ACCEPTANCE CRITERIA FOR
EXPANSION BOLTS IN STRUCTURAL STEEL CONNECTIONS
(BLIND-BOLTS)

AC437

Approved October 2011

PREFACE

Evaluation reports issued by ICC Evaluation Service, LLC (ICC-ES), are based upon performance features of the International family of codes. (Some reports may also reference older code families such as the BOCA National Codes, the Standard Codes, and the Uniform Codes.) Section 104.11 of the International Building Code reads as follows:

The provisions of this code are not intended to prevent the installation of any materials or to prohibit any design or method of construction not specifically prescribed by this code, provided that any such alternative has been approved. An alternative material, design or method of construction shall be approved where the building official finds that the proposed design is satisfactory and complies with the intent of the provisions of this code, and that the material, method or work offered is, for the purpose intended, at least the equivalent of that prescribed in this code in quality, strength, effectiveness, fire resistance, durability and safety.

This acceptance criteria has been issued to provide interested parties with guidelines for demonstrating compliance with performance features of the codes referenced in the criteria. The criteria was developed through a transparent process involving public hearings of the ICC-ES Evaluation Committee, and/or on-line postings where public comment was solicited.

New acceptance criteria will only have an “approved” date, which is the date the document was approved by the Evaluation Committee. When existing acceptance criteria are revised, the Evaluation Committee will decide whether the revised document should carry only an “approved” date, or an “approved” date combined with a “compliance” date. The compliance date is the date by which relevant evaluation reports must comply with the requirements of the criteria. See the ICC-ES web site for more information on compliance dates.

If this criteria is a revised edition, a solid vertical line (│) in the margin within the criteria indicates a technical change from the previous edition. A deletion indicator (→) is provided in the margin where wording has been deleted if the deletion involved a technical change.

ICC-ES may consider alternate criteria for report approval, provided the report applicant submits data demonstrating that the alternate criteria are at least equivalent to the criteria set forth in this document, and otherwise demonstrate compliance with the performance features of the codes. ICC-ES retains the right to refuse to issue or renew any evaluation report, if the applicable product, material, or method of construction is such that either unusual care with its installation or use must be exercised for satisfactory performance, or if malfunctioning is apt to cause injury or unreasonable damage.

NOTE: The Preface for ICC-ES acceptance criteria was revised in July 2011 to reflect changes in policy.

Acceptance criteria are developed for use solely by ICC-ES for purpose of issuing ICC-ES evaluation reports.

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ACCEPTANCE CRITERIA FOR EXPANSION BOLTS IN STRUCTURAL STEEL CONNECTIONS (BLIND-BOLTS) (AC437)

1.0 INTRODUCTION

1.1 Purpose: The purpose of this acceptance criteria is to establish requirements for expansion bolts for structural steel connections, herein referred to as “blind-bolts”, to be recognized in an ICC Evaluation Service, LLC (ICC-ES), evaluation report under the 2009 International Building Code® (IBC) and the 2009 International Residential Code® (IRC). Bases of recognition are IBC Section 104.11 and IRC Section R104.11.

The reason for the development of this acceptance criteria is to provide guidelines for evaluating blind-bolts for structural steel connections, since the codes do not specify procedures for qualifying or installing such products.

1.2 Scope: This criteria applies to blind-bolts used to resist loads in structural steel. The criteria calls for assessment of strength and deformation capacity, service conditions, design procedures, and quality control.

Blind-bolts are alternatives to bolts conforming to the ASTM A 307, A 325 and A 490 specifications, and are permitted to be installed in accordance with AISC 360, AISC 341, and AISC 348. Blind-bolts are installed in standard holes, as defined in AISC 360, with a hole diameter no greater than the blind-bolt’s shell diameter plus 1/16 inch (1.6 mm). This criteria is limited to only the blind-bolt product and assumes that affected elements of members and connecting elements (non-bolt elements) are designed and specified in conformance with AISC 360, AISC 341, and AISC 348. Manufacturers’ design and installation instructions shall inform blind-bolt users that the design of affected elements of members and connecting elements shall be analyzed in accordance with AISC 360, AISC 341, and AISC 348. For example, bearing capacity at bolt holes or plate net section tensile rupture, shall be designed in accordance with AISC 360. For use in seismic force–resisting systems of structures designed in accordance with AISC 341, blind-bolts shall develop a static slip critical shear resistance, as demonstrated by tests specified in this criteria, which exceeds 40 percent of the single plane bolt shear capacity limited by bolt shear.

1.3 Codes and Referenced Standards:


1.3.3 ASTM E 488-96 (2003), Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements, ASTM International.


1.3.5 ASCE/SEI 7-10, Minimum Design Loads for Buildings and Other Structures, American Society of Civil Engineers.

1.3.6 AISI S100-2007, North American Specification for the Design of Cold-Formed Steel Structural Members, American Iron and Steel Institute.

1.3.7 AISC 341-05, Seismic Provisions for Structural Steel Buildings, American Institute of Steel Construction.

1.3.8 AISC 360-05, Specification for Structural Steel Buildings, American Institute of Steel Construction.


1.4 Definition Blind-bolts: Fasteners that are similar in appearance to concrete expansion anchors, but are instead used to connect two steel components. The bolts’ primary use is to provide a blind-side connection solution for attachments to hollow structural section steel and other structural steel framing where access is restricted to one side only. In this connection solution, a hole is drilled into both steel parts, the parts are mated together, and the bolt is inserted into the hole and tightened from one side. As the bolt core is tightened, it expands a sleeve, fixing the anchor on the blind side of the attachment. A torque wrench is used to tighten the anchor to produce controlled tension forces on the bolt, resulting in a pretensioned connection similar to standard connections using ASTM A 325 and ASTM A 490 bolts, designed and installed in accordance with the AISC 360 and AISC 348 specifications. The bolts are typically an assembly of three main steel components as shown in Figure 1: (1) a core, (2) a shell, and (3) a nut. The core is the solid portion of the bolt and is typically used to identify the bolt size. The shell is a hollow tubular element that surrounds the core and is designed to expand in order to lock the bolt in place during installation, thereby acting as a substitute for a washer commonly used in standard threaded bolts. The nut is a conical device that expands the shell as the bolt is tightened.

1.5 Nomenclature

\[ A_c \] Cross-sectional area of the core, in.\(^2\) (mm\(^2\))

\[ A_s \] Cross-sectional area of the shell, in.\(^2\) (mm\(^2\))

\[ F_{yc} \] Yield strength of the core, psi (kN)

\[ F_{ys} \] Yield strength of the shell, psi (kN)

\[ F_{uc} \] Ultimate stress of core, psi (MPa)

\[ F_{us} \] Ultimate stress of shell, psi (MPa)

\[ D_c \] Diameter of core, in. (mm)

\[ D_{s1} \] Inner diameter of shell, in. (mm)

\[ D_{s2} \] Outer diameter of shell, in. (mm)

\[ D_u \] Bolt pretension factor, in. (mm)

\[ hsc \] Hole size factor

\[ N_s \] Number of slip planes in slip-critical connections

\[ R_{n} \] Adjusted nominal strength for each bolt diameter, lb (N)

\[ T_b \] Pretension force of bolt for use in estimating an expected slip-critical shear capacity, lb (N)

\[ \alpha \] Adjustment factor for shear nominal capacity to account for the difference between the actual and specified material and diameter
2.0 BASIC INFORMATION

2.1 General: The following information shall be submitted with ICC-ES evaluation report applications:

2.1.1 Blind-bolts shall be described as to:

2.1.1.1 Generic or trade name.
2.1.1.2 Manufacturer’s catalog number.
2.1.1.3 Nominal thread size and specification.
2.1.1.4 Nominal bolt or sleeve diameter.
2.1.1.5 Length.
2.1.1.6 Permitted manufacturing tolerances.
2.1.1.7 Material specifications (physical and chemical) for all parts, including metallic and nonmetallic coatings.
2.1.1.8 Dimensions for all parts as shown in Figure 1.
2.1.1.9 Manufacturing process.

2.1.2 Installation Instructions: Manufacturer’s published installation instructions shall be submitted and include procedures for typical blind-bolt products as follows:

a. Holes shall be drilled into the sections to be fixed, ensuring that the resulting holes have the correct diameter and spacing according to the manufacturer’s published specifications, and the correct design requirements for the connection. Hole sizes shall be standard diameter holes conforming to AISC 360, where the bolt hole diameters shall be no greater than the bolt shell diameter plus \( \frac{1}{16} \) inch (1.6 mm).

b. Burrs in the holes shall be removed before inserting blind-bolts.

c. The structural steel elements to be fastened adjacent to each other shall be positioned to ensure:
   1. That the two sections are lined up and rest one against the other without any gap. Clamps shall be used as necessary to hold the two sections together and prevent formation of gaps.
   2. That the holes are aligned, using a mandrel if necessary.

d. The blind-bolts shall be positioned in the holes. The shell shall rest flat against the section with no gap.

e. The shell shall be held in position using a suitable open-ended wrench and then the bolt shall be tightened to the specified torque.

f. The tightening tool shall be removed and the tightening torque on the bolt shall be verified. If necessary, the tightening torque shall be corrected.

2.1.3 Packaging and Identification: Identification provisions shall include the evaluation report number and, if applicable, the name or logo of the inspection agency.

2.2 Testing Laboratories: Testing laboratories shall comply with Section 2.0 of the ICC-ES Acceptance Criteria for Test Reports (AC85) and Section 4.2 of the ICC-ES Rules of Procedure for Evaluation Reports.

2.3 Test Reports: Test reports shall comply with AC85.

2.4 Product Sampling: Sampling of the blind-bolts for tests under this criteria shall comply with Section 3.1 of AC85.

3.0 TEST AND PERFORMANCE REQUIREMENTS

3.1 General: Blind-bolts shall be qualified for design using load values derived from tested samples.

3.2 Number of specimens:

3.2.1 Each blind-bolt diameter shall be tested to establish strength values to be used in design.

3.2.2 For each diameter, the longest length and shortest length shall be tested, as a minimum.

3.2.3 A minimum of three tests each (18 tests total) are required for each diameter to establish static tensile design values and static shear design values associated with slip friction and bearing, respectively. The minimum number of tests for each test protocol is summarized in the Table 1.

3.2.4 An additional three tests each (36 tests total) are required to establish cyclic design values for seismic resistance in tension, and shear associated with slip friction and bearing.

3.2.5 Additional tests in accordance with Sections 3.2.3 and 3.2.4 shall be conducted on blind-bolts supplied with finishes such as zinc.

3.3 Loading Conditions: Each of the selected bolt diameters and lengths shall be tested in accordance with the testing protocols described in Section 4.0 to determine nominal tested strength capacities for the following loading conditions:

- Static shear
- Static tension
- Slip-critical shear
- Seismic tension and shear

3.4 Nominal capacity: The nominal capacity of each bolt diameter size, \( R_{tu} \), shall be the lowest adjusted tested capacity of the longest and shortest tested lengths for a particular bolt diameter, for each of the loading conditions. The lowest adjusted tested capacity shall be derived in accordance with Section 3.5. The nominal capacity of the blind-bolt shall not exceed the capacity of a standard threaded bolt as computed in accordance with Section J3 of AISC 360 with a diameter equal to that of the core of the blind-bolt. The value of \( F_{tu} \) used in the calculation for standard threaded bolt shall be equal to the specified ultimate tensile strength of the steel core, \( F_{uoc} \), used in the blind-bolt.
3.5 Tested Capacity: The tested capacity from each test protocol shall be the average peak strength of all tested values. The tested capacity shall be adjusted downward if the actual measured material ultimate strength of the blind-bolt test specimens, as determined in accordance with Section 4.5, is greater than the minimum specified material strength based on the component (i.e., core, shell, or nut) that has the lowest specified to actual material ultimate strength ratio, computed as follows:

Adjusted Shear Capacity = Tested Shear Capacity x \( \alpha_s \)

Adjusted Tension Capacity = Tested Tension Capacity x \( \alpha_t \)

where:

\[ \alpha_s = \text{Adjustment factor for shear} = \frac{[D^2c_{u,s} + (D^2_d - D^2_s)c_{u,s}]}{[D^2c_{u,s} + (D^2_d - D^2_s)c_{u,s}]} \leq 1.0 \]

\[ \alpha_t = \text{Adjustment factor for tension} = \frac{[D^2c_{u,t}]}{[D^2c_{u,t}]} \leq 1.0 \]

3.6 Strength of Testing Apparatus: All components of the apparatus shall have capacities that exceed the ultimate capacity of the bolt for the test type in question (i.e., shear, tension, etc.). No component of the testing apparatus including connecting plates, welds, bolts, load cells, actuators, etc., shall limit the load applied in the test.

3.7 Resistance Factor for LRFD: The resistance factor, \( \Phi \), all be applied to the nominal capacity for determining the load and resistance factor design (LRFD) strength. The LRFD resistance factor shall be computed in accordance with Chapter F of AISI S100 as follows:

\[ \Phi = 1.672e^{-4.0 \sqrt{0.053 + 2m}} \]

where,

\[ V_p = \text{Coefficient of variation of test results} \geq 0.065 \]

\[ C_p = \frac{(1+1/n)m/(m-2)}{n}, \text{if } n \geq 4 \]

\[ = 5.7 \text{ if } n = 3 \]

\[ n = \text{Number of tests} \]

\[ m = n - 1 \]

3.8 LRFD Design Strength: The LRFD design strength shall be determined as follows:

\[ LRFD \text{ design strength} = \Phi R_n \]

3.9 Factor of Safety for ASD: A factor of safety, \( \Omega \), shall be applied to the nominal strength for determining the allowable stress design (ASD) strength. The ASD factor of safety shall be determined in accordance with Chapter F of AISI S100 as follows:

\[ \Omega = 1.6 \Phi \]

3.10 ASD Design Strength: The ASD design strength shall be determined as follows:

\[ ASD \text{ design strength} = R_n / \Omega \]

3.11 Combined Loading: Combined static shear and static tension loading shall be considered for LRFD and ASD in accordance with the following equation:

\[ \left( \frac{\text{Tension Demand}}{\text{Tension Capacity}} \right)^2 + \left( \frac{\text{Shear Demand}}{\text{Shear Capacity}} \right)^2 \leq 1.0 \]

Bolts in slip-critical applications shall not be used in combined shear and tension loading.

4.0 TEST METHODS

4.1 Static Shear Test: Each blind-bolt shall be tested for shear in an assembly that satisfies the following minimum criteria:

4.1.1 The bolt shall be installed in a two-bolt, single shear lap joint assembly with load applied to the outer plates, resulting in a tension loading configuration as shown in Figure 2. The plate adjacent to the nut shall be the minimum thickness for which the bolt is to be qualified. For tests of the shortest length bolt for a particular bolt diameter, both plates shall be of the minimum thickness for which the bolt is to be qualified.

4.1.2 Minimum distances in accordance with Chapter J3 of AISC 360 between the sleeve or nut of the bolt to the edges of its connecting elements shall be provided in all directions. Minimum distance shall be determined based on the outer diameter of the sleeve. The configuration of the test assemblies shall be coordinated such that the load direction engages the least edge distance to be loaded as shown in Figure 2.

4.1.3 A displacement measuring device shall be positioned to permit determination of the shear displacement between the inner and outer plates of the assembly in the direction of applied load as shown in Figure 2.

4.1.4 For purposes of approximating a maximum possible load to be applied in this testing protocol, the blind-bolt shall be assumed to be a single solid dowel with a nominal diameter equal to the outer diameter of the shell, and with an ultimate stress equal to the larger of the ultimate stress of either the shell or the core.

4.1.5 The blind-bolt shall be fastened snug-tight in accordance with Section 8.1 of AISC 348.

4.1.6 An initial load of five percent of the expected ultimate shear capacity of the bolt shall be applied in order to bring all members into full bearing.

4.1.7 A continuous monotonic load shall be increasingly applied at a rate ranging from 25 percent to 100 percent of the expected ultimate shear strength of the bolt per minute until either of the following occurs:

1. There is a sudden failure or zero load resistance measurement.

2. There is a 20 percent reduction in load resistance measurement. This reduction shall not be due to slip or a sudden loss in friction strength and shall be verified during the test. Loading shall continue to be applied if reduction in load resistance measurement is due to slip. Slip shall be determined to be a measurable displacement without increase in load, followed by an increase in load with further displacement.

The total test time shall not be less than one minute.
4.2 Static Shear Test for Slip-Friction (Optional - For Use in Applications Where the Applicable Code Requires Slip-critical Installation): Each bolt shall be tested for slip friction shear resistance in an assembly that satisfies the following minimum criteria:

4.2.1 The bolt shall be installed in a two-bolt, single shear lap joint assembly with load applied to the outer plates, resulting in a tension loading configuration as shown in Figure 2. The test plates shall have Class A faying surfaces in accordance with AISC 360 Section J3.8, consisting of "unpainted clean mill scale steel surfaces or surfaces with Class A coatings on blast-cleaned steel and hot-dipped galvanized and roughened surfaces." The plate adjacent to the nut shall be of the minimum thickness for which the bolt is to be qualified. For tests of the shortest length bolt for a particular bolt diameter, both plates shall be of the minimum thickness for which the bolt is to be qualified.

4.2.2 A minimum distance in accordance with AISC specifications between the sleeve of the bolt and the edges of its connecting elements shall be provided in all directions. Minimum distance shall be determined based on the outer diameter of the sleeve.

4.2.3 A displacement measuring device shall be positioned to permit determination of the shear displacement between the inner and outer plates of the assembly in the direction of applied load.

4.2.4 The bolt shall be pretensioned in accordance with the manufacturer's standard installation procedure. A tension calibrator shall be used to verify the pretension force. Pretension can be verified by using any of the methods in accordance with Section 8.2 of AISC 348.

4.2.5 An expected slip friction capacity shall be computed in accordance with Section J3.8 of AISC 360, assuming the following:

\[
\mu = 0.35 \text{ assuming Class A surface} \\
D_o = 1.13 \text{ bolt pretension factor} \\
hsc = 1.0 \text{ for standard hole size} \\
N_b = 2.0 \text{ for two slip planes} \\
T_b = \text{ The pretension value measured during installation, lbf (N)}.
\]

Blind-bolt strength shall be assumed to be controlled by the properties of the core component.

4.2.6 A minimum of five days shall lapse between pretensioning of the installed blind-bolt and testing to allow for pretension relaxation.

4.2.7 A continuous monotonic load shall be increasingly applied at a rate equal to the lesser of 25 kips (111 kN) per minute or 0.003 inch (0.076 mm) of slip displacement per minute until either of the following occurs:

1. There is 0.05 inch (1.27 mm) of displacement.
2. There is a 20 percent reduction in load resistance measurement.
3. There is a sudden failure or zero load resistance measurement.

The total test time shall be at least one minute.

4.3 Static Tension Test: Each blind-bolt shall be tested for tension in an assembly that satisfies the following minimum criteria:

4.3.1 The blind-bolt shall be installed such that it fastens to two plates: a face plate and a back plate. The face plate shall be attached to a rigid assembly allowing it to be pulled away from the back plate as shown in Figure 3. The back plate shall be fastened to a rigid assembly anchored to a permanent fixture such as the ground. The face and back plates along with the rigid assemblies shall be sufficiently rigid such that any deformation contributed by these elements is less than one percent of the total deflection measured at the load cell or actuator.

4.3.2 A displacement measuring device shall be positioned to measure the displacement between each of the base assemblies.

4.3.3 An expected ultimate tension capacity of the bolt shall be computed in accordance with Section J3.6 of AISC 360 assuming only the contribution of the bolt core without the contribution of the sleeve.

4.3.4 The bolt shall be fastened snug-tight in accordance with Section 8.2 of AISC 348. A continuous monotonic load shall be increasingly applied at a rate ranging from 25 percent to 100 percent of the expected ultimate tension capacity of the bolt per minute until either of the following occurs:

1. There is a 20 percent reduction in load resistance measurement.
2. There is a sudden failure or zero load resistance measurement.

The total test time shall be at least one minute.

4.4 Cyclic Testing: Cyclic testing shall be performed to determine shear, slip-friction, and tension capacities to be used in seismic design. The approach outlined here is based on the testing method described in ATC-24 for cyclic seismic testing of steel components. Since blind-bolts are intended to be used as force-controlled components and are not expected to undergo significant inelastic deformations where they would serve as the primary yielding mechanism in a lateral force resisting system, the procedure outlined here is based on force-controlled behavior as opposed to deformation-controlled behavior. Therefore, the method for cyclic loading described in ATC-24 has been modified here to be based on forces instead of deformations.

4.4.1 Cyclic Shear Test:

a. A target ultimate shear strength, \( V_{UT} \), shall be determined as equal to the unadjusted tested shear capacity derived in accordance with Section 3.5 from the static shear tests in accordance with Section 4.1.

b. A target yield shear strength, \( V_{YT} \), shall be set equal to the observed yield strength, \( V_y \), obtained from the force-displacement plot in the static tests in accordance with Section 4.1 as shown in Figure 4. The observed shear yield strength shall be associated with significant shear yielding observed in the critical region of the test specimen, which should be reflected by a clear nonlinearity in the control force-deformation relationship. If a clear transition point from linearity to nonlinearity cannot be determined, then the target shear yield strength shall be computed as follows:
p shall be

A load-cell actuator shall be provided that is capable of inducing cyclic motion on the test assembly such that forces can be applied continuously in a positive (support plates are loaded in compression) and negative (support plates are loaded in tension) direction.

d. Loading cycles for shear testing shall be determined and applied in accordance with the cyclic pattern shown in Figure 5. Each cycle consists of a positive and negative excursion, where an excursion is defined by a load or deformation history unit that starts and finishes at zero load, and contains a loading and unloading branch.

e. The deflection at peak load of each excursion shall be reported.

4.4.2 Cyclic Shear Test for Slip Friction:

a. A target slip-friction shear capacity, \( V_{FT} \), shall be equal to the unadjusted tested shear friction capacity derived in accordance with Section 3.5 from the static slip friction tests in accordance with Section 4.2.

b. The testing apparatus and setup shall be in accordance with the requirements stated in Section 4.2 for the static testing protocol except that the thickness of all plates shall be sufficient to preclude plate buckling under compression loading. A load cell actuator shall be provided that is capable of inducing cyclic motion on the test assembly such that forces can be applied continuously in a positive (support plates are loaded in compression) and negative (support plates are loaded in tension) direction.

c. Loading cycles for slip-friction testing shall be determined and applied in accordance with the cyclic pattern shown in Figure 6. Each cycle consists of a positive and negative excursion, where an excursion is defined by a load or deformation history unit that starts and finishes at zero load, and contains a loading and unloading branch.

d. The deflection at peak load of each excursion shall be reported.

4.4.3 Cyclic Tension Test:

a. A target ultimate tension strength, \( T_{UT} \), shall be equal to the unadjusted tested tension capacity derived in accordance with Section 3.5 from the static tests in accordance with Section 4.3.

b. A target yield tension strength, \( T_y \), shall be set equal to the observed yield tension strength, \( T_y \), obtained from the force-displacement plot in the static test as shown in Figure 4. The observed tension yield strength shall be associated with significant tension yielding observed in the critical region of the test specimen, which should be reflected by a clear nonlinearity in the control force-deformation relationship. If a clear transition point from linearity to nonlinearity cannot be determined, then the target tension yield strength shall be computed as follows:

\[
T_y = A_{UT}F_{yc}
\]

c. The testing apparatus and setup shall be in accordance with the requirements set forth in Section 4.3 for the static testing protocol. A load cell actuator shall be provided that is capable of inducing cyclic motion on the test assembly such that forces can be applied continuously in the tension loading and unloading directions.

d. Loading cycles for tension testing shall be determined and applied in accordance with the cyclic pattern shown in Figure 7. Each cycle consists of a positive excursion, where an excursion is defined by a load or deformation history unit that starts and finishes at zero load, and contains a loading and unloading branch.

e. The deflection at peak load of each excursion shall be reported.

4.5 Product Identification:

4.5.1 The following characteristics shall be checked by the testing laboratory for conformance to the drawings and specifications:

- Critical dimensions
- Surface finishes
- Coatings
- Fabrication techniques
- Markings

4.5.2 Constituent Materials: Critical constituent materials shall be checked by the testing laboratory for conformance to mechanical and chemical specifications using testing conducted in accordance with applicable procedures such as ASTM A 370 and ASTM F 606. The results shall be used to adjust tested capacities in accordance with Section 3.6 of this criteria.

5.0 QUALITY CONTROL

5.1 Manufacturing: The blind-bolts shall be manufactured under an approved quality control program with inspections by an inspection agency accredited by the International Accreditation Service (IAS) or otherwise acceptable to ICC-ES. A qualifying inspection shall be conducted at each manufacturing facility when required by the ICC-ES Acceptance Criteria for Inspections and Inspection Agencies (AC304).

5.2 Quality Control Documentation: Quality control documentation complying with the ICC-ES Acceptance Criteria for Quality Documentation (AC10) shall be submitted.

5.3 Special Inspection: Special inspection is required in accordance with Section 1704.3 of the IBC. The manufacturer shall submit inspection procedures to verify proper installation of the blind-bolts.

5.4 Seismic or Wind Resistance: Where bolts are used for seismic or wind load resistance, special inspection requirements shall comply with Sections 1705, 1706 and 1707 of the IBC.
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6.0 EVALUATION REPORT RECOGNITION

6.1 The evaluation report shall recognize only tested products, and identify the nominal or design capacities for each tested blind-bolt diameter.

6.2 The evaluation report shall include the following information:

6.2.1 Information described in Section 2.1 of this criteria.

6.2.2 ASD or LRFD design strengths, as determined in accordance with Section 3.0 of this criteria.

6.2.3 The following statement: Calculations and details showing that the blind-bolts are adequate to resist the applied loads must be submitted to the code official for approval. The connected steel base materials and connecting elements also must be adequate to support the applied loads. The calculations and details must be signed and sealed by a registered design professional, when required by the statutes of the jurisdiction in which the project is to be constructed.

6.2.4 Fire-resistant Construction: Where not otherwise prohibited in the code, blind-bolts are permitted for use with fire-resistance rated construction provided that at least one of the following conditions is fulfilled:

- Blind-bolts are used to resist wind or seismic forces only.
- Blind-bolts that support a fire-resistance-rated envelope or a fire-resistance-rated membrane, are protected by approved fire-resistance-rated materials, or have been evaluated for resistance to fire exposure in accordance with recognized standards.
- Blind-bolts are used to support nonstructural elements.

6.2.5 Special Inspection: Special inspection details based on information described in Sections 5.3 and 5.4 of this criteria shall be included in the evaluation report.

6.2.6 Evaluation reports shall note that use of blind-bolts in seismic force-resisting structures assigned to Seismic Design Category D, E or F (IBC) is beyond the scope of the report.

Exception: Blind-bolts qualified in accordance with Section 4.4 of this criteria.

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TABLE 1—MINIMUM NUMBER OF TESTS REQUIRED FOR EACH BOLT DIAMETER SIZE

<table>
<thead>
<tr>
<th>TEST TYPE</th>
<th>MINIMUM NUMBER OF TESTS</th>
<th>MINIMUM NUMBER OF LENGTHS</th>
<th>MINIMUM TOTAL NUMBER OF TESTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shear (bearing)</td>
<td>3</td>
<td>2</td>
<td>3x2 = 6</td>
</tr>
<tr>
<td>Shear (slip-friction)</td>
<td>3</td>
<td>2</td>
<td>3x2 = 6</td>
</tr>
<tr>
<td>Tension</td>
<td>3</td>
<td>2</td>
<td>3x2 = 6</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>18</td>
</tr>
</tbody>
</table>

Notes:

1. In accordance with ASCE/SEI 7, Section 1.3.1.3.2, if the maximum deviation of any single tested capacity from the mean of all tested capacities for each test type exceeds 15 percent, then additional tests shall be performed until the maximum deviation of any single tested capacity is less than or equal to 15 percent.

2. Maximum number of tests for each blind-bolt diameter and length subject to each test type need not exceed six. Therefore, the total number of tests required can be up to 36 tests.

3. The test protocols for each test type shall be in accordance with Sections 4.1, 4.2, and 4.3. For installation in Seismic Design Category D, E, or F, additional tests are required in accordance with Section 4.4.

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FIGURE 1—TYPICAL BLIND-BOLT COMPONENTS

![FIGURE 1—TYPICAL BLIND-BOLT COMPONENTS](image-url)
FIGURE 2—STATIC SHEAR TEST ASSEMBLY

FIGURE 3—STATIC TENSION TEST ASSEMBLY
Distinct point of nonlinearity

Yield

Point of nonlinearity is unclear. Therefore, calculate yield capacity.

FIGURE 4—EXAMPLE CASES OF FORCE-DEFORMATION PLOTS ILLUSTRATING CLEAR AND UNCLEAR POINTS OF NON-LINEARITY
## Load Pattern, Number of Cycles, Applied Shear Load

<table>
<thead>
<tr>
<th>Load Pattern</th>
<th>Number of Cycles</th>
<th>Applied Shear Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>N0</td>
<td>6</td>
<td>0.75(V_{YT})</td>
</tr>
<tr>
<td>N1</td>
<td>3</td>
<td>1.0(V_{YT})</td>
</tr>
<tr>
<td>N2</td>
<td>3</td>
<td>(V_{YT} + 0.25(V_{UT} - V_{YT}))</td>
</tr>
<tr>
<td>N3</td>
<td>3</td>
<td>(V_{YT} + 0.50(V_{UT} - V_{YT}))</td>
</tr>
<tr>
<td>N4</td>
<td>3</td>
<td>(V_{YT} + 0.75(V_{UT} - V_{YT}))</td>
</tr>
<tr>
<td>N5</td>
<td>3</td>
<td>(V_{UT})</td>
</tr>
</tbody>
</table>

**FIGURE 5—CYCLIC LOADING PATTERN FOR SHEAR TESTING**
FIGURE 6—CYCLIC LOADING PATTERN FOR SLIP-FRICTION SHEAR TESTING

<table>
<thead>
<tr>
<th>Load Pattern</th>
<th>Number of Cycles</th>
<th>Applied Slip Friction Shear Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>$n_0$</td>
<td>6</td>
<td>$0.25V_{FT}$</td>
</tr>
<tr>
<td>$n_1$</td>
<td>3</td>
<td>$0.50V_{FT}$</td>
</tr>
<tr>
<td>$n_2$</td>
<td>3</td>
<td>$0.75V_{FT}$</td>
</tr>
<tr>
<td>$n_3$</td>
<td>3</td>
<td>$1.0V_{FT}$</td>
</tr>
</tbody>
</table>
## Table 1: Cyclic Loading Pattern for Tension Testing

<table>
<thead>
<tr>
<th>Load Pattern</th>
<th>Number of Cycles</th>
<th>Applied Tension Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>$n_0$</td>
<td>6</td>
<td>$0.75 \xi T$</td>
</tr>
<tr>
<td>$n_1$</td>
<td>3</td>
<td>$1.0 \xi T$</td>
</tr>
<tr>
<td>$n_2$</td>
<td>3</td>
<td>$\xi T + 0.25(\xi T - \xi T)$</td>
</tr>
<tr>
<td>$n_3$</td>
<td>3</td>
<td>$\xi T + 0.50(\xi T - \xi T)$</td>
</tr>
<tr>
<td>$n_4$</td>
<td>3</td>
<td>$\xi T + 0.75(\xi T - \xi T)$</td>
</tr>
<tr>
<td>$n_5$</td>
<td>3</td>
<td>$\xi T$</td>
</tr>
</tbody>
</table>

**FIGURE 7—CYCLIC LOADING PATTERN FOR TENSION TESTING**