UFC 3-301-02
11 April 2023
Change 1, 25 February 2025

UNIFIED FACILITIES CRITERIA (UFC)

DESIGN OF RISK CATEGORY V STRUCTURES, NATIONAL STRATEGIC MILITARY ASSETS

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UNIFIED FACILITIES CRITERIA (UFC)

DESIGN OF RISK CATEGORY V STRUCTURES, NATIONAL STRATEGIC MILITARY ASSETS

U.S. ARMY CORPS OF ENGINEERS

NAVAL FACILITIES ENGINEERING SYSTEMS COMMAND (Preparing Activity)

AIR FORCE CIVIL ENGINEER CENTER

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

Change No.	Date	Location
1	Feb 25, 2025	See Change Summary

This UFC supersedes UFC 3-301-02, dated 3 March 2020.

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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, its territories, and possessions 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 Military Department's responsibility for providing technical criteria for military construction. Headquarters, U.S. Army Corps of Engineers (HQUSACE), Naval Facilities Engineering Systems Command (NAVFAC), and Air Force Civil Engineer Center (AFCEC) are responsible for administration of the UFC system. Technical content of UFC is the responsibility of the cognizant DoD working group. Defense Agencies should contact the respective DoD Working Group for document interpretation and improvements. Recommended changes with supporting rationale should be sent to the respective DoD working group by submitting a Criteria Change Request (CCR) via the Internet site listed below.

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

- Whole Building Design Guide website https://www.wbdg.org/dod.

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

AUTHORIZED BY:

PETE G. PEREZ, P.E., SES
Chief, Engineering and Construction
U.S. Army Corps of Engineers

R. DAVID CURFMAN, P.E., SES
Chief Engineer
Naval Facilities Engineering Systems Command

DAVID H. DENTINO, SES
Deputy Director of Civil Engineers
DCS/Logistics, Engineering &
Force Protection (HAF/A4C)
HQ United States Air Force

MICHAEL McANDREW, SES
Deputy Assistant Secretary of Defense
(Construction)
Office of the Secretary of Defense

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UNIFIED FACILITIES CRITERIA (UFC)
REVISION SUMMARY SHEET

Document: UFC 3-301-02, Change 1, Dated February 25, 2025
Superseding: UFC 3-301-02, Dated April 11, 2023

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Description of changes
-Adoption of the 2024 I-codes
-Adoption of ASCE 7-22, Minimum Design Loads and Associated Criteria for Buildings and Other Structures

Reason for changes:
Maintain concurrence with model building codes and alignment with DoD building code (1 200 01).

Impact:
Typical of the code update cycle.
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CHAPTER 1 INTRODUCTION

1-1 BACKGROUND.

UFC 1-200-01 uses and supplements 2024 IBC as the building code for DoD. UFC 3-301-01 contains all structural requirements for structures assigned to Risk Category I, II, III, or IV. Only the enhanced structural requirements for RC V structures are contained in this UFC. These enhanced requirements are revised to be consistent with the 2024 IBC and ASCE 7-22.

1-2 REISSUE AND CANCELS.

This edition of UFC 3-301-02 cancels UFC 3-301-02 dated 3 March 2020.

1-3 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 2024 *International Building Code* (2024 IBC) and the structural standard referenced by the 2024 IBC: ASCE/SEI 7-22 *Minimum Design Loads and Associated Criteria for Buildings and Other Structures* (hereafter referred to simply as ASCE 7-22).

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

RC V - is assigned to 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 2024 IBC and ASCE 7-22 for use in analyzing RC V buildings and structures. In cases where a provision in the 2024 IBC or ASCE 7-22 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 modifies the relevant provision, then apply the 2024 IBC and ASCE7-22 directly.

1-4 APPLICABILITY.

This UFC follows the same applicability as UFC 1-200-01, paragraph 1-3, with no exceptions.

1-5 CONFLICTS AND MODIFICATIONS.

The 2024 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 2024 IBC or ASCE 7-22 and this UFC arise, this 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 apply. Notify the SER of where conflicts are discovered.

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 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.

1-7.1 General Building Requirements.

Comply with UFC 1-200-01, *DoD Building Code*. 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.

1-7.2 Structural Requirements.

Comply with UFC 3-301-01, *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.

1-7.3 Progressive Collapse Analysis and Design.

Apply UFC 4-023-03, *Design of Buildings to Resist Progressive Collapse*.

1-7.4 Cybersecurity.

All facility-related control systems (including systems separate from a utility monitoring and control system) must be planned, designed, acquired, executed, and maintained in accordance with UFC 4-010-06, and as required by individual Service Implementation Policy.

1-8 REFERENCES.

APPENDIX A contains a list of references used in this document. The publication date of the code or standard is not included in this document. Unless otherwise specified, the most recent edition of the referenced publication applies.

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CHAPTER 2 DESIGN FOR ENHANCED RC V PERFORMANCE OBJECTIVES

2-1 DESIGN REVIEW.

2-1.1 Independent 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 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. The Independent Reviewer shall not be an employee of, or affiliated with, the design entity. The independent design reviewer must have previous real world design experience commensurate in complexity to the project being reviewed. Selection of the independent design reviewer is subject to the review and approval of the AHJ and the reviewer 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, and so forth.) 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 Independent 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 Independent Structural Reviewer. The Independent Structural Reviewer should create a full 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 stamped by the independent 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. 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, and so forth) 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 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 independent nonstructural component design reviewer is subject to the review and approval of the AHJ and the reviewer must be retained by the A/E design firm (DBB) or the General Contractor (DB). The structural and nonstructural component design review may be conducted by the same independent reviewer subject to the already noted qualifications. The nonstructural 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 Reviewer 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 inspection 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 2-17.8

    c. Component qualification documentation has been incorporated into the Operations & Maintenance Manual as specified in Section 2-17.7.

[C] 2-1.2 Nonstructural Component Design Review.

An independent Nonstructural Component Design Review is to be conducted 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 Reviewer should create a comprehensive report documenting completion of each of the tasks listed in this section. The report should contain 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 have 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, a walk-down inspection of the facility to confirm the following:

a. Location of installed Mission Critical components

b. Installation of identification nameplates as specified in Section 2-17.8 of this UFC

c. Incorporation of component qualification documents into the O&M Manual as specified in Section 2-17.7 of this UFC

2-2 DEFINITIONS AND NOTATIONS.

2-2.1 General.

2024 IBC Section 202, as modified by UFC 3-301-01 and this section applies.

ACTIVE FAULT

An active fault is defined in ASCE 7-22 as follows: A fault determined to be active by the Authority Having Jurisdiction from properly substantiated data (e.g., most recent mapping of active faults by the US Geological Survey).

[C] ACTIVE FAULT

In UFC 3-301-02, 11 April 2023 (the previous version of this UFC), an active fault was 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). This definition dates back to the 2000 IBC.

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 mean high water line where an Exposure D condition exists upwind of the waterline and the basic wind speed, *V*, is 130 mph (58 m/s) or greater; or

2. In areas where the basic 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 (See Section 2-9.1).

DESIGNATED SEISMIC SYSTEMS

Those nonstructural components that require design in accordance with ASCE 7-22 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 2-17.2) must be considered part of the Designated Seismic System.

2-3 CONSTRUCTION DOCUMENTS.

2-3.1 General.

2024 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.

2024 IBC Section 1604, as modified by UFC 3-301-01, applies. UFC 3-301-01 Table 2-2 is to replace 2024 IBC Table 1604.5.

2-4.2 Wind and Seismic Detailing.

2024 IBC Section 1604.9 does not apply to RC V facilities.

2-5 LOAD COMBINATIONS.

2-5.1 General.

2024 IBC Section 1605 applies.

Exceptions**:**

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

2. Only Strength Design load combinations are permitted.

3. In load combinations involving seismic load effects, the combined effect of earthquake forces, *E*, needs to be computed using the procedures outlined in this UFC.

2-6 DEAD LOADS.

2-6.1 General.

2024 IBC Section 1606 applies.

2-7 LIVE LOADS.

2-7.1 General.

2024 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 E-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 2024 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 7-22 Chapter 10.

Exceptions**:**

1. Ground snow loads and winter wind parameter W2 for RC V structures must be determined using a spreadsheet found under related materials on the WBDG Risk Category V Structures UFC.

2. In the determination of atmospheric ice loads for RC V structures, the nominal values of ice thickness, and concurrent wind speed and temperature must be determined using a spreadsheet found under related materials on the WBDG Risk Category V Structures UFC.

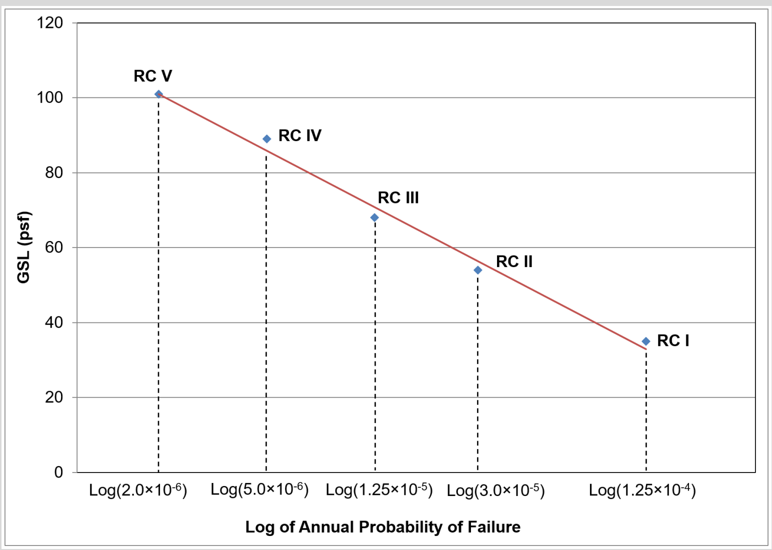
3. At locations where Risk Category V snow or ice loads are not provided, contact the AHJ for further guidance. For OCONUS locations reference the following commentary

[C] 2-8 SNOW AND ICE LOADS

Ground snow load (GSL) for an RC V structure at a given location was determined based on the GSL values at the same location corresponding to RC I, II, III and IV structures obtained from the ASCE Hazard Tool. As explained in ASCE 7-22 Commentary Section C7.2:

The ground snow load, p_g, values contained in the ASCE Design Ground Snow Load Geodatabase, mapped in Figures 7.2-1A through 7.2-1D and provided in the ASCE Hazard Tool are based on a reliability analysis consistent with the targets in Table 1.3-1 for a "failure that is not sudden and does not lead to widespread progression of damage."

In other words, the GSL values for RC I, II, III and IV structures correspond to target annual probabilities of failure (P_F) of 1.25 × 10^{-4}, 3.0 × 10^{-5}, 1.25 × 10^{-5}, and 5.0 × 10^{-6}, respectively. Plotting these GSL values against the Log of their corresponding P_F, it was observed that the points lie on an approximate straight line, as seen in the figure below. The exercise was repeated for more than 300 locations and the same linear relationship was observed. Consequently, it was decided to determine the GSL value for RC V structures based on extrapolation using the best-fitting straight line drawn through the four points described above. From ASCE 7-22 Table 1.3-1, a P_F value of 2.0 × 10^{-6} was deemed appropriate for RC V structures, as can be seen in the figure below.



It can be noted that, in high snow locations, the procedure described above provides lower GSL values when compared to the old method of multiplying an importance factor of 1.5 to the GSL value of RC II structures. This is expected because using a single importance factor for all locations was meant to be conservative.

The same procedure was followed to determine the nominal ice thickness for RC structures. Nominal ice thickness values for RCs I, II, III and IV structures correspond to mean recurrence interval (MRI) of 250, 500, 1000 and 1400 years, respectively. An MRI of 2500 years was assigned to RC V structures for ice loading.

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 100 psf (4.78 KPa). 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.” by Tobiasson and Greatorex and “Site-Specific Case Studies for Determining Ground Snow Loads in the United States” by Buska, Greatorex, and Tobiasson.

[C] 2-8.2 Snow Load Case Studies.

The provisions of this section are similar to those in Section 1608.2.3 in UFC 3-301-01, except that there is a threshold GSL value of 100 psf. In UFC 3-301-01, 11 April 2023, Change 1, 2 October 2023, there was a threshold GSL value of 30 psf for having to do site-specific snow load case studies. The 30 psf service-level GSL was converted to 45 psf strength-level GSL. Since this value was for RC I through IV structures, it was brought up to 70 psf for RC V structures by multiplying with an importance factor 1.5 and then rounding up. The snow load importance factor for RC V structures was scaled up from an importance factor of 1.2 for RC IV structures. The 70 psf was increased to 100 psf based on discussions with the Designated Working Group (DWG).

2-9 WIND LOADS.

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

Risk Category V OCONUS wind speed can be found using a spreadsheet that is located on the Whole Building Design Guide Structural Engineering UFC Page as a related item for download

For Risk Category V CONUS wind speeds use ASCE’s hazard tool and select the wind speed for a 100,000-year return period.

At locations where the basic wind speed is not provided, use the best locally available information.

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

2-10 SOIL LATERAL LOADS.

2-10.1 General.

2024 IBC Section 1610 applies except as follows: The 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.

2024 IBC Section 1611 applies.

Exception:

1. The design rainfall intensity for RC V structures must be must be determined using a spreadsheet found under related materials on the WBDG Risk Category V Structures UFC.

2. At locations where the design rainfall intensity is not provided, contact the AHJ for further guidance and see the following commentary.

[C] 2-11 RAIN LOADS

The design rainfall intensity (in./h or mm/h) for RC V structures is based on 15-min storm of 1000-yr return period. These values can also be obtained from the following webpage on the website of National Oceanic and Atmospheric Administration (NOAA).

https://hdsc.nws.noaa.gov/pfds/pfds_map_cont.html

2-12 FLOOD LOADS.

2-12.1 General.

2024 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 recurrence 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 recurrence 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 2-4.8 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 components 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 7-22 Chapter 21 are 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 2024 IBC and ASCE 7-22, the terms S_{DS} and S_{D1} are to be replaced by S_{MS} and S_{M1}, respectively, obtained from this response spectrum.

A linear response history analysis in accordance with ASCE 7-22 Section 12.9.2 is also to be conducted to determine the in-structure demand for the design and qualification of nonstructural equipment and distributed systems. The ASCE/SEI 43-19, Section 2.4 Criteria for Developing Synthetic or Modified Recorded Acceleration Time Series must be used to develop the seismic response histories for RC V facilities.

Table 2-1 Systems Permitted for Risk Category V Buildings

Basic Seismic Force-Resisting System	Detailing Requirements
Bearing Wall Systems	
Ordinary reinforced concrete shear walls	ACI 318, excluding Ch. 18
Ordinary reinforced masonry shear walls	TMS 402
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. 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
Moment-Resisting Frame Systems	
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	
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. 18

Note: Any system prohibited here may be permitted if approved by the Independent 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.

[redacted] Design Horizontal Response Spectrum.

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

[redacted] 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 7-22 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 7-22 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 forces 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_R-level event. For this reason, application of an importance factor is not required.

2-15.4 Seismic Design Category.

The requirements of ASCE 7-22 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 7-22 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 Structures.

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 MCE_R-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, with each contributing resistance in proportion to its stiffness. Displacements of parallel framing systems must be shown by analysis to be compatible.

2-16.1.3 R, C_d, and Ω_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 Ω_0 are to be set to 1.0.

[C] 2-16.1.3 R, C_d, and Ω_0 Values for Vertical and Horizontal Combinations

The factors R, C_d, and Ω_0 are meant to quantify the inelastic properties of a structure that is designed to undergo inelastic deformations in the course of resisting an MCE-level seismic event. 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 in the design of RC V structures.

ASCE 7-22 has removed virtually all restrictions on the use of the Equivalent Lateral Force (ELF) procedure. However, the mandatory use of the Modal Response

Spectrum Analysis (MRSA) procedure is retained here because it provides a more accurate assessment of seismic structural response.

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 7-22 Sections 12.3.2 and 12.3.3 do not apply.

[C] 2-17.2.1 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 7-22 Section 12.3.4 applies. For the purpose of determining the redundancy factor ρ, assume the seismic design category to be D. Structural systems with a redundancy factor, ρ, equal to 1.3 are not permitted (see Section 2-16.4.1).

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 7-22 Section 12.4.4 applies, except that the net upward force must be 0.8D.

[C] 2-16.2.3 Upward Force for Horizontal Cantilevers.

In ASCE 7-22 Section 12.4.4, a net upward force of 0.2D for horizontal cantilever members is specified for the Design Earthquake with an implicit assumption that an upward seismic force of 1.2D is acting in conjunction with the weight (1.0D) of the cantilever member. For design using MCE_R, the vertical seismic force needs to be scaled up by a factor of 1.5, which produces an upward seismic force of 1.8D. As a result, the net upward force on the member becomes 1.8D – 1.0D = 0.8D.

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 from 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, $E_{T\text{-}max}$, is to be the most severe effects of Equations 2-1, 2-2, or 2-3, for each individual structural element:

$$E_T = \pm [1.0\ E_x + 0.4\ E_y + 0.4\ E_z]$$ **(Equation 2-1)**

$$E_T = \pm [0.4\ E_x + 1.0\ E_y + 0.4\ E_z]$$ **(Equation 2-2)**

$$E_T = \pm [0.4\ E_x + 0.4\ E_y + 1.0\ E_z]$$ **(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, ρ (see Section 2-16.2.2) and Ω_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 7-22 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 7-22 Section 12.9.1. Modal values are to be combined in accordance with the provisions of ASCE 7-22 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 or supplemental damping, horizontal and vertical seismic forces must be determined using nonlinear dynamic analysis, in which the seismic isolators 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 7-22 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.

[redacted] 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).

[redacted] Moderate Seismicity Applications.

In areas of moderate seismic activity (0.25 ≤ S_{MS} ≤ 0.75, 0.10 ≤ S_{M1} ≤ 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 supplemental damping systems are used, they must be designed, tested, and constructed in accordance with the requirements of ASCE 7-22 Chapter 18. Analysis must conform to the requirements of ASCE 7-22 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).

[redacted] 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 7-22 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 7-22 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 7-22 Section 12.8 is not permitted for RC V structures.

[C] 2-16.5 Equivalent Lateral Force Procedure.

ASCE 7-22 has removed virtually all restrictions on the use of the Equivalent Lateral Force (ELF) procedure. However, the prohibition on the use of the procedure for RC V structures is retained here because Modal Response Spectrum Analysis (MRSA) provides a more accurate assessment of seismic structural response.

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 7-22 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 7-22 Section 12.10.

2-16.7.1 Design by ASCE 7-22 Sections 12.10.1 and 12.10.2.

When diaphragm forces are determined from ASCE 7-22 Section 12.10.1, apply a multiplier of 2 to the force at the uppermost level and design the diaphragm at each floor level for that force. In the application of ASCE 7-22 Section 12.10.1, the terms S_{DS} and S_{D1} are to be replaced by S_{MS} and S_{M1}, respectively (see Section 2-15.2.1 of this UFC).

The same adjustment applies to the design of collector elements by ASCE 7-22 Section 12.10.2.

ASCE 7-22 Section 12.10.1.1, is to be modified to delete the maximum force limit ($0.4S_{DS}I_e w_{px}$) that is placed on Equation 12.10-1.

[C] 2-17.7.1 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 7-22 Section 12.10.1 do not result in elastic diaphragm behavior even in the Design Earthquake (DE). 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 (PCI MNL-120,8th 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.

A multiplier of 3 is appropriate when the diaphragm forces are determined based on the DE using S_{DS} and S_{D1}. However, in this UFC, all seismic forces are determined based on the MCE_R using S_{MS} and S_{M1}. As a result, the multiplier was scaled down to 2 in order to avoid an overly conservative design.

ASCE 7-22 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 7-22 Sections 12.10.3.

When the alternative design provisions of ASCE 7-22 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 7-22 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 7-22 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 7-22 Section 12.11.2. ASCE 7-22 lower-bound value for wall anchorage forces must be revised to the larger of $0.3k_a I_e W_p$ and 7.5 lb/ft^2. 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 (Δ) must not exceed the allowable story drift (Δ_a) for RC IV structures in ASCE 7-22 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 7-22 Section 12.12.4 does not apply.

2-17 SEISMIC DESIGN REQUIREMENTS FOR NONSTRUCTURAL COMPONENTS.

2-17.1 General.

2-17.1.1 Scope.

The provisions of ASCE 7-22 Chapter 13, as modified by UFC 3-301-01, apply, except as noted in the following paragraphs. Appendix C of UFC 3-301-01 provides supplementary guidance on design and analysis of architectural, mechanical, and electrical components. Appendix D 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, isolators, and energy dissipation devices, as appropriate, for all components, in addition to the components themselves. Motion amplification through component supports must be determined and accommodated in 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 7-22 Chapter 13 provision that is specific to RC IV structures must also be applied to RC V structures. Where ASCE 7-22 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 7-22 Section 13.2.3 as modified by UFC 3-301-01.

Exception: When shake table testing is performed, the Required Response Spectra (RRS) are 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 reparable 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, and so forth. 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, and so forth.

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 complete description of the equipment or component with cut sheets or photographs containing all germane data including fastening requirements, welds, post-installed anchors, and so forth.
    b. Development of the in-structure response demand for vertical and horizontal shaking.
    c. For MC-1 components, development of the response capacity (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 nonstructural component design reviewer (UFC 3-301-02 Section 2-1.2). 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. Documentation of the 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.

In the application of ASCE 7-22 Section 13.3.1, seismic forces are to be determined using the MCE_R ground motion parameters. The force calculations found in ASCE 7-22 Equations 13.3-1 through 13.3-3 do not apply. The following procedures must be used.

[redacted] 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.

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

Where:
F_p = seismic design force centered at the component's center of gravity and distributed according 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

[redacted] MC-2 Components.

Forces for MC-2 components are to be determined by response spectrum 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 inelasticity in 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 Tables 2-2 and 2-3.

[C] 2-17.3.1.1 and 2-17.3.1.2 MC-1 and MC-2 Components

Major changes are made in ASCE 7-22 in the provisions for determining seismic forces in nonstructural components. One item in this revision is that the Component Response Modification Factor, R_p, is no longer there; a Component Strength Factor, R_{po} appears in its place. The primary difference between these two factors is, while R_p accounted for component ductility and overstrength, R_{po} accounts for only the component overstrength. Component ductility is now incorporated into another new parameter C_{AR} (Component Resonance Ductility Factor), which takes the place of the old a_p parameter.

In other words, in Equation 2-4, R_p cannot simply be replaced by R_{po} because then the effect of component ductility would be lost. At the same time, the new parameter C_{AR} cannot be included in Equation 2-4 either, because it also incorporates dynamic amplification of the component, which is already captured by a_{ip} in the equation.

In view of the above, it was decided to preserve the old R_p parameter in Equation 2-4 and to reproduce its values from ASCE 7-16 Tables 13.5-1 and 13.6-1 in this UFC in Tables 2-2 and 2-3, respectively. These R_p values have been a part of ASCE 7 for a long time, and should be satisfactory for the purpose of this UFC.

Note that while reproducing ASCE 7-16 Table 13.5-1 as Table 2-2, any reference to component connections or attachments have been deleted. This is because this section requires R_p for supports to be set to 1.0.

[redacted] NMC Components.

ASCE 7-22 Equation 13.3-7 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 7-22 Equation 13.3-7, the values of C_{AR} and R_{po} specified in ASCE 7-22 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 7-22 Equation 13.3-7. I_p is to be taken as 1.0, in lieu of the importance factors listed in ASCE 7-22 Sections 13.1.3.

Table 2-2 R_p Values for MC-2 Architectural Components

Architectural Component	R_p
Interior nonstructural walls and partitions	2½
Cantilever elements (unbraced or braced to structural frame below its center of mass)	
Parapets and cantilever interior nonstructural walls	2½
Chimneys where laterally braced or supported by the structural frame	2½
Cantilever elements (braced to structural frame above its center of mass)	
Parapets	2½
Chimneys	2½
Exterior nonstructural walls	2½
Exterior nonstructural wall elements	
Wall element	2½
Veneer	
Limited deformability elements	2½
Low-deformability elements	1½
Penthouses (except where framed by an extension of the building frame)	3½
Ceilings	
All	2½
Cabinets	
Permanent floor-supported storage cabinets more than 6 ft (1,829 mm) tall, including contents	2½
Permanent floor-supported library shelving, book stacks, and bookshelves more than 6 ft (1,829 mm) tall, including contents	2½
Laboratory equipment	2½
Access floors	
Special access floors (designed in accordance with Section 13.5.7.2)	2½
All other	1½
Appendages and ornamentations	2½
Signs and Billboards	3
Other rigid components	
High-deformability elements	3½
Limited-deformability elements	2½
Low-deformability materials	1½
Other flexible components	
High-deformability elements	3½
Limited-deformability elements	2½
Low-deformability materials	1½
Egress stairs and ramp fasteners	2½

Table 2-3 R_p Values for MC-2 Mechanical and Electrical Components

Components	R_p
MECHANICAL AND ELECTRICAL COMPONENTS	
Air-side HVACR, fans, air handlers, air conditioning units, cabinet heaters, air distribution boxes, and other mechanical components constructed of sheet metal framing	6
Wet-side HVACR, boilers, furnaces, atmospheric tanks and bins, chillers, water heaters, heat exchangers, evaporators, air separators, manufacturing or process equipment, and other mechanical components constructed of high-deformability materials	2½
Air coolers (fin fans), air-cooled heat exchangers, condensing units, dry coolers, remote radiators and other mechanical components elevated on integral structural steel or sheet metal supports	3
Engines, turbines, pumps, compressors, and pressure vessels not supported on skirts and not within the scope of Chapter 15	2½
Skirt-supported pressure vessels not within the scope of Chapter 15	2½
Elevator and escalator components	2½
Generators, batteries, inverters, motors, transformers, and other electrical components constructed of high-deformability materials	2½
Motor control centers, panel boards, switch gear, instrumentation cabinets, and other components constructed of sheet metal framing	6
Communication equipment, computers, instrumentation, and controls	2½
Roof-mounted stacks, cooling and electrical towers laterally braced below their center of mass	3
Roof-mounted stacks, cooling and electrical towers laterally braced above their center of mass	2½
Lighting fixtures	1½
Other mechanical or electrical components	1½
VIBRATION-ISOLATED COMPONENTS AND SYSTEMS	
Components and systems isolated using neoprene elements and neoprene isolated floors with built-in or separate elastomeric snubbing devices or resilient perimeter stops	2½
Spring-isolated components and systems and vibration-isolated floors closely restrained using built-in or separate elastomeric snubbing devices or resilient perimeter stops	2
Internally isolated components and systems	2
Suspended vibration-isolated equipment including in-line duct devices and suspended internally isolated components	2½
DISTRIBUTION SYSTEMS	
Piping in accordance with ASME B31 (2001, 2002, 2008, and 2010), including in-line components with joints made by welding or brazing	12
Piping in accordance with ASME B31, including in-line components, constructed of high- or limited-deformability materials, with joints made by threading, bonding, compression couplings, or grooved couplings	6
Piping and tubing not in accordance with ASME B31, including in-line components, constructed of high-deformability materials, with joints made by welding or brazing	9

Components	R_p
Piping and tubing not in accordance with ASME B31, including in-line components, constructed of high- or limited-deformability materials, with joints made by threading, bonding, compression couplings, or grooved couplings	4½
Piping and tubing constructed of low-deformability materials, such as cast iron, glass, and nonductile plastics	3
Ductwork, including in-line components, constructed of high-deformability materials, with joints made by welding or brazing	9
Ductwork, including in-line components, constructed of high- or limited-deformability materials with joints made by means other than welding or brazing	6
Ductwork, including in-line components, constructed of low-deformability materials, such as cast iron, glass, and nonductile plastics	3
Electrical conduit and cable trays	6
Bus ducts	2½
Plumbing	2½
Pneumatic tube transport systems	6

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 determination of accelerations and displacements 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 ASCE 4-16 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 7-22, 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 compressive and tensile forces. Vertical supports and braces designed for compression must have a slenderness ratio, Kl/r, of less than 200. Additional guidance on suspended ceiling design is provided in Section C-2.2.8 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 from building response analysis. Additional guidance on the design of elevator systems is found in Section C-3.3 of UFC 3-301-01.

2-17.7 Component Qualification Documentation and Operations & Maintenance (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 the 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.

2024 IBC Chapter 17, as modified by UFC 1-200-01 and UFC 3-301-01, applies to RC V structures.

2-18.2 Structural Observations for Structures.

Replace the text of IBC Section 1704.6.1 with the following:

Structural observations must be provided for RC V structures.

2-18.3 Special Inspections for Seismic Resistance.

Replace the existing text in 2024 IBC Section 1705.13 with the following:

Special Inspections itemized in Sections 1705.13.1 through 1705.13.9 apply to structures assigned to Risk Category V.

2-18.4 Plumbing, Mechanical and Electrical Components.

Add the following before the existing text in 2024 IBC Section 1705.13.6:

Special inspection and verification are required for Designated Seismic Systems and must be performed as required by the Statement of Special Inspections, and the Schedule of Special Inspections, which must be prepared for each project. Templates for these documents may be downloaded from the following link, under "Related Materials":

https://www.wbdg.org/dod/ufgs/ufgs-01-45-35

The SER must prepare a Statement of Special Inspections in accordance with 2024 IBC Section 1704 for the Designated Seismic Systems.

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 SER.

Designated Seismic Systems require a final walk-down inspection by the SER 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 SER 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 inspected in accordance with the requirements of 2024 IBC Chapter 17, as modified by this UFC.

2-18.5 Testing for Seismic Resistance.

Add the following before the first paragraph in 2024 IBC Section 1705.14:

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.

Such provisions of 2024 IBC Chapter 18 as are consistent with the foundation remaining elastic apply to RC V structures, [except that 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 elastic response of these RC V structures may lead to the existence of significant overturning forces in the structural system, and accompanying foundation element uplift forces or rocking. The SER is to be responsible for evaluating foundation overturning and rocking in the analysis and design, and this evaluation must be reviewed by the Structural Design Reviewer (see Section 2-1.1).

APPENDIX A REFERENCES

UNIFIED FACILITIES CRITERIA

https://www.wbdg.org/dod/ufc

UFC 1-200-01, *DoD Building Code*

UFC 3-301-01, *Structural Engineering*

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

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

AMERICAN CONCRETE INSTITUTE

https://www.concrete.org/

ACI CODE-318, *Building Code Requirements for Structural Concrete and Commentary*

AMERICAN INSTITUTE OF STEEL CONSTRUCTION

https://www.aisc.org/

AISC 360, *Specification for Structural Steel Buildings*

AMERICAN SOCIETY OF CIVIL ENGINEERS

https://www.asce.org/

ASCE/SEI 7, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*

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

ASCE/SEI 4, *Seismic Analysis of Safety-Related Nuclear Structures*

COLD REGIONS RESEARCH AND ENGINEERING LABORATORY

https://www.erdc.usace.army.mil/Locations/CRREL/

Database and Methodology for Conducting Site Specific Snow Load Case Studies for the United States, Tobiasson, W., Greatorex, A., Snow Engineering: Recent Advances, Izumi, Nakamura & Sack (eds), Balkema, Rotterdam, 1997.

ERDC/CRREL SR-20-1*, Site-Specific Case Studies for Determining Ground Snow Loads in the United States*, Buska, J., Greatorex, A., and Tobiasson, W., The U.S.

Army Engineer Research and Development Center (ERDC), Cold Regions Research and Engineering Laboratory (CRREL), Hanover, NH, 2020.

EARTHQUAKE ENGINEERING RESEARCH INSTITUTE

https://www.eeri.org/

Gulerce, Z. and Abrahamson, N. A., *Site-Specific Design Spectra for Vertical Ground Motion*, Earthquake Spectra, V. 27, No. 4, 2011

INTERNATIONAL CODE COUNCIL

https://www.iccsafe.org/

International Building Code

PRECAST/PRESTRESSED CONCRETE INSTITUTE

https://www.pci.org/

PCI MNL-120, *PCI Design Handbook*

PCI MNL-140, *Seismic Design of Precast/Prestressed Concrete Structures*

THE MASONRY SOCIETY

https://masonrysociety.org/

The Masonry Society (TMS), TMS 402-22/ACI 530-22/ASCE 5-22, TMS 602-22/ACI 530.1-22/ASCE 6-22, *Building Code Requirements and Specification for Masonry Structures*