An ACI Standard

Standard Requirements for Seismic Evaluation and Retrofit of Existing Concrete Buildings (ACI 369.1M-17) and Commentary

Reported by ACI Committee 369

ACI 369.1M-17

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PREFACE

This standard 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 standard is to provide a continuously updated resource document for modifications to Chapter 10 of ASCE 41-17, 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. Specifically, this version of ACI 369.1M serves as the basis for Chapter 10, "Concrete," of ASCE 41-17.

This standard should be used in conjunction with Chapters 1 through 7 of ASCE 41-17. Chapter 1 of ASCE 41-17 provides general requirements for evaluation and retrofit, including the selection of performance objectives and retrofit strategies. Chapter 2 of ASCE 41-17 defines performance objectives and seismic hazards. Chapter 3 of ASCE 41-17 provides the requirements for evaluation and retrofit, including treating as-built information and selecting the appropriate screening procedures. Chapter 4 of ASCE 41-17 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 41-17 details analysis procedures referenced in ACI 369.1M, including linear and nonlinear analysis procedures, acceptance criteria, and alternative methods for determining modeling parameters and acceptance criteria. Chapter 8 of ASCE 41-17 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 369.1M. The design professional is referred to FEMA 306, FEMA 307, and FEMA 308 for information on evaluation and repair of damaged concrete wall components.

This standard does not provide modeling procedures, acceptance criteria, and rehabilitation measures for concrete-encased steel composite components. Future versions will provide provision updates for concrete moment frames and will add provisions for concrete components and systems omitted in the present version of the standard.

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INTRODUCTION

Earthquake reconnaissance has clearly demonstrated that existing 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 using new materials in the promotion of sustainability objectives.

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 the standard to do so. The standard provides a basic framework for modeling and evaluation of structures that reflects the latest information available from researchers and practicing engineers, so that seismic evaluation and retrofit can be performed with a consistent set of criteria. Many provisions in the standard rely on the use of sound engineering judgement for their implementation. The commentary of the standard provides references that describe in detail the implementation of methodologies adopted in the standard.

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

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STANDARD

COMMENTARY

CHAPTER 1—GENERAL

1.1—Scope

This standard sets forth requirements for the seismic evaluation and retrofit of concrete components of the seismic-force-resisting system of an existing building. These building standard requirements apply to existing concrete components, retrofitted concrete components, and new concrete components. Provisions of this standard 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.

C1.1—Scope

These standard 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 standard. Such new information can include tests conducted to address specific building conditions.

This standard provides short descriptions of potential seismic retrofit measures for each concrete building system. The licensed design professional, however, 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 standard. 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 standard, and is not covered in this standard. Concrete encasement is often provided for fire protection rather than for strength or stiffness and typically lacks transverse reinforcement. In some cases, the transverse reinforcement does not meet detailing requirements in AISC 360. Lack of adequate confinement can result in lateral expansion of the core concrete, which exacerbates bond slip and undermines the fundamental principle that plane sections remain plane.

Testing and analysis used to determine acceptance criteria for concrete-encased steel composite components should include the effect of bond slip between steel and concrete, confinement ratio, confinement reinforcement detailing, kinematics, and appropriate strain limits.

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