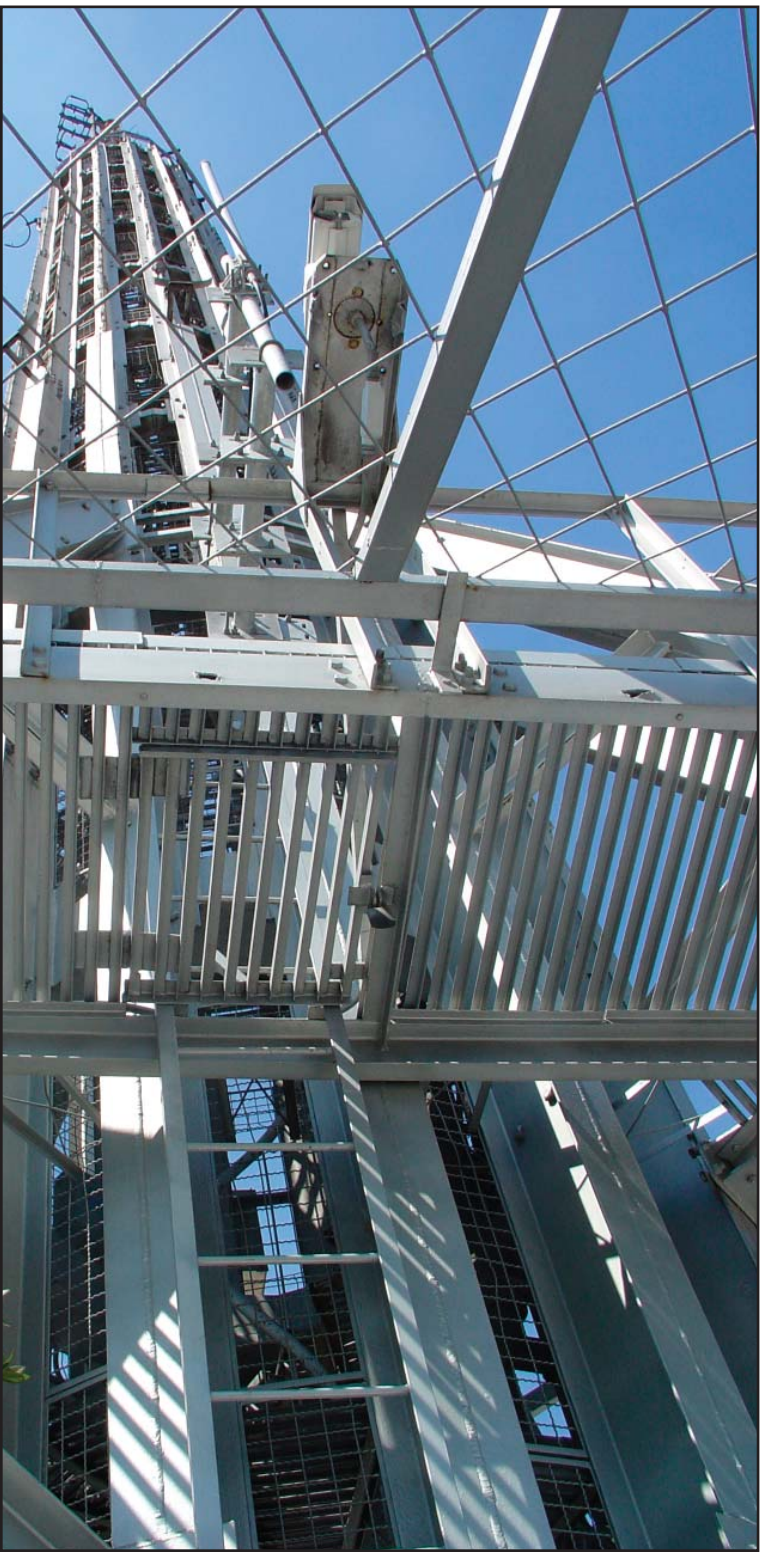
Inspection of Steel Construction

By Robert E. Shaw, Jr., P.E.

Under the *International Building Code* (IBC), the structural engineer has distinct responsibilities regarding the inspection of structural systems, whether structural steel, concrete, or masonry. The IBC administrative provisions call for a "Statement of Special Inspections" to be prepared by a registered design professional as a part of the building permit application, and this task most frequently, and appropriately, falls on the structural engineer. IBC Section 17 contains specific requirements for what is termed "special inspection". These provisions are not completely new to those working previously under the *Uniform Building Code* or the *National Building Code*, which were blended to form the IBC provisions, but are new to those working previously under the *Standard Building Code*.



Even before inspection of the fabricated steel begins, inspection is required to verify the ability of the steel fabricator to perform the necessary fabrication, including their quality control activities, in accordance with code requirements and the project specifications. Such inspections may be waived by the Authority Having Jurisdiction. This is commonly done when the fabricator is certified by the American Institute of Steel Construction (AISC), listed by the International Accreditation Service (IAS), or otherwise accepted by those code jurisdictions, such as the City of Los Angeles, with formal fabricator approval programs.

For structural steel, the three basic tasks for special inspection involve welding, high-strength bolting, and the details of construction such as member locations, bracing, gusset plates, stiffeners and other connection components. In addition to the observation of welding and bolting activities, verifying identification of the structural steel materials, welding filler metals, and high-strength bolts is required, along with reviewing material certifications for these items.

Welding Inspection

Welding inspection tasks are those referenced by the American Welding Society's *D1.1 Structural Welding Code - Steel*. Numerous items are specifically addressed within AWS D1.1. However, under AWS D1.1 it is stated that welding inspection tasks are performed by the fabricator's or erector's own inspectors, and verification inspection is performed only at the prerogative of the Owner. Therefore, it is advisable to specifically list those tasks to be performed by the special inspector.

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The IBC requires continuous special inspection during all welding activities, with certain exceptions and under certain conditions. Continuous special inspection means that the inspector is present, on site, whenever welds are being made. The exception to this general requirement for continuous special inspection is made for single pass fillet welds that are 5/16-inch or less in size, for shear connector (stud) welds, for arc spot (puddle) welds attaching floor and roof decking, for welds on cold-formed sheet steels such as studs and joists, and for welds of stairs and railing systems. When this exception is implemented, pre-welding inspection to confirm the proper materials, welding procedures and welding personnel qualifications are mandated.

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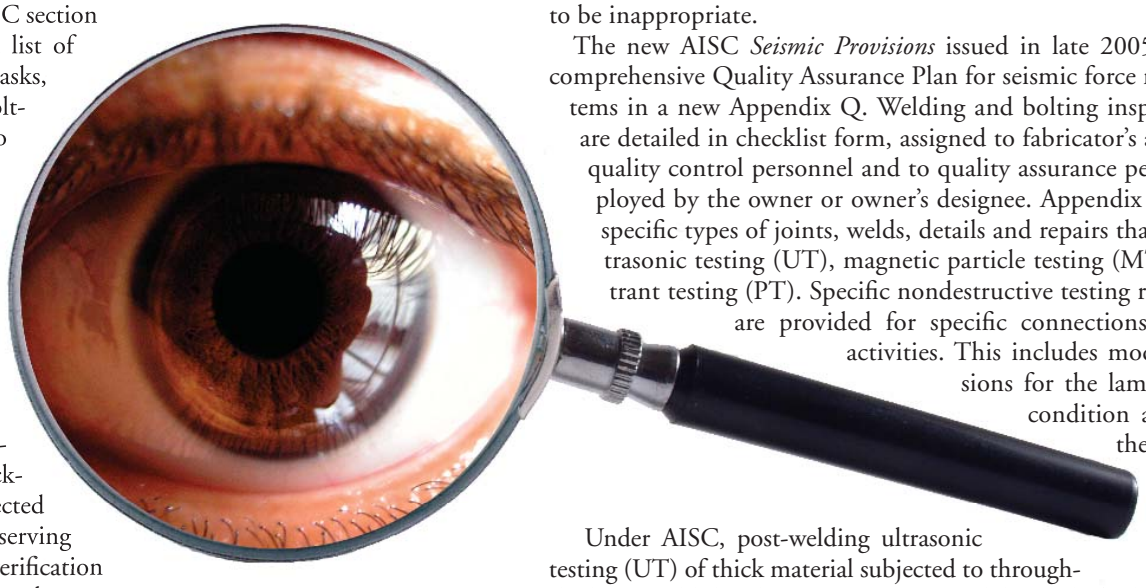
For these cases, periodic inspection of welding operations and final visual inspection of all completed welds is also required.

No nondestructive testing (NDT) is required by the IBC, with the exception of seismic-force-resisting systems in Seismic Design Category D, E or F. Similarly, AWS D1.1 does not require NDT, except for specific conditions such as repairs to certain mislocated holes in fatigue applications or to achieve a given fatigue category for CJP groove-welded joints. Therefore, any NDT required for a project must be specifically identified in the contract documents, identifying the types, categories and/or locations of welds to be tested.

High-Strength Bolting Inspection

The IBC contains specific requirements for the inspection of high-strength bolted connections. It directly references the AISC *Specification for Structural Steel Buildings*, which in turns references the RCSC (Research Council on Structural Connections) *Specification for Structural Joints Using ASTM A325 or A490 Bolts*. In addition, IBC section 1704.3.3 provides a list of bolting inspection tasks, then categorizes bolting inspection into periodic or continuous inspection depending upon the joint type and the method of installation.



Inspection tasks include verifying bolting materials, reviewing the material certifications, checking that the connected parts are correct, observing the pre-installation verification testing performed by the contractor, and observing the pretensioning operations. For snug tight joints, only periodic inspection is required, including checking materials and certifications, connected parts and visually inspecting the completed joint. No pre-installation testing is needed. Periodic special inspection is also called for with turn-of-nut installation when match-marking is employed, with twist-off bolt installation, and with direct tension indicator installation. Continuous special inspection is needed with turn-of-nut installation when match-marking is not employed, and with calibrated wrench installation. It should be noted that neither the RCSC nor IBC provisions call for any degree of torque testing of installed bolts, an inspection "tradition" whose time has passed.

Should there be a dispute regarding the installed bolt pretensions achieved for a particular connection or group of connections, the RCSC provides methodologies to be employed for slip-critical joints and specific pretensioned joints. The vast majority of pretensioned joints, and all snug-tight joints, fall outside the need for dispute resolution.

Details

In addition to the inspection of welding and bolting operations, inspection is to be performed to ensure proper placement of members and braces, and the proper use of connection details such as stiffeners. Such inspections are to be performed on a periodic basis.

Seismic-Force-Resisting Systems

Structures that fall into Seismic Design Category C, D, E or F must have a Quality Assurance Plan for the seismic-force-resisting system that includes additional special inspection requirements and structural testing. The Plan must be prepared by a registered design professional, and this task typically falls on the structural engineer.

The IBC references the AISC *Seismic Provisions for Structural Steel Buildings* for structural steel inspection and for nondestructive testing. The emphasis of the AISC *Seismic Provisions* has been visual welding inspection during welding operations, supplemented with specific nondestructive testing requirements for groove welds. The IBC requires continuous special inspection for seismic-force-resisting system welding, rather than periodic inspection, with exceptions provided for small single-pass fillet welds and for welds attaching floor and roof decks. The IBC also requires ultrasonic testing for lamellar tearing when welds are made to the side of materials thicker than 1-½ inches; however the acceptance criteria cited is quite liberal and considered by many to be inappropriate.

The new AISC *Seismic Provisions* issued in late 2005 provides a comprehensive Quality Assurance Plan for seismic force resisting systems in a new Appendix Q. Welding and bolting inspection tasks are detailed in checklist form, assigned to fabricator's and erector's quality control personnel and to quality assurance personnel employed by the owner or owner's designee. Appendix Q identifies specific types of joints, welds, details and repairs that require ultrasonic testing (UT), magnetic particle testing (MT), or penetrant testing (PT). Specific nondestructive testing requirements are provided for specific connections and repair activities. This includes modified provisions for the lamellar tearing condition addressed in the IBC.

Under AISC, post-welding ultrasonic testing (UT) of thick material subjected to through-thickness weld shrinkage strains is required, but only for limited welds, and a more rational acceptance criteria is provided.

The new AISC *Seismic Provisions* includes a new Appendix W on specific welding issues, including weld material and quality issues, to address these concerns until the American Welding Society issues the new *AWS D1.8 - Structural Welding Code - Seismic Supplement*.

Windforce-Resisting Systems

Similar to seismic systems, structures in Wind Exposure Categories A and B with a 3-second gust wind speed of 120 mph or greater, and in Wind Exposure Categories C and D with a three-second gust wind speed of 110 mph or greater, must have a Quality Assurance Plan for the windforce-resisting system. The Plan must be prepared by a registered design professional, and this task typically falls on the structural engineer.

Unlike seismic-force-resisting systems, the IBC does not reference any additional standards for either inspection or nondestructive testing. The Engineer must identify these needs in the contract documents.

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Structural Observations

Structural observation is the visual observation of the structural system for compliance to the design, and is performed at significant stages of construction and at the completion of the structural system. Under the IBC, structural observations by a registered design professional are required for certain structures in Seismic Design Categories D, E and F, and for certain structures located where the basic wind speed exceeds 110 mph. In addition, the jurisdiction may require such observations, or the engineer may call for such observations to be performed.

Structural observation is not a replacement for inspection, and should not be used as a means to secure a certificate of occupancy when inspection has not been performed. The tasks to be performed during structural observation are not defined in the IBC or in other standards, but references such as FEMA 353 are frequently used for seismic-force-resisting systems.

Conclusions

Special inspections of structural systems are mandated under the International Building Code for virtually any project in which structural engineers are involved. The structural engineer should take the lead in establishing the required statement of special inspections to ensure that the structure is constructed in compliance with the engineer's design. The engineer will likely have a lead role in reviewing structural inspection reports and addressing the inevitable issues that arise during construction. In addition, there may be a need for the engineer to make onsite visits to conduct structural observations.

For steel construction, the inspection and testing tasks are well-defined by the IBC, with technical provisions provided in AISC, AWS and RCSC specifications. The structural engineer should be familiar with these standards to ensure that needed inspections are addressed in contract documents and appropriately performed before, during and upon completion of the structure.▪

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