

**PART II**  
**RECOMMENDED QUALITY ASSURANCE**  
**GUIDELINES**



## Part II: RECOMMENDED QUALITY ASSURANCE GUIDELINES

### 1. GENERAL

#### 1.1 Scope

Part II of these *Recommendations* is to provide information relevant to the quality control (QC) and quality assurance (QA) of the seismic-force-resisting systems of steel moment-frame buildings, in regions subject to potential damaging earthquake ground motion. It is intended to be used in coordination with, and in supplement to, locally applicable building codes and those national standards referenced by the building code. Included are discussions on:

- the various terms used regarding inspection functions (Part II, Chapter 1),
- basic quality control and quality assurance issues (Part II, Chapter 1),
- recommended Contractor (fabricator or erector) qualifications and Quality Control Program for the control of the quality of fabricated and erected structural steel (Part II, Chapter 2),
- recommended Quality Assurance (inspection and testing) Agency qualifications and the qualifications and duties of individual inspection and testing personnel (Part II, Chapter 3),
- recommended requirements and practices for structural steel material (quality, control, and inspection) (Part II, Chapter 4),
- recommended requirements and practices for welding material (quality, control, and inspection); and welding operations (quality and inspection) (Part II, Chapter 5),
- recommended requirements and practices for bolting material (quality, control, and inspection); and bolting operations (quality and inspection) (Part II, Chapter 6).

*Commentary: These Recommended Quality Assurance Guidelines apply to the construction of steel moment frames used as the seismic-force-resisting elements of buildings and other structures. As used in these Recommendations, the terms “steel structure” or “steel framing” apply to the structural steel elements of the seismic-force-resisting system as defined in FEMA-302. The quality assurance and control guidelines contained in these Recommendations could be extended to the construction of other types of seismic-force-resisting systems and even to elements of structures that are not intended to be part of the seismic-force-resisting system. However, extension of these Recommendations to these other construction types and elements could result in a significant construction cost premium. These Recommendations are deemed appropriate to application to the construction of steel moment frames used in seismic-force-resisting systems due to the severe service conditions anticipated for those frames and the proven sensitivity of frame performance to construction quality. Specifically, investigations of damaged steel moment-frame connections following the 1994 Northridge earthquake revealed numerous instances of construction that did not conform to the applicable standards. Common deficiencies included the use of improper weld tabs, welded*

*joints with excessive bead size and, frequently, large zones at the roots of critical welded joints with lack of fusion and with slag inclusions. These defects contributed directly to the initiation of fractures in these joints. Further, investigations performed as part of this project confirm the following: the importance of weld quality and toughness to connection performance; the sensitivity of welded joint toughness to welder technique; and the general inability of inspection practices commonly employed in the past to provide adequate control to obtain reliable performance. The Quality Assurance Guidelines recommended herein are intended to address these issues directly. Although quality control of other construction systems is also important, it has not been demonstrated that the specific recommendations contained herein are either appropriate or necessary to obtaining reliable performance of those other construction systems.*

## **1.2 Terms**

This section describes some of the basic elements of a program necessary to ensure that construction meets the required standards. It also describes the recommended roles and responsibilities of key project participants in this process.

### **1.2.1 Quality Control**

Quality Control (QC) includes those functions to be performed by the Contractor to ensure that the material and workmanship of construction meet the Quality Requirements. QC includes inspection and testing of fabrication and erection, as defined by AWS *D1.1-2000*, unless otherwise provided for in the Quality Assurance Plan or the Contract Documents. Fabrication and erection inspection includes routine welding inspection items such as personnel control, material control, dimensional control, preheat measurement, monitoring of welding procedures, visual inspection and nondestructive testing when specified.

*Commentary: QC functions vary considerably between shop and field operations. For field work, less QC is typically provided, and there is a higher reliance upon Quality Assurance. Nonetheless, field QC is necessary to ensure quality in field operations, and must be provided by the Contractor performing field welding, field bolting, and related steel construction work.*

### **1.2.2 Quality Assurance**

Quality Assurance (QA) consists of those inspection services to be performed by an agency or firm other than the Contractor. QA is performed at the prerogative of the Owner, and may be mandated by the building code. QA includes monitoring the performance of the Contractor in implementing the Contractor's QC Program, ensuring that designated QC functions are performed properly by the Contractor on a routine basis. To ensure compliance, QA may also include performance of specific inspection tasks that may be similarly included in the Contractor's QC Plan, including the performance of nondestructive testing. Quality Assurance is termed "Verification Inspection" in AWS *D1.1-2000*.

### 1.2.3 Quality Control Plan

The Quality Control Plan is a written statement, prepared by the Contractor, of all measures that will be taken to ensure that steel moment-frame construction conforms to the applicable standards, project specifications, and the Quality Assurance Plan. Key parts of the QC Plan should include a description of the organizational structure, responsibilities, practices, procedures, processes, and resources for implementing and maintaining the project quality requirements, and ongoing efforts to monitor the effectiveness of the Plan. The Contractor's QC Plan should ensure that all parties understand what is to be constructed and the standards that apply.

### 1.2.4 Quality Assurance Plan

The Quality Assurance Plan is a written statement of the quality requirements for the project, prepared by the Engineer and typically containing two components: (1) the set of material and workmanship standards that the finished construction must meet, and (2) the set of procedures that are to be followed to confirm compliance with these requirements.

Elements in an acceptable Quality Assurance Plan must meet or exceed the requirements of the building code.

The Quality Assurance Plan should include:

- identification of the seismic force resisting system elements subject to the Plan,
- required Contractor Quality Control procedures,
- required services of the Engineer, including but not limited to the following:
  - review of required Contractor submittals,
  - monitoring of required inspection reports and test results,
  - construction consultation as required by the Contractor on the intent of the construction documents,
  - procedures for modification of the construction documents to reflect the demands of unforeseen field conditions discovered during construction,
- a listing of all Special Inspections and testing required by the building code, supplemental inspections and testing required by the Engineer, as well as the reference standards and the project standards,
- the type and frequency of Special Inspections, including a schedule for any periodic inspections,
- the type and frequency of testing,
- the frequency and distribution of special inspection and testing reports,
- the structural observations to be performed, and
- the frequency and distribution of structural observation reports.

The Quality Assurance Plan is typically prepared using reference to building code requirements and approved national standards, and supplemented by individual project specifications.

*Commentary: A Quality Assurance Plan is required under the provisions of IBC Section 1705. The minimum requirements for the Plan are provided in IBC Section 1705.2.*

*A registered design professional must prepare the Quality Assurance Plan. See IBC Section 1705.2. Commonly, the Owner contracts with the engineer in responsible charge of the design for the preparation of the Quality Assurance Plan for the structural system. It is recommended in FEMA-302 that this engineer prepare the Quality Assurance Plan for the structural system, as this person is most familiar with the critical features of the designs that are important to its performance.*

### 1.2.5 Contract Documents

The Contract Documents are all those drawings, specifications, notes and other documents prepared by the Engineer or other registered design professional, that define the structural system and quality requirements. The Contract Documents should include the specification of:

- the Quality Assurance Plan,
- the construction material,
- the requirements for Contractor material controls,
- if necessary, special material inspection requirements beyond standard practice or those designated in ASTM, AISC or AWS requirements,
- quality acceptance criteria,
- fabrication, erection, and installation tolerances, by reference to industry standards, and supplemented as needed for project-specific conditions, and
- the method of resolution of disputes regarding structural integrity.

The basic code requirements for structural welding of steel structures are contained in AWS *D1.1 - Structural Welding Code – Steel*. AWS *D1.1* uses the term “Fabrication/Erection Inspection” synonymously with the Quality Control function. The term “Verification Inspection” is used to describe the Quality Assurance function. AWS *D1.1* requires inspection for many items in Section 6, Part A, but does not specify whether the inspection is performed as either QC or QA. For this reason, distinction between QC and QA must be provided in the Quality Assurance Plan and Contract Documents.

Fabrication/Erection Inspection (or Quality Control), Verification Inspection (or Quality Assurance), and Nondestructive Testing should be performed at the same time whenever possible, to ensure that the Contractor's QC program is meeting the requirements of the Contract Documents.

### 1.2.6 Owner

Construction is performed on behalf of the owner. The Owner is responsible for providing Quality Assurance. The Owner must ensure that a suitable Quality Assurance Plan is established and implemented. The Owner should employ one or more Special Inspectors to observe the construction for compliance with the applicable standards and project specifications. The Owner may also direct the Engineer or other registered design professional to oversee the Quality Assurance function.

*Commentary: Should the Owner have insufficient expertise or knowledge related to construction, the Owner should retain a qualified Engineer or other registered design professional to advise the Owner, prepare the Quality Assurance Plan, and oversee the QA program.*

### 1.2.7 Engineer

The Engineer is the registered design professional in responsible charge of the design of the structural steel framing system. The Owner may select other registered design professionals for other related functions, including the preparation of the Quality Assurance Plan.

*Commentary: The Engineer or other registered design professional may assist the Owner in:*

- *establishing the Quality Requirements for the project, including the standards that the construction must meet and the QC and QA measures that are to be followed,*
- *establishing the Quality Assurance Plan for the project,*
- *establishing the necessary qualifications of the Contractor,*
- *establishing the necessary qualifications of the Quality Assurance Agency or firm,*
- *establishing the necessary qualifications of the individuals responsible for inspection and testing,*
- *evaluating the Contractor's Quality Control Plan, and*
- *evaluating the Quality Assurance Agency's Written Practice.*

The Engineer should additionally review Contractor submittals and prepare revisions to the structural drawings when necessitated by changes in the work.

### 1.2.8 Contractor

For the purposes of these *Recommendations*, the Contractor is the firm performing the fabrication or erection of the structural steel framework.

### 1.2.9 Building Official

As used in these *Recommendations*, the term Building Official is applied to the regulatory agency having jurisdiction of the building.

The Building Official should:

- require that construction documents, including the Quality Assurance Plan with at least the following items, be submitted prior to the issuance of a building permit:
  - a complete list of material and work requiring special inspections,
  - the inspections to be performed, and
  - a list of the individuals, approved agencies or firms intended to be retained for conducting such inspections;
- approve the final selection of Special Inspectors;
- maintain files of inspection reports for a defined length of time following completion;
- ascertain that all reported noncompliances have been rectified, or accepted by the Engineer as acceptable; and
- issue a certificate of occupancy.

*Commentary: Section 1704.1.1 of the International Building Code requires the listed items to be submitted prior to issuance of a building permit. Section 1704.1 requires the approval of the Special Inspector by the Building Official.*

### 1.2.10 Quality Assurance Agency

The Quality Assurance (QA) Agency is the independent testing organization selected by the Owner, or Owner's designee, to perform the Quality Assurance inspection and testing required by the Quality Assurance Plan, the specifications and the Contract Documents.

### 1.2.11 Special Inspector

The Special Inspector, as required by *International Building Code (IBC)* Section 1704.1, must be "a qualified person who shall demonstrate competence, to the satisfaction of the Building Official, for inspection of the particular type of construction or operation requiring special inspection." The Special Inspector is employed by the Owner, to provide the special inspections required. "Employed" in this case may be through a contractual relationship.

### 1.2.12 Special Inspection

Special Inspection is a Quality Assurance activity mandated by the Building Code. Special Inspection is defined by the *IBC* Section 1702.1 as "inspection as herein required of the materials, installation, fabrication, erection or placement of components and connections requiring special expertise to ensure compliance with approved construction documents and referenced standards."

Special Inspection is the detailed and specific inspection to ensure compliance with the Building Code. The duty of a Special Inspector is defined in *IBC* Section 1704.

#### **1.2.12.1 Continuous Special Inspection**

Continuous Special Inspection is the full-time observation and inspection of work requiring Special Inspection by an approved Special Inspector who is present in the area where the work is being performed.

#### **1.2.12.2 Periodic Special Inspection**

Periodic Special Inspection is the part-time or intermittent observation of work requiring Special Inspection by an approved Special Inspector who is present intermittently in the area where the work is being performed and who is present at the completion of the work.

#### **1.2.13 Nondestructive Testing**

Nondestructive testing (NDT) includes magnetic particle testing (MT), liquid dye penetrant testing (PT), radiographic testing (RT) and ultrasonic testing (UT). For the purpose of these *Recommendations*, the terms nondestructive examination (NDE) and nondestructive testing (NDT) are identical.

*Commentary: The purpose of NDT is to serve as a backup to Visual Inspection (VI) and to detect flaws and defects in base metals and welds that are not otherwise visible. NDT is not a replacement for an adequate program of QC, QA and VI, and should not be used as such.*

#### **1.2.14 Structural Observation**

Structural Observation is defined by the *IBC* in Section 1702.1 as “the visual observation of the structural system by a registered design professional for general conformance to the approved construction documents at significant construction stages and at completion of the structural system.”

Structural Observation should also include review of testing and inspection reports for general compliance with the construction documents. Observed deficiencies should be reported in writing to the Owner’s representative, Special Inspector, Contractor, and Building Official. A report to the same parties should be made at the completion of the structural work regarding the observations that have been made.

Structural Observation does not replace or waive Special Inspection, nor does it serve the same function. Requirements for Structural Observation are contained in *IBC* Section 1709. A recommended checklist for structural observation is included in Figure 1-1.

## Structural Observation Checklist

### (Steel Moment Frames for Seismic Application)

Perform Structural Observation upon completion of the first few moment connections and column splices, prior to placement of decking, covering by fireproofing, encasement in concrete or placement of other finishes. After verification of these moment connections, conduct Structural Observation on a periodic basis or when structural details or requirements change, and also upon completion of the structural framing.

Observation of welded joints is for general configuration of the joint only (for example, placement of components, weld type, backing presence, joint finishing), not for weld quality.

Measurement of members, connection material and welds is not a part of Structural Observation, as this is performed as a part of inspection.

#### *Checklist*

- Orientation and placement of connected components
- Removal of backing bars, as required
- Placement of reinforcing fillets, as required
- Removal and finishing of runoff tabs, as required
- Presence of continuity plates, as required
- Welding of continuity plates, as required
- Presence and type of doubler plates, as required
- Welding of doubler plates, as required
- Configuration and finish of access holes
- Placement of beam stiffeners, as required
- Contour and finish of RBS profile, if applicable
- Placement of welds for web connection, as required
- Type and placement of bolts
- Inaccessible conditions

### Figure 1-1 Structural Observation Checklist

*Commentary: Structural Observation, when required, must be performed by a registered design professional, typically the Engineer or the Engineer's designated representative.*

#### 1.2.15 Written Practice

The Written Practice is a document prepared by the Quality Assurance Agency describing its procedures for determining and ensuring the acceptability of the structure in accordance with the applicable codes, standards, specifications and procedures, including general inspection, material controls, visual welding inspection, and bolting inspection.

The Written Practice should describe the selection and administration of inspection personnel, and the training, experience and examination requirements for qualification and certification of inspection personnel.

### **1.2.16 Hold Point**

A Hold Point is a stage of interim construction completion, beyond which the work should not proceed until the designated inspector has completed the inspection tasks specified for this stage.

### **1.2.17 Observation Point**

An Observation Point is a stage of interim construction completion, beyond which work may proceed after the worker has completed the worker's own inspection, with further inspection provided by the designated inspector through observation of the work operations on a routine, occasional, random basis.

## **1.3 Pre-Job Meeting**

It is recommended that a pre-job meeting or series of meetings be held with the Owner's representative responsible for the preparation and administration of the Quality Assurance Plan, the Fabricator's and Erector's Quality Control personnel, and the Quality Assurance Agency's personnel to plan and discuss the project, fabrication procedures, erection procedures, and inspection procedures. Topics of discussion at such meetings should include:

- overall scope of work for the project,
- any special construction required by the Contract Documents,
- inspection responsibilities, including the duties of welding, bolting and other fabrication and erection personnel, the Fabricator's and Erector's QC personnel, and the QA Agency's personnel,
- the use of hold and observation points,
- any specific nondestructive testing requirements that apply to the project, particularly those exceeding Code requirements or typical practice,
- method of notification and approval relative to determining correction of nonconforming work,
- locations and production schedules for off-site work,
- schedule and application of any approved periodic inspection,
- conditions requiring notification of the Engineer or Building Official, or both, and
- reporting procedures and frequency.

Either through a meeting or by direct dissemination of the information, inspection personnel should also be provided information regarding project-specific requirements.

## **1.4 Fabrication and Erection Drawings**

The Contract Documents should require submittal of erection and shop drawings for the work. Shop drawings should provide sufficient information to allow fabrication to be performed. The erection drawings should identify piece marks for each fabricated element to be incorporated into the work, coordinated with the individual shop drawings. Any special erection sequence or erection instructions should be included on the erection drawings. The Engineer should review the shop and erection drawings to ensure that the overall structural configuration and detailing requirements conform to the design intent.