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An ACI Standard

Seismic Evaluation and Retrofit of Existing Concrete Buildings—Code and Commentary

Reported by ACI Committee 369

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ACI CODE-369.1-22 (SI Units)

Seismic Evaluation and Retrofit of Existing Concrete Buildings—Code and Commentary

Reported by ACI Committee 369

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This code provides retrofit and rehabilitation criteria for reinforced concrete buildings based on results from the most recent research on the seismic performance of existing concrete buildings. The intent of this code is to provide provisions related to concrete material and concrete members, including material testing criteria, modeling parameters, and acceptance criteria for use within the ASCE 41 framework, similar to how the National Earthquake Hazards Reduction Program (NEHRP) Recommended Seismic Provisions produced by the Federal Emergency Management Agency (FEMA) (FEMA 450) have served as source documents for the International Building Code (IBC) and its predecessor building codes. Starting in the 2023 edition, ASCE 41 references ACI 369.1 directly for concrete-related provisions. Chapter and section numbers of ASCE 41 cited in ACI 369.1 correspond to ASCE 41-17 unless otherwise noted.

This code should be used in conjunction with Chapters 1 through 8 of ASCE 41-17 and applicable sections of the ACI 318-19 Building Code. Chapter 1 of ASCE 41 provides general requirements for evaluation and retrofit, including the selection of performance objectives and retrofit strategies. Chapter 2 of ASCE 41 defines performance objectives and seismic hazards. Chapter 3 of ASCE 41 provides requirements for evaluation and retrofit, including treating as-built information and selecting appropriate screening procedures. Chapter 4 of ASCE 41 summarizes Tier 1 screening procedures, while Chapters 5 and 6 summarize Tier 2 deficiency-based procedures and Tier 3 systematic procedures for evaluation and retrofit, respectively. Chapter 7 of ASCE 41 details analysis procedures referenced in ACI 369.1, including linear and nonlinear analysis procedures, acceptance criteria, and alternative methods for determining modeling parameters and acceptance criteria. Chapter 8 of ASCE 41 provides geotechnical engineering provisions for building foundations and assessment of seismic-geologic site hazards. References to these chapters can be found throughout the standard. The design professional is referred to FEMA 547 for detailed information on seismic rehabilitation measures for concrete buildings. Repair techniques for earthquake-damaged concrete components are not included in ACI 369.1. The licensed design professional is referred to ACI 562, FEMA 306,

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ACI CODE-369.1-22 (SI Units) supersedes ACI 369.1M-17 and was adopted and published in April 2023.

FEMA 307, and FEMA 308 for information on evaluation and repair of damaged concrete wall components.

This code does not provide modeling procedures, acceptance criteria, or rehabilitation measures for concrete-encased steel composite components.

Keywords: acceptance criteria; building; deformation-controlled; dynamic analysis; earthquake; force-controlled; modeling parameters; nonlinear analysis; retrofit; seismic evaluation, seismic assessment; structural evaluation.

INTRODUCTION

Earthquake reconnaissance has clearly demonstrated that concrete buildings designed before the introduction of seismic design codes in the 1980s are more vulnerable to severe damage or collapse when subjected to strong ground motion than concrete buildings built after that period. Seismic rehabilitation of existing buildings where new components are added or existing components are modified or retrofitted with new materials, or both, can be used to mitigate the risk to damage in future earthquakes. Seismic rehabilitation is encouraged not only to reduce the risk of damage and injury in future earthquakes but also to extend the life of existing buildings and reduce the need for new construction in the promotion of sustainability objectives.

This code is intended to cover all buildings of the usual types, both large and small. Requirements more stringent than the code provisions may be desirable for unusual construction. It is not possible to codify all problems encountered in the process of performing the seismic evaluation and retrofit of reinforced concrete buildings, nor is the intent of this code to do so. This code provides a basic framework for modeling and evaluation of structures that reflects the latest information available from researchers and practicing engineers enabling seismic evaluation and retrofit to be performed with a consistent set of criteria. Many provisions in this code rely on the use of sound engineering judgment for their implementation. The code and commentary cannot replace sound engineering knowledge, experience, and judgment. The commentary of this code provides references that describe in detail the implementation of methodologies adopted in the standard.

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CODE

CHAPTER 1—GENERAL

1.1—Scope

This code sets forth requirements for the seismic evaluation and retrofit of concrete components of the seismic-force-resisting system of an existing building. These requirements apply to existing concrete components, retrofitted concrete components, and new concrete components. Provisions of this code do not apply to concrete-encased steel composite components.

Chapter 2 specifies data collection procedures for obtaining material properties and performing condition assessments. Chapter 3 provides general analysis and design requirements for concrete components. Chapters 4 through 9 provide modeling procedures, component strengths, acceptance criteria, and retrofit measures for cast-in-place and precast concrete moment frames, concrete frames with masonry infills, cast-in-place and precast concrete structural walls, and concrete-braced frames. Chapters 10 through 12 provide modeling procedures, strengths, acceptance criteria, and retrofit measures for concrete diaphragms and concrete foundation systems.

COMMENTARY

CHAPTER R1—GENERAL

R1.1—Scope

These requirements were developed based on the best knowledge of the seismic performance of existing concrete buildings at the time of publication. These requirements are not intended to restrict the licensed design professional from using new information that becomes available before the issuance of the next edition of this code. Such new information can include tests conducted to address specific building conditions.

This code provides short descriptions of potential seismic retrofit measures for each concrete building system. The licensed design professional is referred to FEMA 547 for detailed information on seismic retrofit measures for concrete buildings. Repair techniques for earthquake-damaged concrete components are not included in this code. The licensed design professional is referred to FEMA 306, FEMA 307, and FEMA 308 for information on evaluation and repair of damaged concrete wall components.

Concrete-encased steel-composite components behave differently from concrete sections reinforced with steel reinforcement. Concrete-encased steel-composite components frequently behave as over-reinforced sections. This type of component behavior was not represented in the data sets used to develop the force-deformation modeling relationships and acceptance criteria in this code, and is not covered herein.

To preserve historic buildings, care should be exercised in selecting the appropriate retrofit approaches and techniques for application.