

Chapter 2

QUALITY ASSURANCE

2.1 GENERAL

2.1.1 Scope. This chapter provides minimum requirements for quality assurance for seismic-force-resisting systems and designated seismic systems. These requirements supplement the testing and inspection requirements contained in the reference standards given elsewhere in these *Provisions*.

2.1.2 References. The following documents shall be used as specified in this chapter.

- ACI 318 *Building Code Requirements for Structural Concrete*, American Concrete Institute, 1999.
- ACI 530 *Building Code Requirements for Masonry Structures* (ACI 530-99/ASCE 5-99/TMS 402-99), American Concrete Institute/American Society of Civil Engineers/The Masonry Society, 1999.
- ACI 530.1 *Specifications for Masonry Structures* (ACI 530.1-99/ASCE 6-99/TMS 602-99), American Concrete Institute/American Society of Civil Engineers/The Masonry Society, 1999.
- AISC LRFD *Load and Resistance Factor Design Specification for Structural Steel Buildings*, American Institute of Steel Construction, 1993.
- AISC Seismic *Seismic Provisions for Structural Steel Buildings*, Part I, American Institute of Steel Construction, 1997, including Supplement No. 2 (2000).
- ASTM A 435 *Standard Specification for Straight Beam Ultrasound Examination of Steel Plates* (A 435-90), American Society for Testing and Materials, 1996.
- ASTM A 615 *Standard Specification for Deformed and Plain Billet-steel Bars for Concrete Reinforcement* (A 615/A 615M-96a), American Society for Testing and Materials, 1996.
- ASTM A 898 *Standard Specification for Straight Beam Ultrasound Examination for Rolled Steel Structural Shapes* (A 898/A 898M-91), American Society for Testing and Materials, 1996.

2.1.3 Definitions

Approval: The written acceptance by the authority having jurisdiction of documentation that establishes the qualification of a material, system, component, procedure, or person to fulfill the requirements of these *Provisions* for the intended use.

Boundary elements:

In wood construction, members at the boundaries of diaphragms and shear walls to which sheathing transfers forces. Such elements include chords and drag struts at diaphragm and shear wall perimeters, interior openings, discontinuities, and re-entrant corners.

In concrete and masonry construction, portions along wall and diaphragm edges strengthened by longitudinal and transverse reinforcement and/or structural steel members.

Component: See Sec. 1.1.4.

Construction documents: The written, graphic, electronic, and pictorial documents describing the design, locations, and physical characteristics of the project required to verify compliance with these *Provisions*.

Continuous special inspection: A full-time observation of the work by an approved special inspector who is present in the area where work is being performed.

Designated seismic system: Those architectural, mechanical, and electrical systems and their components that require design in accordance with Sec. 6.1 and that have a component importance factor, I_p , greater than 1.

Design strength: See Sec. 4.1.3.

Diaphragm: See Sec. 4.1.3.

Drag strut: See Sec. 4.1.3.

Glazed curtain wall: See Sec. 6.1.3.

Glazed storefront: See Sec. 6.1.3.

Intermediate moment frame: See Sec. 4.1.3.

Isolation system: See Sec. 13.1.2.

Isolator unit: See Sec. 13.1.2.

Moment frame: See Sec. 4.1.3.

Partition: See Sec. 5.1.2.

Periodic special inspection: The part-time or intermittent observation of the work by an approved special inspector who is present in the area where work has been or is being performed.

Quality Assurance: The systematic program of special inspections, structural observations, testing and reporting which provides the independent documentation that the project is constructed in accordance with the construction documents.

Quality Assurance Plan: A detailed, written procedural document, prepared by one or more registered design professionals, that establishes the systems and components subject to special inspection and testing.

Quality Control: The operational procedures provided by contractors to ensure compliance with the construction documents and regulatory requirements.

Registered design professional: An architect or engineer, registered or licensed to practice professional architecture or engineering, as defined by statutory requirements of the professional registrations laws of the state in which the project is to be constructed.

Seismic Design Category: See Sec. 1.1.4.

Seismic-force-resisting system: See Sec. 1.1.4.

Seismic Use Group: See Sec. 1.1.4.

Shear panel: See Sec. 4.1.3.

Shear wall: See Sec. 4.1.3.

Special inspection: The observation of the work by the special inspector to determine compliance with the approved construction documents and these *Provisions*.

Special inspector: A person or persons approved by the authority having jurisdiction as being qualified to perform special inspection required by the approved quality assurance plan. The quality assurance personnel of a fabricator are permitted to be approved by the authority having jurisdiction as a special inspector.

Special moment frame: See Sec. 4.1.3.

Story: See Sec. 4.1.3.

Structural observations: The visual observations performed by the registered design professional in responsible charge (or another registered design professional) to determine that the seismic-force-resisting system is constructed in general conformance with the construction documents.

Structure: See Sec. 1.1.4.

Testing agency: A company or corporation that provides testing and/or inspection services. The person in responsible charge of the special inspector and the testing services shall be a registered design professional.

Tie-down: See Sec. 12.1.3.

Veneer: Facing or ornamentation of brick, concrete, stone, tile, or similar materials attached to a backing.

2.1.4 Notation

S_{DS} See Sec. 3.1.4.

2.2 GENERAL REQUIREMENTS

As required in this section, a quality assurance plan shall be submitted to the authority having jurisdiction. A quality assurance plan, special inspection, and testing as set forth in this chapter shall be provided for the following:

1. The seismic-force-resisting systems in structures assigned to Seismic Design Category C, D, E, or F.
2. Designated seismic systems in structures assigned to Seismic Design Category D, E, or F.

Exception: Structures that comply with item a and item b and with either item c or item d of the following criteria are exempt from the preparation of a quality assurance plan but are not exempt from special inspection or testing requirements:

- a. The structure is assigned to Seismic Use Group I.
- b. The structure does not have any of the following irregularities as defined in Tables 4.3-2 and 4.3-3:
 - i. Torsional irregularity,
 - ii. Extreme torsional irregularity,
 - iii. Nonparallel systems,
 - iv. Stiffness irregularity—soft story,
 - v. Stiffness irregularity—extreme soft story,
 - vi. Discontinuity in capacity—weak story.
- c. The structure is constructed of light wood framing or light gauge cold-formed steel framing, S_{DS} does not exceed 0.5, and the height of the structure does not exceed 35 ft above grade.
- d. The structure is constructed using a reinforced masonry structural system or reinforced concrete structural system, S_{DS} does not exceed 0.5, and the height of the structure does not exceed 25 ft above grade.

2.2.1 Details of quality assurance plan. The registered design professional in responsible charge of the design of a seismic-force-resisting system or a designated seismic system shall be responsible for the portion of the quality assurance plan applicable to that system. The quality assurance plan shall include:

1. A listing of the seismic-force-resisting systems and designated seismic systems that are subject to quality assurance in accordance with this chapter.
2. The required special inspection and testing.
3. The type and frequency of testing.

4. The type and frequency of special inspection.
5. The frequency and distribution of testing and special inspection reports.
6. The structural observations to be performed.
7. The frequency and distribution of structural observation reports.

2.2.2 Contractor responsibility. Each contractor responsible for the construction of a seismic-force-resisting system, designated seismic system, or component listed in the quality assurance plan shall submit a written contractor's statement of responsibility to the authority having jurisdiction and to the owner prior to the commencement of work on the system or component. The contractor's statement of responsibility shall contain the following:

1. Acknowledgment of awareness of the requirements contained in the quality assurance plan;
2. Acknowledgment that control will be exercised to obtain conformance with the construction documents approved by the authority having jurisdiction;
3. Procedures for exercising control within the contractor's organization, the method and frequency of reporting, and the distribution of the reports; and
4. Identification and qualifications of the person(s) exercising such control and their position(s) in the organization.

2.3 SPECIAL INSPECTION

The owner shall employ a special inspector who, at a minimum, shall perform the following inspections:

2.3.1 Piers, piles, and caissons. Continuous special inspection during driving of piles and placement of concrete in piers, piles, and caissons. Periodic special inspection during construction of drilled piles, piers, and caissons including the placement of reinforcing steel.

2.3.2 Reinforcing steel

2.3.2.1. Periodic special inspection during and upon completion of the placement of reinforcing steel in intermediate moment frames, in special moment frames, and in shear walls.

2.3.2.2. Continuous special inspection during the welding of reinforcing steel resisting flexural and axial forces in intermediate moment frames and special moment frames, in boundary elements of concrete shear walls, and during welding of shear reinforcement.

2.3.3 Structural concrete. Periodic special inspection during and on completion of the placement of concrete in intermediate moment frames, in special moment frames, and in boundary elements of shear walls.

2.3.4 Prestressed concrete. Periodic special inspection during the placement and after completion of placement of prestressing steel and continuous special inspection during all stressing and grouting operations and during the placement of concrete.

2.3.5 Structural masonry

2.3.5.1. Periodic special inspection during the preparation of mortar, the laying of masonry units, and placement of reinforcement, and prior to placement of grout.

2.3.5.2. Continuous special inspection during the welding of reinforcement, grouting, consolidation, reconsolidation, and placement of bent-bar anchors as required by Sec. 11.6.4.1.

2.3.6 Structural steel

2.3.6.1. Continuous special inspection for all structural welding.

Exception: Periodic special inspection is permitted for single-pass fillet or resistance welds and welds loaded to less than 50 percent of their design strength provided the qualifications of the

welder and the welding electrodes are inspected at the beginning of the work and all welds are inspected for compliance with the approved construction documents at the completion of welding.

2.3.6.2. Periodic special inspection in accordance with AISC LRFD for installation and tightening of fully tensioned high-strength bolts in slip-critical connections and in connections subject to direct tension. Bolts in connections identified as not being slip-critical or subject to direct tension need not be inspected for bolt tension other than to ensure that the plies of the connected elements have been brought into snug contact.

2.3.7 Structural wood

2.3.7.1. Continuous special inspection during all field gluing operations of elements of the seismic-force-resisting system.

2.3.7.2. Periodic special inspection for nailing, bolting, anchoring, and other fastening of components within the seismic-force-resisting system including drag struts, braces, and tie-downs.

2.3.7.3. Periodic special inspection for wood shear walls, shear panels, and diaphragms that are included in the seismic-force-resisting system and for which the *Provisions* require the spacing of nails, screws, or fasteners for wood sheathing to be 4 in. or less on center.

2.3.8 Cold-formed steel framing

2.3.8.1. Periodic special inspections during all welding operations of elements of the seismic-force-resisting system.

2.3.8.2. Periodic special inspections for screw attachment, bolting, anchoring, and other fastening of components within the seismic-force-resisting system, including struts, braces, and tie-downs.

2.3.9 Architectural components. Special inspection for architectural components shall be as follows:

1. Periodic special inspection during the erection and fastening of exterior cladding, interior and exterior nonbearing walls, and interior and exterior veneer in Seismic Design Category D, E, or F.

Exceptions:

- a. Architectural components less than 30 ft (9 m) above grade or walking surface
 - b. Cladding and veneer weighing 5 lb/ft² (24.5 N/m²) or less
 - c. Interior nonbearing walls weighing 15 lb/ft² (73.5 N/m²) or less.
2. Periodic special inspection during erection of glass 30 ft (9 m) or more above an adjacent grade or walking surface in glazed curtain walls, glazed storefronts, and interior glazed partitions in Seismic Design Category D, E, or F.
 3. Periodic special inspection during the anchorage of access floors, suspended ceiling grids, and storage racks 8 ft (2.4 m) or more in height in Seismic Design Category D, E, or F.

2.3.10 Mechanical and electrical components. Special inspection for mechanical and electrical components shall be as follows:

1. Periodic special inspection during the anchorage of electrical equipment for emergency or standby power systems in Seismic Design Category C, D, E, or F;
2. Periodic special inspection during the installation of anchorage of all other electrical equipment in Seismic Design Category E or F;
3. Periodic special inspection during installation for flammable, combustible, or highly toxic piping systems and their associated mechanical units in Seismic Design Category C, D, E, or F;

4. Periodic special inspection during the installation of HVAC ductwork that will contain hazardous materials in Seismic Design Category C, D, E, or F; and
5. Periodic special inspection during the installation of vibration isolation systems where the construction documents call for a nominal clearance (air gap) between the equipment support frame and restraint less than or equal to 0.25 inches.

2.3.11 Seismic isolation system. Periodic special inspection during the fabrication and installation of isolator units and energy dissipation devices if used as part of the seismic isolation system.

2.4 TESTING

The special inspector shall be responsible for verifying that the testing requirements are performed by an approved testing agency for compliance with the following:

2.4.1 Reinforcing and prestressing steel. Special testing of reinforcing and prestressing steel shall be as follows:

2.4.1.1. Examine certified mill test reports for each shipment of reinforcing steel used to resist flexural and axial forces in reinforced concrete intermediate frames, special moment frames, and boundary elements of reinforced concrete shear walls or reinforced masonry shear walls and determine conformance with the construction documents.

2.4.1.2. Where ASTM A 615 reinforcing steel is used to resist earthquake-induced flexural and axial forces in special moment frames and in wall boundary elements of shear walls in structures assigned to Seismic Design Category D, E, or F, verify that the requirements of Sec. 21.2.5 of ACI 318 have been satisfied.

2.4.1.3. Where ASTM A 615 reinforcing steel is to be welded, verify that chemical tests have been performed to determine weldability in accordance with Sec. 3.5.2 of ACI 318.

2.4.2 Structural concrete. Samples of structural concrete shall be obtained at the project site and tested in accordance with requirements of ACI 318.

2.4.3 Structural masonry. Quality assurance testing of structural masonry shall be in accordance with the requirements of ACI 530 and ACI 530.1.

2.4.4 Structural steel. The testing needed to establish that the construction is in conformance with these *Provisions* shall be included in a quality assurance plan. The minimum testing contained in the quality assurance plan shall be as required in AISC Seismic and the following requirements:

2.4.4.1 Base metal testing. Base metal thicker than 1.5 in. (38 mm), where subject to through-thickness weld shrinkage strains, shall be ultrasonically tested for discontinuities behind and adjacent to such welds after joint completion. Any material discontinuities shall be accepted or rejected on the basis of ASTM A 435 or ASTM A 898 (Level 1 Criteria) and criteria as established by the registered design professional in responsible charge and the construction documents.

2.4.5 Mechanical and electrical equipment. As required to ensure compliance with the seismic design requirements herein, the registered design professional in responsible charge shall clearly state the applicable requirements on the construction documents. Each manufacturer of designated seismic system components shall test or analyze the component and its mounting system or anchorage as required and shall submit evidence of compliance for review and acceptance by the registered design professional in responsible charge of the designated seismic system and for approval by the authority having jurisdiction. The evidence of compliance shall be by actual test on a shake table, by three-dimensional shock tests, by an analytical method using dynamic characteristics and forces, by the use of experience data (i.e., historical data demonstrating acceptable seismic performance), or by more rigorous analysis providing for equivalent safety. The special inspector shall examine the designated seismic system and shall determine whether the anchorages and label conform with the evidence of compliance.

2.4.6 Seismically isolated structures. Isolation system components shall be tested in accordance with Sec 13.6.

2.5 STRUCTURAL OBSERVATIONS

Structural observations shall be provided for those structures assigned to Seismic Design Category D, E, or F where one or more of the following conditions exist:

1. The structure is included in Seismic Use Group II or Seismic Use Group III or
2. The height of the structure is greater than 75 ft above the base or
3. The structure is in Seismic Design Category E or F and Seismic Use Group I and is greater than two stories in height.

Observed deficiencies shall be reported in writing to the owner and the authority having jurisdiction.

2.6 REPORTING AND COMPLIANCE PROCEDURES

Each special inspector shall furnish copies of inspection reports, noting any work not in compliance with the approved construction documents and corrections made to previously reported work to the authority having jurisdiction, registered design professional in responsible charge, the owner, the registered design professional preparing the quality assurance plan, and the contractor. All deficiencies shall be brought to the immediate attention of the contractor for correction.

At completion of construction, each special inspector shall submit a report certifying that all inspected work was completed substantially in compliance with the approved construction documents. Work not in compliance with the approved construction documents shall be described in the report.

At completion of construction, the contractor shall submit a final report to the authority having jurisdiction certifying that all construction work incorporated into the seismic-force-resisting system and other designated seismic systems was constructed substantially in compliance with the approved construction documents.

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