Chapter 3 Primary Rigid Frames

3.1 Rigid Frames

A rigid frame is a system of structural steel columns, rafters, and connections between the columns and rafters that can resist loads both vertically and horizontally. These rigid frame components are shop fabricated by the metal building manufacturer and bolted together in the field. Metal building systems commonly employ the primary rigid frames to transfer loads from both the roof and wall cladding and secondary framing (purlins, joists, girts, etc.) to the foundation. The rafter and column members of a rigid frame can be provided as either uniform depth or tapered depth members. The materials used to construct the rigid frame member may vary in width and thickness within the member as well. The rigid framing system should not be modified in the field to allow access for duct work or for other reasons without prior written approval by the registered design professional or the manufacturer's engineer.

Figure 3.1-1: Example of Rigid Frames

3.2 Tolerances

Variations are to be expected in the finished overall dimensions of structural steel rigid frames. Such variations are deemed to be within the limits of good practice if they do not exceed the cumulative effect of rolling, fabricating, and erection tolerances.

Inspection for conformity to fabrication and erection tolerances is performed by visual observations and measurements using tools such as rulers, tape measures, squares, calipers, string lines, and in the case of erection tolerances, surveying instruments. See Appendix A for the fabrication tolerances associated with built-up structural members. The construction documents will specify the tolerances permitted for a given project, which may differ from those referenced in this Guide.

Erection tolerances are set forth in the AISC Code of Standard Practice (AISC 303) Section 7. Individual structural members are considered plumb, level, and aligned if the deviation from plumb does not exceed 1:500 (See Figure 3.2-1). Additional tolerances are recommended for crane support systems in metal building system projects. Erection tolerances for crane runway

Figure 3.2-1: Non-Acceptable Vertical Tolerance

beams are given in Appendix A. This information was taken from the MBMA Common Industry Practices, MBSM Chapter IV. For additional information on cranes and metal buildings, refer to the MBSM Chapter II.

3.3 IBC Special Inspection Requirements for Fabricated Steel

When IBC Section 1705 requires special inspection or testing, the submittal documents that are part of an application for building permit must include a Statement of Special Inspections prepared by the registered professional in responsible charge, per IBC Section 1704.3.1. However, IBC Section 1704.2.5.2 excludes approved fabricators from this requirement.

Special inspections of structural load-bearing members and assemblies that are fabricated in a shop, such as that of the metal building manufacturer, are covered in the IBC Section 1704.2.5. The inspection requirements depend on whether a fabricator is approved by the Building Official in accordance with Section 1704.2.5.2. An approved fabricator is exempt from the special inspections required by IBC Section 1705.

If the fabricator that performs the work is not approved, IBC Section 1704.1 requires the owner or the registered design professional in responsible charge to employ an approved agency to perform inspections during construction for the types of work listed in IBC Section 1705.

3.3.1 Approved Fabricator

Special inspections normally called for by IBC Section 1705 are not required where the work is done on the premises of a fabricator registered and approved to perform such work without special inspection (see IBC Section 1704.2.5.2). The exemption further explains that this approval is based upon review of the fabricator's written procedural and quality control manuals and periodic auditing of fabrication practices by an approved special inspection agency.

MBMA and the International Accreditation Service (IAS), which is a wholly owned subsidiary of the International Code Council (ICC), developed a third-party accreditation program specifically for metal building system manufacturers. The IAS *Inspection Programs for Manufacturers of Metal Building Systems* (AC 472) is based on the requirements of Chapter 17 of the IBC and provides building officials with a means to approve manufacturers involved in the fabrication of metal building systems. The fabricator approval can eliminate the requirement for third party inspections in the manufacturer's shop, as explained in this Guide and in the MBMA Technical Bulletin, *IBC Special Inspection Requirements - Approved Fabricators are Exempted*, Spring 2012.

While the approved fabricator is exempt from special inspections, IBC Section 1704.2.5.2 still requires that "at completion of fabrication, the approved fabricator shall submit a certificate of compliance to the building official stating that the work was performed in accordance with the approved construction drawings."

3.3.2 Non-Approved Fabricator

IBC Section 1704.2.5 requires special inspection of structural load-bearing members and assemblies that are fabricated on the premises of a non-approved fabricator's shop. For a non-approved steel fabricator, the special inspection requirements of IBC Section 1705.2 for structural steel are to be in accordance with the quality assurance requirements of AISC Specification (AISC 360) Chapter N.

3.4 Inspection of Welding

The primary inspection method for welding is visual inspection. As noted above, special inspections would not be required for an approved fabricator unless called out on the approved construction documents. For a non-approved fabricator, welding inspection provisions may be required. Additionally, any on-site welding would need to be inspected as required in AISC Specification (AISC 360) Chapter N.

3.4.1 One-Sided Welds

The metal building industry has pioneered the use of one-sided web to flange welding techniques. AISC 360 and AWS D1.1 Specifications do not disallow the use of one-sided welds, and if such welds are used, proper controls on the welding techniques are required to make sure the joint is properly executed. The web to flange welds in metal buildings are typically not loaded in tension but are primarily loaded in shear. This permits the use of one-sided fillet welds without concerns of rotation about the longitudinal axis of the weld. However, if the fillet weld is subject to loads that impart significant rotation, stiffeners or other means should be used to preclude this rotational loading on the weld.

3.5 Inspection of High Strength Bolted Connections

The inspection of bolting depends on the type of joint and the installation technique used. AISC Specification (AISC 360) Section N5.6 refers to the *Specification for Structural Joints Using High-Strength Bolts*, published by the Research Council on Structural Connections (RCSC). The RCSC Specification identifies three types of joints: Snug-Tightened Joints (Section 4.1), Pre-tensioned Joints (Section 4.2), and Slip-Critical Joints (Section 4.3). Snug-tightened joints are the most common used in a metal building system and are detailed in Section 3.5.1 of this Guide. Pre-tensioned joints and slip critical joints are very similar in their inspection requirements and are detailed in Section 3.5.2 of this Guide. The manufacturer's erection drawings provide information on bolt or fastener type, which type of joint is to be used, as well as the sequence of bolting connections to allow proper access to tighten the bolts when necessary. RCSC defines a high-strength bolt as an ASTM A325 or A490 bolt, an ASTM F1852 or F2280 twist-off-type tension-control bolt or an alternative-design fastener that meets the requirement in RCSC Section 2.8.

> Users note: Although this publication references the AISC 360-10 and subsequent ASTM standards referenced therein, the AISC 360-16 edition, that will be adopted into the

2018 IBC, has an update to the ASTM standards noted in the preceding paragraph. ASTM has created a consolidated standard for high-strength bolts with the reference ID of ASTM F3125-15a, *Standard Specification for High Strength Structural Bolts, Steel and Alloy Steel, Heat Treated, 120 ksi and 150 ksi Minimum Tensile Strength* (ASTM, 2015). The previous ASTM A325, A490, F1852, and F2280 standards are now obsolete and each of the bolt types covered by those standards is now indicated as an ASTM F3125 grade. Field markings will remain the same, but the base standard has changed. Although the current published RCSC Specification still references the four individual ASTM standards, it is expected the next updated edition of the RCSC Specification will include this new information.

Connection plates that are bolted together, such as those in a bolted end-plate connection (see Figure 3.5-1), should have no spaces between them within a circle three times the nominal diameter of the bolt (d_b) as illustrated in Figure 3.5-2. Gaps in excess of $^1/_{16}$inch in these areas should be shimmed. Gaps outside of these areas need no corrective action. Although Figure 3.5-2 was derived from the RCSC Specification Bolted Parts (Section 3) that illustrates the minimum unpainted area of the plane of contact between two plies of a joint (a.k.a. faying surface), it has been interpreted by the RCSC Committee to be an appropriate zone for considering gaps between the two plates. Gaps at the outer extremities of the plates due to plate warpage caused by welding do not generally have to be filled to achieve appropriate performance of that joint.

Figure 3.5-1: Bolted End-Plate Connection

This inspection of bolted connections is typically requested by the general contractor to be performed by a building inspector or an independent inspector. Generally, bolted connections are outside of the experience level of most building inspectors and this would typically be required by a special inspector employed by the building owner. Furthermore, it is the responsibility of the erector to ensure the fastener components are protected from dirt and moisture in closed containers at the project site. RCSC Specification Section 2.2 states high- strength bolts, nuts, washers and other fastener components are to be stored in a protected environment with the intent that the condition of the components be maintained as nearly as possible to the as-manufactured condition until they are installed in the work. Only as many fastener components as are anticipated to be installed during the work shift shall be taken from protected storage.

Fastener components that are not incorporated into the work shall be returned to protected storage at the end of the work shift. The AISC Specification (AISC 360) lists bolting inspection tasks in its Table N5.6-1, Table N5.6-2 and Table N5.6-3. These inspection tasks are consistent with those contained in the RCSC Specification. The inspection provisions of the RCSC Specification rely upon observation of the work; hence all tables use Observe for the designated tasks.

> User Note: For snug-tightened bolts, neither pre-installation verification, nor monitoring of installation procedures are required for QA or QC. Inspectors need not be present during the installation of fasteners in snug-tight joints. However, the work is still required to be visually inspected and documented. See Section 3.5.1 for more information.

The inspection of high-strength bolting involves inspection tasks prior, during, and after bolting. This includes verification that the correct fasteners are being used, that the connected plies conform to specified requirements, and that the holes that receive the fasteners conform to specified requirements.

The frequency of inspection tasks is characterized as follows:

> **O** - Observe these items on a random basis. Operations need not be delayed pending these inspections.
>
> **P** - Perform these tasks for each welded joint member or bolted connection.

Note that the terms observe (O) and perform (P) do not indicate when the inspections are to be performed, only their frequency.

AISC 360 - Table N5.6-1

Inspection Tasks Prior to Bolting	QC	QA
Manufacturer's certifications available for fastener materials	O	P
Fasteners marked in accordance with ASTM requirements	O	O
Proper fasteners selected for the joint detail (grade, type, bolt length if threads are to be excluded from shear plane)	O	O
Proper bolting procedure selected for joint detail	O	O
Connecting elements, including the appropriate faying surface condition and hole preparation, if specified, meet applicable requirements	O	O
Pre-installation verification testing by installation personnel observed and documented for fastener assemblies and methods used	P	O
Proper storage provided for bolts, nuts, washers and other fastener components	O	O

AISC 360 - Table N5.6-2

Inspection Tasks During Bolting	QC	QA
Fastener assemblies, of suitable condition, placed in all holes and washers (if required) are positioned as required.	O	O
Joint brought to the snug-tight condition prior to the pre-tensioning operation.	O	O
Fastener component not turned by the wrench prevented from rotating.	O	O
Fasteners are pre-tensioned in accordance with the RCSC *Specification*, progressing systematically from the most rigid point toward the free edges.	O	O

AISC 360 - Table N5.6-3

Inspection Tasks After Bolting	QC	QA
Document acceptance or rejection of bolted connections.	P	P

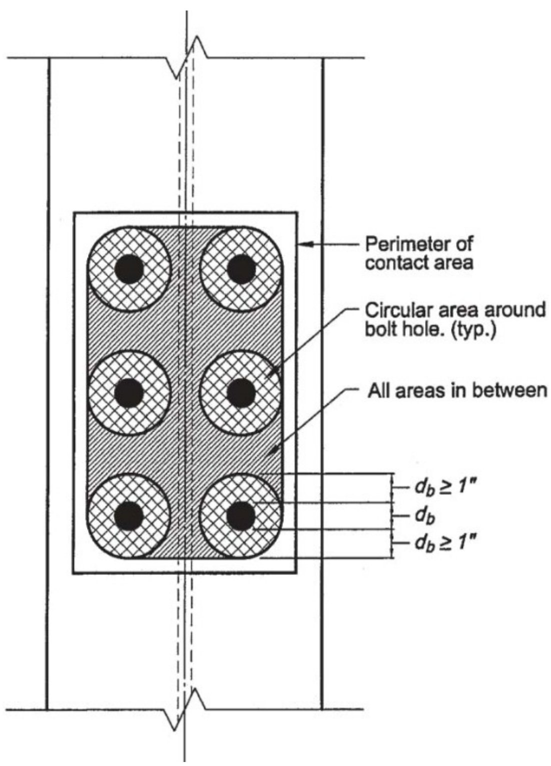

Figure 3.5-2: Bolted End-Plate Connection with Gaps