

ACI 301M-16

An ACI Standard

# Specifications for Structural Concrete

Reported by ACI Committee 301



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## Specifications for Structural Concrete

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# Specifications for Structural Concrete

An ACI Standard

Reported by ACI Committee 301

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*This is a Reference Specification that the Architect/Engineer can apply to any construction project involving structural concrete by citing it in the Project Specifications. A mandatory requirements checklist and an optional requirements checklist are provided to assist the Architect/Engineer in supplementing the provisions of this Specification as required or needed by designating or specifying individual project requirements.*

*The first five sections of this Specification cover general construction requirements for cast-in-place structural concrete and slabs-on-ground. These sections cover materials and proportioning of concrete; reinforcement and prestressing steel; production, placing, finishing, and curing of concrete; formwork performance criteria and construction; treatment of joints; embedded items; repair of surface defects; and finishing of formed and unformed surfaces. Provisions governing testing, evaluation, and acceptance of concrete as well as acceptance of the structures are included. The remaining sections are devoted to architectural concrete, lightweight concrete, mass concrete, post-tensioned concrete, shrinkage compensating*

*concrete, industrial floor slabs, tilt-up construction, precast structural concrete, and precast architectural concrete.*

**Keywords:** architectural; cold weather; compressive strength; consolidation; curing; durability; finish; formwork; grouting; hot weather; industrial floors; inspection; joints; lightweight concrete; mass concrete; mixture proportions; placing; post-tensioned; precast; prestressing steel; repair; reshoring; shoring; shrinkage-compensating; slab; slabs-on-ground; steel reinforcement; testing; tilt-up; tolerance; welded wire.

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**SECTION 1—GENERAL REQUIREMENTS****1.1—Scope**

**1.1.1** This Specification covers construction of cast-in-place concrete, architectural concrete, lightweight concrete, mass concrete, post-tensioned concrete, shrinkage-compensating concrete, industrial floor slabs cast on ground, tilt-up construction, precast structural concrete, and precast architectural concrete.

**1.1.2** Sections 1 through 5 apply to projects where this Specification is referenced. Work covered by Sections 6 through 14 apply only if that Work is designated in Contract Documents.

**1.1.3** This Specification becomes part of the Contract Document and provides requirements for Contractor.

**1.1.4** This Specification governs for construction within its scope, except Contract Documents govern if there is a conflict.

**1.1.5** *Work not specified*—The following Work is not in the scope of this Specification:

- (a) Manufactured concrete products specified by ASTM standards
- (b) Environmental concrete structures
- (c) Heavyweight shielding concrete
- (d) Paving concrete
- (e) Terrazzo
- (f) Insulating concrete
- (g) Refractory concrete
- (h) Nuclear containment structures
- (i) Concrete piles; drilled piers; and caissons assigned to Seismic Design Categories A, B, and C
- (j) Fire safety (Underwriter Laboratories [UL] designs)
- (k) Shotcrete
- (l) Slipformed concrete walls

**1.1.6** This Specification governs if there is a conflict with referenced materials and testing standards.

**1.1.7** Contractor is permitted to submit written alternatives to any provision in this Specification.

**1.1.8** Ignore provisions of this Specification that are not applicable to the Work.

**1.1.9 Units**—Values in this Specification are stated in inch-pound units.

**1.1.10** Unless otherwise stated, the inch-pound system of units shall be applicable in ASTM combined standards referenced in this Specification.

**1.1.11** The Notes to Specifier are not part of this Specification.

## 1.2—Interpretation

**1.2.1** Unless otherwise explicitly stated, this Specification shall be interpreted using the following principles:

**1.2.1.1** Interpret this Specification consistent with the plain meaning of the words and terms used.

**1.2.1.2** Definitions provided in this Specification govern over the definitions of the same or similar words or terms found elsewhere.

**1.2.1.3** Headings are part of this Specification and are intended to identify the scope of the provisions or sections that follow. If there is a difference in meaning or implication between the text of a provision and a heading, the meaning of the text governs.

**1.2.1.4** Notes to a table are part of this Specification. The meaning of the provision text governs in the event of a difference in meaning or implication between the provision text and a note to a table.

**1.2.1.5** If a provision of this Specification involves two or more items, conditions, requirements, or events connected by the conjunctions “and” or “or,” interpret the conjunction as follows:

(a) “And” indicates that all of the connected items, conditions, requirements, or events apply.

(b) “Or” indicates that the connected items, conditions, requirements, or events apply singularly.

**1.2.1.6** The use of the verbs “may” or “will” indicates that the specification provision is for information to Contractor.

**1.2.1.7** The phrase “as indicated in Contract Documents” means the specifier included the provision requirements in Contract Documents.

**1.2.1.8** The phrase “unless otherwise specified” means the specifier may have included an alternative to the default requirement in Contract Documents.

## 1.3—Definitions

**acceptable** or **accepted**—determined to be satisfactory by Architect/Engineer.

**acceptance**—acknowledgment by Architect/Engineer that submittal or completed Work is acceptable.

**ACI Concrete Field Testing Technician Grade I**—a person who has demonstrated knowledge and ability to perform and record the results of ASTM standard tests on freshly mixed concrete and to make and cure test specimens; knowledge and ability shall be demonstrated by passing prescribed written and performance examinations and having credentials that are current with the American Concrete Institute.

**aggressive environment**—an environment that exposes a structure to moisture and external sources of chlorides from

deicing chemicals, salt, brackish water, seawater, or spray from these sources; for stressing pockets subject to wetting or direct contact with soils during service.

**Architect/Engineer** or **Engineer/Architect**—Architect, Engineer, architectural firm, engineering firm, or architectural and engineering firm issuing Contract Documents or administering the Work under Contract Documents, or both.

**architectural concrete**—concrete that is typically exposed to view, is designated as architectural concrete in Contract Documents, and therefore requires care in selection of the concrete materials, forming, placing, and finishing to obtain the desired architectural appearance.

**backshores**—shores placed snugly under a concrete slab or structural member after the original formwork and shores have been removed from a small area at a time, without allowing the slab or member to deflect, or support its own weight or existing construction loads.

**cast-in-place concrete**—concrete that is deposited and allowed to harden in the place where it is required to be in the completed structure.

**check test**—test performed to verify result of previous test result of freshly-mixed concrete.

**Contract Documents**—a set of documents supplied by Owner to Contractor as the basis for construction; these documents contain contract forms, contract conditions, specifications, drawings, addenda, and contract changes.

**Contractor**—the person, firm, or entity under contract for construction of the Work.

**defective work**—construction or material that does not comply with Contract Documents.

**design reference sample**—sample of precast architectural concrete color, finish, and texture that is submitted for initial verification of design intent.

**duct**—a conduit in a concrete member to accommodate the prestressing steel of a post-tensioning tendon and provide an annular space for protective coating.

**encapsulated tendon**—a tendon that is enclosed completely in a watertight covering from end to end, including anchorages, sheathing with coating, and caps over the strand tails.

**equivalent diameter of bundle**—the diameter of a circle having an area equal to the sum of the bar areas in a bundle of reinforcing bars.

**expansive cement**—a cement that, when mixed with water, produces a paste that, after setting, increases in volume and is used to compensate for volume decrease due to shrinkage or to induce tensile stress in reinforcement.

**exposed to view**—portion of structure that can be observed by the public during normal use.

**high-early-strength concrete**—concrete that, through the use of additional cement, high-early-strength cement, admixtures, or other acceptable methods, has accelerated early-age strength development.

**jack clearance**—minimum space required to safely install, operate, and remove a hydraulic jack through its full range of movement in stressing of a tendon.

**licensed design engineer**—an individual retained by the Contractor who is licensed to practice engineering as defined



by the statutory requirements of the professional licensing laws of the state or jurisdiction in which the project is to be constructed.

**lightweight concrete**—structural concrete containing lightweight aggregate conforming to **ASTM C330/C330M** and having an equilibrium density, as determined by **ASTM C567/C567M**, between 1440 and 1840 kg/m<sup>3</sup>.

**mass concrete**—volume of structural concrete in which a combination of dimensions of the member being cast, the boundary conditions, the characteristics of the concrete mixture, and the ambient conditions can lead to undesirable thermal stresses, cracking, deleterious chemical reactions, or reduction in the long-term strength as a result of elevated concrete temperature due to heat of hydration.

**movement joint**—an interface between adjacent portions of the Work that allows movement in one or more direction.

**nonencapsulated tendon**—a tendon that has bare metallic anchorages and sheathing that is continuous between anchorages but not connected to the anchorages.

**normalweight concrete**—structural concrete containing aggregate that conforms to **ASTM C33/C33M** and that typically has a density between 2160 and 2560 kg/m<sup>3</sup>.

**Owner**—the corporation, association, partnership, individual, public body, or authority for whom the Work is constructed.

**placing drawing**—drawing that gives size, location, and spacing of reinforcement, and other information required for site-cast concrete construction.

**point of placement**—location where concrete is placed in structure.

**post-tensioning**—a method of prestressing reinforced concrete in which tendons are tensioned after the concrete has attained a specified minimum in-place strength or a specified minimum age.

**precast concrete**—concrete cast elsewhere than its final position.

**prestressed concrete**—concrete in which internal stresses have been introduced to reduce potential tensile stresses in concrete resulting from loads (see **post-tensioning** and **pretensioning**).

**prestressing sheathing**—a material encasing prestressing steel to prevent bonding of the prestressing steel with the surrounding concrete, to provide corrosion protection, and to contain the corrosion-inhibiting coating.

**prestressing steel**—high-strength steel element; for example, strand, bars, or wire, used to impart prestress forces to concrete.

**pretensioning**—method of prestressing in which prestressing steel is tensioned before the concrete is placed.

**Project Drawings**—graphic presentation that details requirements for Work.

**Project Specifications**—the written document that details requirements for Work.

**pull-on method**—method of seating fixed-end anchorage by tensioning prestressing steel.

**quality assurance**—actions taken by Owner or Owner's Representative to provide confidence that Work done and materials provided are in accordance with Contract Documents.

**quality control**—actions taken by Contractor to ensure that Work meets the requirements in Contract Documents.

**reference specification**—a standardized mandatory-language document prescribing materials, dimensions, and workmanship, incorporated by reference in Contract Documents.

**referenced standards**—standardized mandatory-language documents of a technical society, organization, or association, including codes of local or federal authorities, which are incorporated by reference in Contract Documents.

**required**—required in this Specification or in Contract Documents.

**reshores**—shores placed snugly under a stripped concrete slab or other structural member after the original forms and shores have been removed from a large area, thus requiring the new slab or structural member to deflect and support its own weight and existing construction loads.

**shop drawings**—drawings that provide details for a particular portion of Work that are prepared by Contractor in accordance with Contract Documents and are reviewed by Architect/Engineer.

**shore**—vertical or inclined support members designed to support the weight of the formwork, concrete, and construction loads above.

**shrinkage-compensating concrete**—a concrete that increases in volume after setting, designed to induce compressive stresses in concrete restrained by reinforcement or other means, to offset tensile stresses resulting from shrinkage.

**strength test**—standard test conducted for evaluation and acceptance of concrete determined as the average of the compressive strengths of at least two 150 x 300 mm cylinders or at least three 100 x 200 mm cylinders made from the same sample of concrete, transported, and standard cured in accordance with **ASTM C31/C31M** and tested in accordance with **ASTM C39/C39M** at 28 days or at test age designated for  $f'_c$ .

**structural concrete**—plain or reinforced concrete in a member required to transfer gravity loads, lateral loads, or both, to the ground.

**submit**—provide to Architect/Engineer for review.

**submittal**—documents or materials provided to Architect/Engineer for review and acceptance.

**surface defects**—imperfections in concrete surfaces defined in Contract Documents requiring repair.

**tendon**—in pretensioned applications, the tendon is the prestressing steel; in post-tensioned applications, the tendon is a complete assembly consisting of anchorages, prestressing steel, and sheathing with coating for unbonded applications or ducts with grout for bonded applications.

**tilt-up**—a construction technique for casting concrete members in a horizontal position at the project site and then erecting them to their final upright position in a structure.

**waste slab**—temporary slab to provide a casting surface for tilt-up panels.

**Work**—the entire construction or separately identifiable parts required to be furnished under Contract Documents.

## 1.4—Referenced standards

**1.4.1 Referenced standards**—Standards referred to in this Specification are listed with serial designation including year of adoption or revision.

### 1.4.1.1 American Concrete Institute standards

ACI 117M-10(15)—Specifications for Tolerances for Concrete Construction and Materials and Commentary

ACI 216.1M-14—Code Requirements for Determining Fire Resistance of Concrete and Masonry Construction Assemblies

ACI 423.7-14—Specification for Unbonded Single-Strand Tendon Materials

ACI ITG-7M-09—Specification for Tolerances for Precast Concrete

### 1.4.1.2 ASTM International standards

ASTM A36/A36M-14—Standard Specification for Carbon Structural Steel

ASTM A47/A47M-99(2014)—Standard Specification for Ferritic Malleable Iron Castings

ASTM A108-13—Standard Specification for Steel Bar, Carbon and Alloy, Cold-Finished

ASTM A123/A123M-15—Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products

ASTM A153/A153M-16—Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware

ASTM A184/A184M-06(2011)—Standard Specification for Welded Deformed Steel Bar Mats for Concrete Reinforcement

ASTM A193/A193M-16—Standard Specification for Alloy-Steel and Stainless Steel Bolting for High Temperature or High Pressure Service and Other Special Purpose Applications

ASTM A276/A276M-16—Standard Specification for Stainless Steel Bars and Shapes

ASTM A307-14—Standard Specification for Carbon Steel Bolts, Studs, and Threaded Rod 60000 PSI Tensile Strength

ASTM A325-14—Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength

ASTM A416/A416M-15—Standard Specification for Low-Relaxation, Seven-Wire Steel Strand for Prestressed Concrete

ASTM A421/A421M-15—Standard Specification for Stress-Relieved Steel Wire for Prestressed Concrete

ASTM A490-14a—Standard Specification for Structural Bolts, Steel, Heat Treated, 150 ksi Minimum Tensile Strength

ASTM A500/A500M-13—Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes

ASTM A563-15—Standard Specification for Carbon and Alloy Steel Nuts

ASTM A572/A572M-15—Standard Specification for High Strength Low-Alloy Columbium-Vanadium Structural Steel

ASTM A615/A615M-16—Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement

ASTM A666-15—Standard Specification for Annealed or Cold-Worked Austenitic Stainless Steel Sheet, Strip, Plate, and Flat Bar

ASTM A675/A675M-14—Standard Specification for Steel Bars, Carbon, Hot-Wrought, Special Quality, Mechanical Properties

ASTM A706/A706M-16—Standard Specification for Deformed and Plain Low-Alloy Steel Bars for Concrete Reinforcement

ASTM A722/A722M-15—Standard Specification for High-Strength Steel Bars for Prestressing Concrete

ASTM A767/A767M-09(2015)—Standard Specification for Zinc-Coated (Galvanized) Steel Bars for Concrete Reinforcement

ASTM A775/A775M-07b(2014)—Standard Specification for Epoxy-Coated Steel Reinforcing Bars

ASTM A779/A779M-12—Standard Specification for Steel Strand, Seven-Wire, Uncoated, Compacted, for Prestressed Concrete

ASTM A780/A780M-09(2015)—Standard Practice for Repair of Damaged and Uncoated Areas of Hot-Dip Galvanized Coatings

ASTM A820/A820M-15—Standard Specification for Steel Fibers for Fiber-Reinforced Concrete

ASTM A882/A882M-04a(2010)—Standard Specification for Filled Epoxy-Coated Seven-Wire Prestressing Steel Strand

ASTM A884/A884M-14—Standard Specification for Epoxy-Coated Steel Wire and Welded Wire Reinforcement

ASTM A886/A886M-12—Standard Specification for Steel Strand, Indented, Seven-Wire, Stress-Relieved for Prestressed Concrete

ASTM A910/A910M-12—Standard Specification for Uncoated, Weldless, 2-Wire and 3-Wire Steel Strand for Prestressed Concrete

ASTM A934/A934M-16—Standard Specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars

ASTM A955/A955M-15—Standard Specification for Deformed and Plain Stainless-Steel Bars for Concrete Reinforcement

ASTM A970/A970M-15e1—Standard Specification for Headed Steel Bars for Concrete Reinforcement

ASTM A992/A992M-11(2015)—Standard Specification for Structural Steel Shapes

ASTM A996/A996M-16—Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement

ASTM A1022/A1022M-16—Standard Specification for Deformed and Plain Stainless Steel Wire and Welded Wire for Concrete Reinforcement

ASTM A1035/A1035M-16a—Standard Specification for Deformed and Plain, Low-Carbon, Chromium, Steel Bars for Concrete Reinforcement

ASTM A1044/A1044M-16—Standard Specification for Steel Stud Assemblies for Shear Reinforcement of Concrete

ASTM A1055/A1055M-10e1—Standard Specification for Zinc and Epoxy Dual-Coated Steel Reinforcing Bars

ASTM A1060/A1060M-16—Standard Specification for Zinc-Coated (Galvanized) Steel Welded Wire Reinforcement, Plain and Deformed, for Concrete