Frequency interval of the response spectra is to be set based on Section 6.2.2. However, the lower-bound frequency is to be set at 0.1 Hz. Increments above 34 Hz are to be at 3 Hz and increments below 0.5 Hz are to be at 0.10 Hz.

Exception: In the application of ASCE 4-16 Section 6, those provisions that relate to spectra-to-spectra analysis in Section 6.2.1.2 do not apply.

#### **2-17.5 Design of Architectural Components.**

##### **2-17.5.1 Suspended Ceilings.**

In addition to the provisions of ASCE 7-16, as modified by UFC 3-301-01, suspended ceilings are to 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 2-18.4) to ensure splay wires are taut. Positive attachment is required to be provided to prevent vertical movement of ceiling elements. Vertical support elements need to be capable of resisting both compression and tensile forces. Vertical supports and braces designed for compression must have a slenderness ratio,  $K/r$ , of less than 200. Additional guidance on suspended ceiling design is provided in Section D-2.3.8 of UFC 3-301-01.

#### **2-17.6 Design of Mechanical and Electrical Components.**

##### **2-17.6.1 Seismic Controls for Elevators.**

For buildings that are assigned to RC V, seismic switches are not permitted to be used. Elevator system design for RC V buildings must ensure elevator operability at accelerations computed in building response modeling. Additional guidance on the design of elevator systems is found in Section D-3.4 3 of UFC 3-301-01.

## **2-17.7 Component Qualification Documentation and O&M Manual.**

All MC-1 and MC-2 equipment qualification documentation as outlined in Section 2-17.2.5 must be maintained in a file identified as "Mission Critical Components and Equipment Qualifications Manual" that is to 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 to state that replaced or modified components need to be qualified per the original qualification criteria.

## **2-17.8 Component Identification Nameplate.**

All MC-1 and MC-2 equipment must bear permanent marking or nameplates constructed of a durable heat and water resistant material. Nameplates must be mechanically attached to all nonstructural components and placed on the component for clear identification. The nameplate must 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 must 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 must also contain the component identification number in accordance with the drawings/specifications and the O&M manuals. Continuous piping, and conduits must be similarly marked as specified in the contract documents.

## **2-18 SPECIAL INSPECTIONS AND TESTS.**

### **2-18.1 General.**

2018 IBC Chapter 17, as modified by UFC 1-200-01 and UFC 3-301-1, apply to RC V buildings.

### **2-18.2 Structural Observations for Seismic Resistance.**

Replace Item 1 of 2018 IBC Section 1704.6.2 with the following:

1 - The structure is classified as Risk Category V in accordance with Table 2-2 of UFC 3-301-01.

### **2-18.3 Special Inspections for Seismic Resistance.**

Add the following before the paragraph in 2018 IBC Section 1705.12:

Special Inspections itemized in Sections 1705.12.1 through 1705.12.9 apply to structures assigned to Risk Category V.

### **2-18.4 Plumbing, Mechanical and Electrical Components.**

Add the following before the paragraph in 2018 IBC Section 1705.12.6:

Special inspection and verification are required for Designated Seismic Systems and are to be performed as required by this section and Table 2-3 of UFC 3-301-01.

The Registered Design Professional in Responsible Charge must prepare a Statement of Special Inspections in accordance with Section 1704 for the Designated Seismic Systems. A template for the Statement of Special Inspections is provided at:

[https://www.wbdg.org/FFC/NAVGRAPH/Statement\\_of\\_Special\\_Inspections.xlsx](https://www.wbdg.org/FFC/NAVGRAPH/Statement_of_Special_Inspections.xlsx)

The Statement of Special Inspections is required to define the periodic walk-down inspections that must be performed to ensure that the nonstructural elements satisfy life safety mounting requirements. The walk-down inspections must be performed by design professionals who are familiar with the construction and installation of mechanical and electrical components, and their vulnerabilities to earthquakes. The selection of the design professional is subject to the approval of the AHJ.

Designated Seismic Systems are to require a final walk-down inspection by the Registered Design Professional in Responsible Charge and by the Nonstructural Component Design Reviewer (see Section 2-1.2). The final review must be documented in a report. The final report prepared by the Registered Design Professional in Responsible Charge needs to include the following:

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

### **2-18.5 Testing for Seismic Resistance.**

Add the following before the first paragraph in 2018 IBC Section 1705.13:

Any requirements for structural testing for structures assigned to Seismic Design Category C or higher also apply to structures assigned to Risk Category V.

## **2-19 SOILS AND FOUNDATIONS.**

The provisions of 2018 IBC Chapter 18 apply to RC V buildings, except the minimum Chapter 18 provisions applied are to be those required for SDC D structures. In addition, the requirement in the following paragraph applies.

### **2-19.1 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 is to be

responsible for evaluating foundation overturning and rocking in the design analysis, and this evaluation must be reviewed by the Structural Design Reviewer (see Section 2-1.1).

CANCELLED

## APPENDIX A REFERENCES

### GOVERNMENT PUBLICATIONS:

Department of Defense  
1090 Vermont Avenue, NW, Suite  
700 | Washington, DC 20005-4950  
<http://dod.wbdg.org/>

UFC 1-200-01, *DoD Building Code (General Building Requirements)*, 2016 Edition

UFC 3-301-01, *Structural Engineering*, 2018 Edition [verify title and date]

UFC 4-010-01, *DoD Minimum Antiterrorism Standards for Buildings*, 2012 Edition

UFC 4-023-03, *Design of Buildings to Resist Progressive Collapse*, 2009 Edition

U.S. Department of Energy  
1000 Independence Ave., SW  
Washington, DC 20585  
<http://energy.gov/ehss/doeeh-0545-seismic-evaluation-procedure-equipment-us-department-energy-facilities-1997>

DOE STD 1020, *Natural Phenomena Hazards Design and Evaluation Criteria for Department of Energy Facilities*, 2016

### NON-GOVERNMENT PUBLICATIONS:

American Concrete Institute  
38800 Country Club Dr.  
Farmington Hills, MI 48331-3439  
<http://www.concrete.org/>

ACI 318, *Building Code Requirements for Structural Concrete*, 2014 Edition

American Institute of Steel  
Construction  
One East Wacker Drive, Suite 700  
Chicago, IL 60601-1802  
<http://www.aisc.org/>

AISC 360, *Specification for Structural Steel Buildings*, 2016 Edition

American Society of Civil Engineers  
1801 Alexander Bell Dr,  
Reston, VA 20191  
<http://www.asce.org>

ASCE 7, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*, 2016 Edition

ASCE/SEI 43, *Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities*, 2005 Edition

ASCE 4, *Seismic Analysis of Safety-Related Nuclear Structures*, 2016 Edition

Cold Regions Research and Engineering Laboratory  
72 Lyme Road  
Hanover, New Hampshire  
<http://www.erdc.usace.army.mil/locations/ColdRegionsResearchandEngineeringLaboratory.aspx>

*Database and Methodology for Conducting Site Specific Snow Load Case Studies for the United States*

International Code Council  
500 New Jersey Ave.  
NW, 6<sup>th</sup> Floor  
Washington, DC 20001  
<http://www.iccsafe.org/>

*International Building Code* , 2018 Edition

Precast/Prestressed Concrete Institute  
200 West Adams Street, #2100  
Chicago, IL 60606-6938  
<http://www.pci.org>

PCI MNL-120, *Design Handbook*, 7<sup>th</sup> Edition, 2010

PCI MNL-140, *Seismic Design of Precast/Prestressed Concrete Structures*, 2<sup>nd</sup> Edition, 2012

The Masonry Society  
105 South Sunset St., Suite Q  
Longmont, CO 80501-9215  
<http://www.masonrysociety.org>

Masonry Standard Joint Committee's (MSJC), TMS 402-16, TMS 602-13/ACI 530.1-13/ASCE 6-13, *Building Code Requirements and Specification for Masonry Structures*