ACI 550.4M-18

An ACI Standard

Qualification of Precast Concrete Diaphragm Connections and Reinforcement at Joints for Earthquake Loading (ACI 550.4M-18) and Commentary (ACI 550.4RM-18)

Reported by Joint ACI-ASCE Committee 550

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ACI 550.4M prescribes testing and evaluation requirements for mechanical connections and reinforcement at joints intended for use under the design provisions of ASCE/SEI 7 and ACI 318M for precast concrete diaphragms subject to earthquake loading. These mechanical connections and reinforcement at joints transfer the vertical and in-plane forces between the precast concrete members that comprise the diaphragm, and between the diaphragm and vertical elements of the seismic-force-resisting system of the structure. The response of precast concrete diaphragms under earthquake loading depends not only on the strength of the connections and the reinforcement at joints, but also on their stiffness and deformation capacities. The seismic forces specified in ASCE/SEI 7 for the design of precast concrete diaphragms, including chords and collectors, in structures assigned to Seismic Design Category (SDC) C, D, E, or F are tied to the shear overstrength provided by the connections and the reinforcement at joints. This overstrength depends, in turn, on the design methodology, elastic or ductile, used for the diaphragm. ACI 550.4M prescribes the experimental procedures needed to assess the stiffness, strength, and deformation capacity of mechanical connections and reinforcement at joints for diaphragm flange-to-flange connections, including chord connections, of double-tee (DT) beams for earthquake loadings and evaluation procedures to categorize connection performance for use with the design procedures specified for precast concrete diaphragms in ASCE/SEI 7 and ACI 550.5M. ACI 550.4M does not prescribe experimental procedures for assessing the same information for connections for hollow-core members used in the untopped condition.

Keywords: connection category; diaphragm connections; precast concrete; qualification criteria; seismic design; test method..

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CODE

CHAPTER 1—GENERAL

1.1—Introduction

ACI 550.4M specifies the minimum experimental evidence that shall be provided by tests on individual connections and defines the minimum information required for the design of double-tee (DT) precast concrete diaphragms satisfying the lateral load performance requirements of Chapter 18 of ACI 318M-14.

Consistent with ACI 318M requirements for analysis, ACI 550.4M specifies that prior to the testing of individual connectors, a design procedure shall have been developed for precast concrete DT diaphragms having the generic form for which acceptance is sought, and that design procedure used to proportion the connections used in the testing required by ACI 550.4M. One such design procedure has evolved from research and is specified in ACI 550.5M-18. These procedures supplement the provisions of Chapter 18 of ACI 318M-14 and do not supplant them. The procedure is applicable only to the lateral load design of precast concrete DT diaphragms using connection performance characteristics determined using ACI 550.4M.

COMMENTARY

R1—GENERAL

R1.1—Introduction

For structures assigned to high Seismic Design Categories (SDCs), Chapter 18 of ACI 318M-14 permits the use of structural systems that do not meet the prescriptive requirements of the chapter if certain experimental evidence and analytical results are provided. Precast concrete double-tee (DT) members are extensively used in the construction of floor and roof diaphragms. Gravity load design requirements for diaphragms of precast concrete construction are covered by the general provisions of ACI 318M. However, unless a diaphragm of precast concrete construction is provided with a topping that meets all the prescriptive requirements for diaphragms in that chapter, the precast concrete diaphragm cannot be designed directly using Chapter 18 of ACI 318M-14. In precast concrete DT diaphragms without a topping, structural integrity and force transfer within the diaphragm are provided by the discrete web and chord connections or reinforcement that join the individual precast concrete members. If a precast concrete DT diaphragm without a topping is to provide a structural system with a lateral load performance equal to or exceeding that of a comparable cast-in-place diaphragm, accurate knowledge of the strength, stiffness, and deformability of the individual connections used in the diaphragm needs to be available.

Precast concrete floor diaphragms are extensively used for parking structures and residential and commercial buildings. Those diaphragms frequently consist of precast concrete members connected to one another through discrete embedded mechanical connectors or reinforcement at joints. Industry practice has been to use those diaphragms in an untopped condition in buildings assigned to SDC C or lower SDCs and with topping in buildings assigned to SDC D or higher SDCs. Where topped diaphragms with a topping thickness of 75 mm or less are subjected to significant earthquake loading, the topping is likely to crack along the edges of the precast member. Once cracking occurs, unless large amounts of reinforcement are continuous across the member edges, the topped diaphragm behaves similarly to a diaphragm composed of untopped precast concrete members.

Where mechanical connections are used to join the precast concrete members forming a diaphragm, the effects of all vertical and in-plane shear forces acting between members on these connections should be considered. Under earthquake loadings, the connections are subject to combinations of in-plane shear and tensile or compressive forces, the values of which depend on the magnitude of the earthquake motions and the response of the structure to those motions.

Post-earthquake reconnaissance following the 1994 Northridge earthquake (Iverson and Hawkins 1994) revealed that precast concrete diaphragms with toppings having thickness less than 75 mm or limited amounts of reinforcement were susceptible to damage, and that the degree of susceptibility increased as the aspect ratio for the diaphragm increased and as the span length of the diaphragm between lateral-force-