An ACI Standard

Acceptance Criteria for Special Unbonded Post-Tensioned Precast Structural Walls Based on Validation Testing and Commentary

Reported by Innovation Task Group 5

ACI 550.6-19

American Concrete Institute
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First Printing
August 2019
ISBN: 978-1-64195-079-4

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This document applies to structures in regions of high seismic risk or to structures assigned to high seismic performance or design categories. It defines the minimum experimental evidence that can be deemed to satisfy the use of unbonded post-tensioned precast structural walls (shear walls) for bearing wall and building frame special reinforced concrete shear wall systems, as defined in ASCE/SEI 7-10, when those walls do not fully satisfy the intent of the prescriptive requirements of Chapter 18 of ACI 318-14. This document includes mandatory Acceptance Criteria and nonmandatory Commentary, and has been written in such a form that its requirements can be coordinated directly with the requirements for special precast structural walls in 18.11 of ACI 318-14. Among the subjects covered are requirements for the procedures that shall be used to design unbonded post-tensioned precast test modules and their configurations, as well as requirements for testing, reporting, and assessing satisfactory performance of the test modules.

The references of the Commentary provide documentary evidence, additional to the references of Chapter 18 of ACI 318R-14, that support the acceptance criteria. Consistent with the approach of ACI 318, no comparison is made, either in the body of the Acceptance Criteria or Commentary, of research results for precast test modules satisfying ACI 318 with those for modules that, although not satisfying ACI 318, do satisfy the Acceptance Criteria. Such comparisons, both experimental and analytical, are available in the Commentary references.

In this document, consistent with the format of ACI 318-14, the word "Section" is not included before a reference to a section of ACI 318-14. To more clearly designate a section in this document, however, the word "Section" is used before any reference to a section of this document.

The section numbering for the Commentary is the same as that for the Standard, with numbers preceded by an "R" and the text in italics to distinguish them from the corresponding section numbers of the Standard.

Keywords: acceptance criteria; coupling element; drift; drift angle; energy dissipation; lateral resistance; post-tensioning; precast concrete; prestressed concrete; seismic design; shear wall; structural wall; test module; toughness.

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ACI 550.6-19 supersedes ITG 5.1-01, was adopted October 24, 2007, and published August 2019.

CHAPTER 1—INTRODUCTION AND SCOPE

1.1—Introduction

For seismic design, 18.2.1.7 of ACI 318-14 specifies that "a reinforced concrete structural system not satisfying the requirements of this chapter (Chapter 18) shall be permitted if it is demonstrated by experimental evidence and analysis that the proposed system has strength and toughness equal to or exceeding those provided by a comparable monolithic reinforced concrete structure satisfying this chapter." This document defines the minimum experimental evidence required to validate the use of special unbonded post-tensioned precast structural wall systems in regions of high seismic risk or for structures assigned to high seismic performance or design categories when those systems do not satisfy fully the prescriptive requirements of Chapter 18 of ACI 318. The provisions of this document are intended to supplement the provisions of Chapter 18 of ACI 318 and not to supplant them.

Consistent with the 18.2.1.7 requirement of ACI 318, this document specifies that, before the validation testing mandated by the document is undertaken, a design procedure shall have been developed for prototype unbonded post-tensioned precast structural walls having the generic form for which acceptance is sought. Further, the same design procedure shall be used to proportion the test modules. The document also requires that the prototype buildings that contain the unbonded post-tensioned precast structural walls have proportions that are essentially regular in the vertical direction, having no significant physical discontinuities in plan, in vertical configuration, or in their lateral-force-resisting systems.

This document is intended for walls that might, for example, involve the use of precast elements, precast/prestressed elements, post-tensioned reinforcement or combinations of those elements and reinforcement. Comprehensive prescriptive requirements for unbonded post-tensioned precast structural walls constructed with such elements are not included in ACI 318.

1.2—Scope and general requirements

R1.2—Scope and general requirements

While only ACI Committee 318 can specify the requirements necessary for unbonded post-tensioned precast walls to meet the provisions of 18.2.1.7 of ACI 318, 1.10 of ACI 318 permits the building official to accept precast wall systems, other than those explicitly covered by Chapter 18 of ACI 318, provided specific tests, load factors, deflection limits, construction procedures, and other pertinent requirements have been established for acceptance of such systems consistent with the intent of the Code. This document provides a framework that establishes the specific tests, load factors, deflection limits, and other pertinent requirements appropriate for acceptance for regions of high seismic risk or for structures assigned to high seismic performance or design categories of unbonded post-tensioned precast wall systems, including unbonded post-tensioned precast coupled wall systems, not satisfying all the prescriptive requirements of Chapter 18 of ACI 318.

This document assumes that the unbonded post-tensioned precast wall system to be tested has details that differ from those prescribed by 18.10 of ACI 318 for conventional monolithic reinforced concrete construction. Such walls may, for example, involve the use of precast elements, precast prestressed elements, post-tensioned reinforcement, or combinations of those elements and reinforcement. Life safety and toughness are theoretically enhanced by mild steel reinforcement grouted across the wall to foundation interface. The presence of mild steel reinforcement, however, makes erection more difficult, and may inhibit the self-centering action provided by unbonded post-tensioning crossing the same interface. For an uncoupled wall, mild steel reinforcement, or some other form of energy-dissipating base connection, is necessary to meet the relative energy dissipation requirements of this document. For coupled walls, however, energy-dissipating coupling elements can be used along the vertical boundaries between walls so that only unbonded post-tensioning tendons need to cross the wall to foundation interface. Life safety for coupled walls is then more critically dependent on the unbonded post-tensioning not fracturing under the seismic event. In that case, careful attention should be paid to corrosion protection of the tendon and to stress increases in the tendon during the seismic event.

For monolithic reinforced concrete walls, a fundamental design concept underlying the Chapter 18 provisions of ACI 318 is that walls with $\mathbf{h_w/\ell_w}$ exceeding 1.0 should be proportioned so that their inelastic response is dominated by flexural action on a critical section located near the base of the wall. That same basic fundamental concept is retained in this document. The limiting $\mathbf{h_w/\ell_w}$ value, however, is reduced to 0.5. The basis for that lower limit is discussed in R1.2.2.

Tests on modules, as envisioned in this document, cannot be extrapolated with confidence to the performance of panelized walls of proportions differing from those tested for the development of Chapter 18 of ACI 318 if the shear-slip displacement pattern or excessive joint opening pattern of Fig. R2.3 is significant in the response developed in the test on the module.

Two other fundamental requirements of Chapter 18 of ACI 318 are for closely spaced ties around heavily strained boundary element reinforcement and the provision of minimum amounts of uniformly distributed horizontal and vertical reinforcement in the web of the wall. Ties around boundary element reinforcement to inhibit its buckling in compression are required where the strain in the extreme compression fiber exceeds 0.003 and spalling of the cover concrete may occur. Those ties then provide confinement that maintains the integrity of the boundary element and permits the confined concrete to develop increasing compressive forces with increasing lateral displacements in spite of the loss of the concrete cover. Minimum amounts of uniformly distributed horizontal and vertical reinforcement over the height and length of the wall are required to restrain the opening of inclined cracks and allow the development of