An ACI Standard

Code Requirements for the Design of Precast Concrete Diaphragms for Earthquake Motions (ACI 550.5M-18) and Commentary

Reported by Joint ACI-ASCE Committee 550

ACI 550.5M-18

American Concrete Institute
Always advancing

American Concrete Institute
Always advancing

First Printing
September 2018
ISBN: 978-1-64195-027-5

Code Requirements for the Design of Precast Concrete Diaphragms for Earthquake Motions (ACI 550.5M-18) and Commentary

The technical committees responsible for ACI committee reports and standards strive to avoid ambiguities, omissions, and errors in these documents. In spite of these efforts, the users of ACI documents occasionally find information or requirements that may be subject to more than one interpretation or may be incomplete or incorrect. Users who have suggestions for the improvement of ACI documents are requested to contact ACI via the errata website at http://concrete.org/Publications/DocumentErrata.aspx. Proper use of this document includes periodically checking for errata for the most up-to-date revisions.

ACI committee documents are intended for the use of individuals who are competent to evaluate the significance and limitations of its content and recommendations and who will accept responsibility for the application of the material it contains. Individuals who use this publication in any way assume all risk and accept total responsibility for the application and use of this information.

All information in this publication is provided “as is” without warranty of any kind, either express or implied, including but not limited to, the implied warranties of merchantability, fitness for a particular purpose or non-infringement.

ACI and its members disclaim liability for damages of any kind, including any special, indirect, incidental, or consequential damages, including without limitation, lost revenues or lost profits, which may result from the use of this publication.

It is the responsibility of the user of this document to establish health and safety practices appropriate to the specific circumstances involved with its use. ACI does not make any representations with regard to health and safety issues and the use of this document. The user must determine the applicability of all regulatory limitations before applying the document and must comply with all applicable laws and regulations, including but not limited to, United States Occupational Safety and Health Administration (OSHA) health and safety standards.

Participation by governmental representatives in the work of the American Concrete Institute and in the development of Institute standards does not constitute governmental endorsement of ACI or the standards that it develops.

Order information: ACI documents are available in print, by download, through electronic subscription, or reprint and may be obtained by contacting ACI.

Most ACI standards and committee reports are gathered together in the annually revised the ACI Collection of Concrete Codes, Specifications, and Practices.

American Concrete Institute
38800 Country Club Drive
Farmington Hills, MI 48331
Phone: +1.248.848.3700
Fax: +1.248.848.3701

www.concrete.org

ACI 550.5M-18

Code Requirements for the Design of Precast Concrete Diaphragms for Earthquake Motions (ACI 550.5M-18) and Commentary

An ACI Standard

Reported by Joint ACI-ASCE Committee 550

Larbi M. Sennour*, Chair

Lance Osborne, Secretary

Suzanne Aultman
Roger J. Becker*
Te-Lin Chung
Ned M. Cleland*
Manuel Conde Fuentes
Thomas J. D'Arcy*
William K. Doughty
Semeh Ibrahim El Ashri
Alvin C. Ericson
Mostafa Mohamed Gad Alla
Harry A. Gleich
Neil M. Hawkins†
Augusto H. Holmberg
L. S. Paul Johal
Jason J. Krohn*
Emily B. Lorenz
Kenneth A. Luttrell
Vilas S. Mujumdar
Clay J. Naito*
Clifford R. Ohlwiler
Victor F. Pizano-Thomen
Charles L. Pizzano
Jose I. Restrepo*
Sami H. Rizkalla
Mario E. Rodriguez*
Joseph C. Sanders*
James Schroder
John F. Stanton
P. Jeffrey Wang
Cloyd E. Warnes
Michael H. Weber

*Diaphragm Subcommittee members who developed this code
†Diaphragm Subcommittee Chair

Special thanks to S. K. Ghosh and S. Nakaki for their contributions to this standard.

This standard describes code requirements for the design of precast concrete diaphragms subject to earthquake motions where used under the design provisions of ASCE/SEI 7-16 Section 12.10.3 and ACI 318M. The response of precast concrete diaphragms under earthquake motions depends primarily on the strength, stiffness, and deformation capacities of the connectors and the reinforcement at joints between the precast concrete members. The seismic forces specified in ASCE/SEI 7 for the design of precast concrete diaphragms, their chords, and collectors in structures assigned to Seismic Design Category (SDC) C, D, E, or F are tied to force reduction factors specified in ASCE/SEI 7-16 Chapter 12, and to the shear overstrength provided by the connections and the reinforcement at joints specified in ASCE/SEI 7-16 Chapter 14. The shear overstrength depends on the design methodology, elastic or ductile, used for the diaphragm and targets elastic response for the maximum considered earthquake for shear connections regardless of the design option selected. The design option that can be used depends on the assigned design category and on the span and aspect ratio of the diaphragm. The selection of the design option is associated with minimum requirements for the tensile deformation capacity of the connections and the reinforcement at joints.

Keywords: connections; diaphragms; earthquake-resistant structures; precast concrete; seismic design.

ACI 550.5M-18 was adopted August 13, 2018, and published September 2018.

CONTENTS

CHAPTER 1—GENERAL

1.1—Introduction

1.1.1 Consistent with ACI 318M requirements for analysis, this standard specifies expected performance and design requirements for precast concrete diaphragms subject to earthquake loading. This standard is meant to replace the design procedure for precast concrete diaphragms for structures assigned to Seismic Design Category (SDC) C, D, E, or F that was developed and accepted for use by ASCE/SEI 7-16 in Section 14.2.4. The procedure described herein and that of ASCE/SEI 7-16 supplement the provisions of Chapter 18 of ACI 318M-14 and do not supplant them.

1.1.2 The procedure described herein may also be used for precast concrete diaphragms in structures assigned to SDC B.

R1—GENERAL

R1.1—Introduction

Precast concrete diaphragms are extensively used for parking structures and residential and commercial buildings. Those diaphragms frequently consist of large precast, prestressed concrete members such as double-tee (DT) or hollow-core (HC) members. Double-tee members are connected to one another through discrete mechanical connections or by reinforcement that crosses the joint between members. Industry practice is to use these DT diaphragms in an untopped condition in buildings assigned to SDC A and B, and in a topped condition in buildings assigned to SDC C, D, E, or F. Hollow-core members are primarily used in an untopped condition in buildings assigned to SDC A and B.

Design requirements for precast concrete diaphragms are covered by the general provisions of ACI 318M. However, unless a precast concrete diaphragm includes a topping that meets all the prescriptive requirements for diaphragms in Chapter 18 of ACI 318M-14, the precast concrete diaphragm cannot be designed directly using that chapter. For DT diaphragms made composite with a topping or without a topping, structural integrity and force transfer within the diaphragm are provided by the discrete web and chord connections that join the individual precast concrete members. If a precast concrete diaphragm made composite with a topping or without a topping is to provide a structural system with an earthquake loading performance equal to or exceeding that of a comparable cast-in-place concrete diaphragm, accurate knowledge of the strength, stiffness, and deformability of the individual connections used in the diaphragm is needed. Results from tests on individual connections in accordance with ACI Standard 550.4M-18 are needed to obtain the information on stiffness, shear strength, tensile strength, and tensile deformation capacity required for the design of connections and reinforcement at joints for precast concrete diaphragms satisfying the lateral load performance requirements of this standard, Section 12.10.3 of ASCE/SEI 7-16, and Chapter 18 of ACI 318M-14.

Post-earthquake reconnaissance following the 1994 Northridge earthquake (Iverson and Hawkins 1994) revealed that when precast concrete diaphragms with topping of 75 mm or less were subjected to significant earthquake motions, the topping was likely to crack along the edges of the precast concrete members. Consequently, reinforcement crossing the edges was susceptible to damage and the degree of susceptibility increased as the aspect ratio for the diaphragm increased and as the larger dimension of the diaphragm between seismic-force-resisting vertical elements increased.

Those observations on the behavior of large precast concrete diaphragms resulted in a comprehensive research study (Fleischman 2014) to develop better design models for precast concrete diaphragms and comprehensive studies of the strength and deformation capacity of diaphragm connections. In the improved design methodology resulting from that research, the choice of connection type is tied to the tension deformations and shear overstrength needed in the diaphragm to achieve the required design performance.