SI International System of Units

An ACI Standard

Load Testing of Concrete Structures—Code and Commentary

Reported by ACI Committee 437

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Load Testing of Concrete Structures—Code and Commentary

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

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K. Nam Shiu
J. Gustavo Tumialan
Jeffery S. West

Consulting Members

Marco Arduini
JoAnn P. Browning
Grant T. Halvorsen
Carl J. Larosche
Habib M. Zien Alabideen

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This Code provides requirements for test load magnitudes, test protocols, and acceptance criteria for conducting a load test as a means of evaluating the safety and serviceability of concrete structural members and systems of structures. A load test may be conducted as part of a structural evaluation to determine whether a structure requires repair and rehabilitation, or to verify the adequacy of repair and rehabilitation measures.

Keywords: acceptance criteria; cyclic loading; load test; monotonic loading; test load magnitude; test protocol.

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CODE

CHAPTER 1—GENERAL

1.1—Scope

1.1.1 The scope, purpose, applicability, limitations, interpretation principles, and units of measure are defined in this chapter.

1.2—General

1.2.1 The requirements of this Code shall govern for the evaluation of safety and serviceability of members in concrete structures by load testing.

1.2.2 The requirements of this Code shall apply to reinforced concrete structures, or portions of reinforced structures, with prestressed reinforcement, nonprestressed reinforcement, or both.

1.2.3 Procedures and requirements provided in this Code are not applicable to structures having concretes with compressive strengths above 8000 psi unless permitted by the licensed design professional.

COMMENTARY

CHAPTER R1—GENERAL

R1.1—Scope

R1.1.1 A load test is required if the effect of a strength deficiency is not well understood, or it is not practicable to measure the dimensions and determine the material properties of the members required for analysis.

R1.2—General

R1.2.1 The determination of situations where a load test is required is outside the scope of this Code. Furthermore, this Code does not address procedures for analytical strength evaluations, condition evaluation of structures, or assessment of structural deterioration and its consequences. The licensed design professional should advise the owner and parties participating in the load testing of a structure of the potential for damage or even failure of the portions of the structure to be load tested in accordance with the procedures of this Code.

This Code may be used to evaluate whether a structure or a portion of a structure satisfies safety requirements. A strength evaluation may be required if the materials are considered deficient in quality, if there is evidence of faulty construction, if a structure will be used for a new function, or if, for any reason, a structure or a portion of it does not appear to satisfy safety requirements. In such cases, this Code provides minimum requirements for performing a strength evaluation of the structure by load testing.

If a load test is prescribed as part of the strength evaluation process, all parties should agree on the region to be loaded, the magnitude of the load, the load test protocol, and the applicable acceptance criteria before conducting the load test. If the safety concerns are related to an assemblage of members or an entire structure, it may not be feasible to load test every member and section. In such cases, an investigation plan should be developed to address the specific safety concerns.

R1.2.2 If there is doubt or concern about the shear strength of a member or members, or the development of reinforcement, a load test may be the most efficient solution to confirm the safety of the member or structure.

A load test may also be appropriate if it is not feasible to determine the material properties and structural dimensions required for analysis, even if the cause of the concern relates to flexure or axial load.

R1.2.3 Experience is lacking in the application of the procedures and requirements in this Code to structures having high-strength concrete—that is, compressive strengths over 8000 psi as defined in ACI 363R. Structures or members constructed of high-strength concrete may exhibit a response that is nearly linear as the structure approaches its load-carrying limit and, therefore, may provide little warning of an impending failure. Structures or members constructed of high-strength concrete may also experience a more brittle

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1.2.4 Load testing of structures or portions of structures shall be performed after 56 days of casting unless the owner, contractor, licensed design professional, and other interested parties agree to perform the load test at an earlier age.

1.3—Purpose

1.3.1 The purpose of this Code is to establish the minimum requirements for the test load magnitudes, load test procedures, and acceptance criteria applied to concrete structures as part of an evaluation of safety, serviceability, or both, to determine whether a structure requires repair and rehabilitation, to verify the adequacy of repair and rehabilitation measures applied to a structure, or to provide for public health and safety through structural safety and serviceability.

1.3.2 Load tests shall be conducted according to the load test procedures described in Chapter 5.

1.3.3 All references in this Code to the licensed design professional shall be understood to mean a person licensed to practice structural design in the jurisdiction where this Code is being used. The licensed design professional for a project is responsible for and in charge of the evaluation of safety and serviceability of the structure.

1.4—Applicability

1.4.1 This Code does not apply to slabs-on-ground, or structures whose responses are dominated by in-plane actions.

1.4.2 This Code shall not be used for product development testing where load testing is used for quality control or approval of mass-produced members.

1.4.3 This Code does not apply to testing for resistance to load effects of fatigue, wind, and earthquakes.

1.4.4 This Code does not apply to determining design strength or load-carrying limit at failure.

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failure in comparison to structures with concrete strengths less than 8000 psi.

R1.2.4 Loading concrete structures at early ages may affect both immediate and long-term response. Concrete creep depends on age of loading (ACI 209R). Other involved parties may include building officials, concrete subcontractors, and persons with a future interest in the structure.

R1.4—Applicability

R1.4.1 The procedures and requirements in this Code have been developed and applied to structural members subjected to gravity loads and where the structural response is dominated by flexure, such as typical members of the gravity load-resisting system in a structure. This Code is not applicable to structures where the response involves significant in-plane or membrane action, where soil-structure interaction may govern behavior. Structures that should generally not be evaluated on the basis of the requirements of this Code include shells, arches, bins and silos, and chimneys. The response to blast loading should also not be evaluated by the requirements of this Code.

R1.4.4 The procedures and requirements of this Code are not intended to provide any indication of the design strength or load-carrying limit of a member or structure at failure. The term "design strength" refers to the strength of a member or cross section as used in the context of the basic requirement for strength design, expressed as "design strength ≥

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1.4.5 This Code does not cover load testing for the approval of new design or construction methods.

1.5—Interpretation

1.5.1 The official version of this Code is the English language version using inch-pound units published by the American Concrete Institute.

1.5.2 In case of conflict between the official version of this Code and other versions of this Code, the official version governs.

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required strength" (based on factored load combinations of the general building code). The design strength is calculated in accordance with the provisions and assumptions of the strength design method of the general building code and includes the appropriate strength reduction factor ϕ.

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CHAPTER 2—NOTATION AND TERMINOLOGY

2.1—Notation

D = total dead load: $D_w + D_s$, or related internal moments or forces

D_s = superimposed dead load, or related internal moments or forces

D_w = load due to self-weight of the concrete structural system, and other permanent structural framing members of which the effects are in-place

F = load due to weight and pressure of fluids with well-defined densities and controllable maximum heights, or related internal moments or forces

I_{DL} = deviation from linearity index

I_{Pi} = permanency index for the i-th cycle at specified load level of a cyclic load test

$I_{P(i+1)}$ = permanency index for the $(i + 1)$-th cycle at specified load level of a cyclic load test

I_{pr} = permanency ratio index

L = live load due to use and occupancy of the structure not including snow or rain load and superimposed dead load, or related internal moments or forces

L_r = roof live load produced during maintenance by workers, equipment, and materials or during life of structure by moveable objects such as planters and people, or related internal moments or forces

ℓ_t = span of member under load test and taken as the smaller of: (a) distance between centers of supports; and (b) clear distance between supports plus thickness h of member; span for a cantilever shall be taken as twice the distance from face of support to cantilever end, mm

P_i = applied load corresponding to point i in load-deflection envelope in a cyclic load test, used for calculation of α_i in I_{DL} acceptance criterion, kN

P_{max} = applied load corresponding to 100% of test load magnitude, kN

P_{min} = minimum load to be maintained during a cyclic load test, kN

P_{ref} = reference load corresponding to the peak load of the first cycle (reference point) in a cyclic load test, used for computation of α_{ref} in I_{DL} acceptance criterion, kN

R = rain load, or related internal moments and forces

S = snow load, or related internal moments or forces

$\tan(\alpha_i)$ = slope of secant line of point i in load-deflection envelope, where secant line passes through origin and point of interest, i, in a cyclic load test

$\tan(\alpha_{ref})$ = slope of reference secant line in load-deflection envelope, where reference secant line passes through origin and peak load of the first cycle (reference point) in a cyclic load test

COMMENTARY

CHAPTER R2—NOTATION AND TERMINOLOGY

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