

Specification for High-Strength Concrete in Moderate to High Seismic Applications

Reported by ACI Innovation Task Group 4
and Other Contributors



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This specification is a reference specification that the licensed design professional can make applicable to any construction project by citing it in the project specifications. The licensed design professional supplements the provisions of this reference specification as needed by designating or specifying individual project requirements.

This specification covers cast-in-place, normalweight, high-strength concrete in structures that must be designed for moderate to high seismic applications. More specifically, this specification applies to structures:

- Located in Seismic Zones 2, 3, or 4 defined by the Uniform Building Code;
- Assigned to Seismic Performance Categories C, D, or E of the BOCA/ National Building Code (1993 and subsequent editions) or the Standard Building Code (1994 or subsequent editions); or
- Seismic Design Categories C, D, E or F of the International Building Code or the National Fire Protection Association (NFPA) 5000 Building Construction and Safety Code.

Irrespective of seismic hazard, seismic performance, or design category, these requirements shall apply to normalweight, high-strength concrete in intermediate or special moment frames and intermediate or special structural walls.

Keywords: curing; high-strength concrete; mixture proportioning; placement; quality control; seismic application; temperature; trial batch.

NOTES TO SPECIFIER

This specification is incorporated by reference in the project specification using the wording in P3 of the preface and including information from the mandatory requirements, optional requirements, and submittals checklists following the specification.

PREFACE

P1. ACI Specification ITG-4.1 is intended to be used by reference or incorporation in its entirety in the project specification. Do not copy individual parts, sections, articles, or

paragraphs into the project specification, because taking them out of context may change their meaning.

P2. If sections or parts of ACI Specification ITG-4.1 are copied into the project specifications or any other document, do not refer to them as an ACI specification because the specification has been altered.

P3. A statement such as the following will serve to make ACI Specification ITG-4.1 a part of the project specification:

“Work on (Project Title) shall conform to all requirements of ACI ITG-4.1-XX published by the American Concrete Institute, Farmington Hills, Michigan, except as modified by these contract documents.”

P4. Each technical section of ACI Specification ITG-4.1 is written in the three-part section format of the Construction Specifications Institute, as adapted for ACI requirements. The language is imperative and terse.

P5. The specification is written to the contractor. When a provision of this specification requires action on the contractor's part, the verb “shall” is used. If the contractor is allowed to exercise an option, the verb “may” or, when limited alternatives are available, the conjunctive phrase “shall either... or...” is used. Statements provided in the specification as information to the contractor use the verbs “may” or “will.” Informational statements typically identify activities or options that “will” be taken or “may” be taken by the owner or the licensed design professional.

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SECTION 1—GENERAL REQUIREMENTS

1.1—Scope

1.1.1 General—This specification covers normalweight, high-strength concrete in structures that must be designed for moderate to high seismic applications. More specifically, this specification applies to structures:

- Located in Seismic Zones 2, 3, or 4 defined by the *Uniform Building Code*;
- Assigned to Seismic Performance Categories C, D, or E of the *BOCA/National Building Code* (1993 and subsequent editions) or the *Standard Building Code* (1994 or subsequent editions); or
- Seismic Design Categories C, D, E, or F of the *International Building Code* or the National Fire Protection Association (NFPA) 5000 *Building Construction and Safety Code*.

Irrespective of seismic zone, seismic performance, or seismic design category, this specification shall apply to normalweight, high-strength concrete in intermediate or special moment frames and intermediate or special structural walls as defined in ACI 318-05.

1.1.2 Supplemental specification—This specification supplements “Specifications for Structural Concrete (ACI 301-05)” by providing more restrictive selected requirements when high-strength concrete is used in moderate to high seismic applications. The requirements of ACI 301-05 shall apply unless otherwise specified in this specification.

1.1.3 High-strength concrete—Unless otherwise specified, high-strength concrete is defined as concrete having a specified compressive strength for design of 6000 psi (41 MPa) or greater.

1.1.4 Dual units—The values stated in inch-pound or SI units shall be regarded separately as standard. The SI units are shown in brackets. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other.

1.2—Definitions

admixture—material other than water, aggregates, or hydraulic cement, used as an ingredient of concrete and added to concrete before or during mixing to modify its properties.

aggregate—granular material, such as sand, gravel, crushed stone, and iron blast-furnace slag, used with a cementing medium to form a hydraulic cement concrete or mortar.

concrete, flowing—concrete that maintains a slump greater than 7-1/2 in. (190 mm) while remaining cohesive.

concrete, hydraulic-cement—mixture of portland cement or any other hydraulic cement, fine aggregates, coarse aggregates, and water, with or without admixtures.

concrete, high-strength—concrete that has a specified compressive strength for design of 6000 psi (41 MPa) or greater.

concrete, mass—a volume of concrete with dimensions large enough to require that measures be taken to cope with the generation of heat and temperature gradients from hydration of the cementitious materials, and attendant volume change.

concrete, self-consolidating—fresh concrete that can flow around reinforcement and consolidate within formwork under its own weight without vibration, and that exhibits no defect due to segregation or bleeding.

creep—time-dependent increase in deformation due to sustained load; determined in accordance with ASTM C 512.

curing—provision of moisture and appropriate temperatures for sufficient time for the concrete to develop the required properties.

modulus of elasticity—ratio of normal stress to corresponding strain for tensile or compressive stress below the proportional limit of the material, determined in accordance with ASTM C 469.

modulus of rupture—a measure of the load-carrying capacity of a beam and sometimes referred to as rupture modulus or rupture strength; it is the apparent tensile stress in the extreme tension fiber of a test specimen subject to bending under the load that produces rupture; determined in accordance with ASTM C 78 (third-point loading), and ASTM C 293 (center-point loading).

slump—a measure of consistency of freshly mixed concrete, mortar, or stucco equal to the subsidence measured to the nearest 1/4 in. (6 mm) of the molded specimen immediately after removal of the slump cone, determined in accordance with ASTM C 143.

shrinkage—decrease in either length or volume. (Note: may be restricted to the effects of moisture content or chemical changes).

splitting tensile strength—tensile strength of concrete determined by applying a diametrical compressive force along the length of a cylindrical concrete specimen, in accordance with ASTM C 496.

strength, compressive—the measured maximum resistance of a concrete or mortar specimen to axial compressive loading; expressed as force per unit cross-sectional area; or the specified resistance used in design calculations.

strength, specified compressive—compressive strength of concrete used in design.

1.3—Referenced standards and cited publications

1.3.1 Referenced standards—Standards of ACI and ASTM referred to in this specification are listed with serial designation including year of adoption or revision and are part of this specification.

1.3.1.1 ACI standards

301-05 Specifications for Structural Concrete
318-05 Building Code Requirements for Structural Concrete

1.3.1.2 ASTM standards

C 33-03 Standard Specification for Concrete Aggregates

C 39/C 39M-04a Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
C 78-02 Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
C 94/C 94M-04a Standard Specification for Ready-Mixed Concrete
C 138/C 138M-01a Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
C 143/C 143M-03 Standard Test Method for Slump of Hydraulic-Cement Concrete
C 150-04ae1 Standard Specification for Portland Cement
C 231-04 Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
C 260-01 Standard Specification for Air-Entraining Admixtures for Concrete
C 293-02 Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Center-Point Loading)
C 469-94e1 Standard Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression
C 494/C 494M-05 Standard Specification for Chemical Admixtures for Concrete
C 496-96 Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens
C 512-02 Standard Test Method for Creep of Concrete in Compression
C 566-97 (2004) Standard Test Method for Total Evaporable Moisture Content of Aggregate by Drying
C 595-03 Standard Specification for Blended Hydraulic Cements
C 618-03 Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
C 989-05 Standard Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars
C 1017/C 1017M-03 Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete
C 1064-05 Standard Test Method for Temperature of Freshly Mixed Portland Cement Concrete
C 1157-03 Standard Performance Specification for Hydraulic Cement
C 1240-04 Standard Specification for Silica Fume Used in Cementitious Mixtures
C 1602-04 Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete