**ACI 437.2M-13**

**(metric)**

# Code Requirements for Load Testing of Existing Concrete Structures (ACI 437.2M-13) and Commentary

An ACI Standard

Reported by ACI Committee 437

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# Code Requirements for Load Testing of Existing Concrete Structures and Commentary

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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 for existing buildings as provided for by ACI 562-13. A load test may be conducted as part of a structural evaluation to determine whether an existing building requires repair and rehabilitation, or to verify the adequacy of repair and rehabilitation measures applied to an existing building, or both. This code contains provisions for both a cyclic load test and a monotonic load test procedure.*



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


## CONTENTS


**CHAPTER 1—GENERAL, p. 3**
1.1—General, p. 3
1.2—Scope, p. 3
1.3—Purpose, p. 3
1.4—Limitations, p. 4
1.5—Interpretation, p. 4
1.6—Language and units of measurement, p. 4

**CHAPTER 2—NOTATION AND DEFINITIONS, p. 5**
2.1—Notation, p. 5
2.2—Definitions, p. 6

**CHAPTER 3—REFERENCED STANDARDS, p. 8**

**CHAPTER 4—TEST LOAD, p. 9**
4.1—Service loads, p. 9
4.2—Test load magnitude, p. 9



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Full document details: ACI 437.2M-13

**CHAPTER 5—LOADING PROTOCOL, p. 11**
5.1—Safety, p. 11
5.2—Load arrangement, p. 11
5.3—Monotonic loading protocol, p. 12
5.4—Cyclic loading protocol, p. 12
5.5—Load application, p. 13
5.6—Response measurements, p. 14
5.7—Visual inspection, p. 14

**CHAPTER 6—ACCEPTANCE CRITERIA, p. 15**
6.1—Distress caused by load test, p. 15
6.2—Performance assessment at service load level, p. 16
6.3—Acceptance criteria for monotonic loading protocol, p. 17
6.4—Acceptance criteria for cyclic loading protocol, p. 17
6.5—Provision for lower load rating, p. 19

**R7—COMMENTARY REFERENCES, p. 21**
Cited references, p. 21

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## CODE

## CHAPTER 1—GENERAL

### 1.1—General

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

**1.1.2** This code supplements and is part of the "Code Requirements for Evaluation, Repair, and Rehabilitation of Existing Concrete Buildings (ACI 562-13) and Commentary" through reference.

### 1.2—Scope

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

**1.2.2** The requirements of this code shall apply to reinforced concrete with prestressed reinforcement, nonprestressed reinforcement, or both.

**1.2.3** Procedures and requirements provided in this code are not applicable to existing structures having concretes with compressive strengths above 55 MPa unless permitted by the licensed design professional.

**1.2.4** For structures being erected under the requirements of a legally adopted general building code, of which ACI 318-11 forms a part, this standard shall not replace Chapter 20 of ACI 318-11.

### 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 existing concrete structures as part of an evaluation of safety and serviceability to determine whether an existing structure requires repair and rehabilitation, to verify the adequacy of repair and rehabilitation measures applied to an existing structure, or to provide for public health and safety through structural safety and serviceability.

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

## COMMENTARY

## R1—GENERAL

### R1.1—General

**R1.1.2** Through its reference by ACI 562-13, this code is to be used only when ACI 562-13 governs. In those cases in which the general building code governs, then the applicable provisions of Chapter 20 of ACI 318-11 dealing with load testing are to be used.

### R1.2—Scope

**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 existing 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. Refer to 5.1 for provisions relating to safety and shoring.

**R1.2.4** Experience is lacking in the application of the procedures and requirements in this code to structures having high-strength concrete (concrete compressive strengths over 55 MPa). Structures with high-strength concrete may exhibit a more linear response as the structure approaches its load-carrying limit and may experience a more brittle failure in comparison to structures with strengths less than 55 MPa.

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## CODE

**1.3.3** All references in this code to the licensed design professional shall be understood to mean persons who are 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.

### 1.4—Limitations

**1.4.1** This code does not apply to foundations, slabs-on-ground, structures whose responses are dominated by in-plane actions, or structures having unusual design concepts as determined by the licensed design professional.

**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** Testing for resistance to load effects of fatigue, wind, and earthquakes is outside the scope of this code.

**1.4.4** Load testing to determine design strength or load-carrying limit at failure is outside the scope of this code.

### 1.5—Interpretation

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

**1.5.2** In case of conflict between the official version of the code and other versions of the code, the official version governs.

### 1.6—Language and units of measurement

Values in this code are stated in inch-pound units. A companion code in SI units is also available.

## COMMENTARY

### R1.4—Limitations

**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 elements of the gravity load-resisting system in a building. This code is not applicable to structures where the response involves significant in-plane or membrane action, where soil-structure interaction is present, or in situations where the structural behavior is not typical of building structural elements. Structures where the response may be inappropriate for use with the requirements of this code include shells, arches, bins and silos, blast-resistant structures, and chimneys.

**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 ≥ required strength" (based on factored load combinations of the general existing building code). The design strength is calculated in accordance with the provisions and assumptions of the strength design method of the general existing building code and multiplied by the appropriate strength reduction factor $\phi$.

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## CHAPTER 2—NOTATION AND DEFINITIONS

### 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

$F$ = 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 building not including environmental 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; for a cantilever, it 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 $\alpha_i$ in $I_{DL}$ acceptance criterion, kN

$P_{max}$ = applied load corresponding to 100 percent 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 $\alpha_{ref}$ in $I_{DL}$ acceptance criterion, kN

$R$ = rain load, or related internal moments and forces

$S$ = snow load, or related internal moments or forces

$\alpha_i$ = 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, degrees

$\alpha_{ref}$ = 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, degrees

$\Delta_i$ = measured deflection corresponding to point $i$ in load-deflection envelope in a cyclic load test, used for computation of $\alpha_i$ in $I_{DL}$ acceptance criterion, mm.

## COMMENTARY

## R2—NOTATION AND DEFINITIONS

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## CODE

$\Delta_l$ = maximum measured deflection (cyclic or monotonic load test), mm

$\Delta_{l2}$ = maximum deflection measured during a retest relative to the position of the structure at the beginning of the retest, mm

$\Delta_r$ = residual deflection measured after the 24-hour recovery period following complete removal of the load at the completion of the load test, mm

$\Delta_{ref}$ = measured reference deflection corresponding to the peak load of the first cycle (reference point) in a cyclic load test, used for computation of $\alpha_{ref}$ in $I_{DL}$ acceptance criterion, mm

$\Delta_{rrt}$ = permanent or residual deflection measured after the 24-hour recovery period following complete removal of the load at the completion of the repeat load test; residual deflection during the repeat test is relative to the position of the structure at the beginning of the repeat test, mm

$\Delta^1_{max}$= measured maximum deflection at the end of the *i*-th cycle at a given load level of a cyclic load test, mm

$\Delta^1_r$ = measured residual deflection after unloading to the minimum load, $P_{min}$, at the completion of the *i*-th cycle at a given load level of a cyclic load test, mm

$\Delta^2_{max}$= measured maximum deflection at the end of the $(i + 1)^{th}$ cycle at a given load level of a cyclic load test, mm

$\Delta^2_r$ = measured residual deflection after unloading to the minimum load, $P_{min}$, at the completion of the $(i + 1)^{th}$ cycle at a given load level of a cyclic load test, mm

## COMMENTARY

### 2.2—Definitions

**acceptance criteria**—set of explicit and quantitative rules to establish whether or not a structure (or a portion of it) passes a load test.

**applied test load (ATL)**—load applied to the structure, in addition to dead load already in place, to produce test load magnitude.

**cyclic load test**—application of test load magnitude using a defined set of increasing, repeated load cycles and then maintaining the test load magnitude for at least 24 hours.

**failure**—when referred to the performance of a structure (or a portion of it) under load test, it indicates that one or more acceptance criteria are not met.

**licensed design professional**—engineer or architect who is licensed to practice structural design as defined by the statutory requirements of the professional licensing laws of a state or jurisdiction; or the architect or engineer, licensed as described, who is responsible for the structural design of a particular project.

**load-deflection envelope**—curve enclosing the points on a plot of applied load versus measured deflection from a cyclic load test. Only those loads that are greater than or equal to any previously applied load cycle are included.

**load level**—maximum load attained during a loading cycle in a cyclic load test or an intermediate load before the full test load magnitude is applied in a monotonic load test.

### R2.2—Definitions

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