



ICC Evaluation Service, Inc.
Birmingham Regional Office
900 Montclair Road, Suite A
Birmingham, AL 35213
tel: 205.599.9800
fax: 205.599.9850
www.icc-es.org

January 14, 2010

**TO: PARTIES INTERESTED IN EVALUATION REPORTS ON
EXPANSION ANCHORS IN MASONRY ELEMENTS**

**SUBJECT: Revisions to the Acceptance Criteria for Expansion Anchors in
Masonry Elements, Subject AC01-1209-R1 (ME/BG)**

Dear Madam or Sir:

In December 2009, proposed revisions to the subject acceptance criteria were posted on the ICC-ES web site for public comment, under the alternative criteria process. The revised criteria was concurrently balloted to the ICC-ES Evaluation Committee, which approved the revisions with an effective date of January 1, 2010, with the following editorial changes to what was initially proposed:

Following is added to Section 7.5, item no. 2: "When using the basic load combinations in accordance with IBC Section 1605.3.1 or UBC Section 1612.3.1, allowable loads are not permitted to be increased for seismic or wind loading. When using the alternative basic load combinations in IBC Section 1605.3.2 or UBC Section 1612.3.2 that include seismic or wind loads, the allowable shear and tension loads for anchors are permitted to be increased by $33\frac{1}{3}$ percent."

A copy of the revised acceptance criteria is enclosed. Evaluation reports issued on or after the effective date noted above, and falling within the scope of this criteria, will be required to comply with the enclosed edition of the criteria. Evaluation reports issued prior to the effective date may be in compliance either with the enclosed criteria or with the previous edition. Evaluation reports based on a superseded version of an acceptance criteria must be brought into compliance with the most recent edition at the time the reports are reissued. Therefore, affected report holders should submit data verifying compliance at the time they apply for re-examination.

If you have any questions, please contact Brian Gerber at (800) 423-6587, extension 3260. You may also reach us by e-mail at es@icc-es.org.

Yours very truly,

A handwritten signature in black ink that reads 'Gary G. Nichols'.

Gary G. Nichols, P.E., SECB
Vice President

GN/raf

Enclosure

cc: Evaluation Committee

ACCEPTANCE CRITERIA FOR EXPANSION ANCHORS IN MASONRY ELEMENTS

AC01

Approved December, 2009

Effective January 1, 2010

Previously approved December 2006, June 2005, October 2004, April 2002,
November 2001, January 2001, January 1999, September 1997, January 1993

PREFACE

Evaluation reports issued by ICC Evaluation Service, Inc. (ICC-ES), are based upon performance features of the International family of codes and other widely adopted code families, including the Uniform Codes, the BOCA National Codes, and the SBCCI Standard 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.

Similar provisions are contained in the Uniform Codes, the National Codes, and the Standard Codes.

This acceptance criteria has been issued to provide all interested parties with guidelines for demonstrating compliance with performance features of the applicable code(s) referenced in the acceptance criteria. The criteria was developed and adopted following public hearings conducted by the ICC-ES Evaluation Committee, and is effective on the date shown above. All reports issued or reissued on or after the effective date must comply with this criteria, while reports issued prior to this date may be in compliance with this criteria or with the previous edition. If the criteria is an updated version from the previous edition, a solid vertical line (|) in the margin within the criteria indicates a technical change, addition, or deletion from the previous edition. A deletion indicator (→) is provided in the margin where a paragraph has been deleted if the deletion involved a technical change. This criteria may be further revised as the need dictates.

ICC-ES may consider alternate criteria, provided the report applicant submits valid 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. Notwithstanding that a product, material, or type or method of construction meets the requirements of the criteria set forth in this document, or that it can be demonstrated that valid alternate criteria are equivalent to the criteria 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 an evaluation report, if the product, material, or type 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 unreasonable property damage or personal injury or sickness relative to the benefits to be achieved by the use of the product, material, or type or method of construction.

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

ACCEPTANCE CRITERIA FOR EXPANSION ANCHORS IN MASONRY ELEMENTS (AC01)

1.0 INTRODUCTION

1.1 Purpose: The purpose of this criteria is to establish requirements for expansion anchors in masonry elements to be recognized in an ICC Evaluation Service, Inc. (ICC-ES), evaluation reports under the 2009 *International Building Code*[®] (IBC), 2006 *International Building Code*[®] (IBC), the 2009 *International Residential Code*[®] (IRC), 2006 *International Residential Code*[®] (IRC) and the 1997 *Uniform Building Code*[™] (UBC). Bases of recognition is IBC Section 104.11, IRC Section R104.11 and UBC Section 104.2.8. The reason for the development of this criteria is to provide guidelines for the evaluation of alternative fasteners to those addressed by the code.

1.2 Scope: Anchors recognized under this criteria are limited to allowable stress design applications and uncracked masonry as an alternative to Section 1912 of IBC and Section 2.1.4 of ACI 530/ASCE 5/TMS 402 as referenced in Section 2107.1 of the IBC, Section R301.1.3 of the IRC or Sections 1923.1 and 2107.1.5 of the UBC.

1.3 Referenced Documents: Editions of standards applicable to evaluation under the various codes are summarized in Table 9.

1.3.1 2009 *International Building Code*[®] (IBC), International Code Council.

1.3.2 2009 *International Residential Code*[®] (IRC), International Code Council.

1.3.3 2006 *International Building Code*[®] (IBC), International Code Council.

1.3.4 2006 *International Residential Code*[®] (IRC), International Code Council.

1.3.5 1997 *Uniform Building Code*[™] (UBC), International Conference of Building Officials.

1.3.6 ICC-ES Acceptance Criteria for Test Reports and Product Sampling (AC85).

1.3.7 ICC-ES Acceptance Criteria for Quality Control Manuals (AC10).

1.3.8 1997 UBC Standard 7-1, Fire Tests of Building Construction and Materials, International Conference of Building Officials.

1.3.9 1997 UBC Standard 21-1, Building Brick, Facing Brick and Hollow Brick (Made From Clay Or Shale), International Conference of Building Officials.

1.3.10 1997 UBC Standard 21-3, Concrete Building Brick, International Conference of Building Officials.

1.3.11 1997 UBC Standard 21-4, Hollow and Solid Load-bearing Concrete Masonry Units, International Conference of Building Officials.

1.3.12 1997 UBC Standard 21-15, Mortar for Unit Masonry and Reinforced Masonry Other than Gypsum, International Conference of Building Officials.

1.3.13 1997 UBC Standard 21-17, Test Method for Compressive Strength of Masonry Prisms, International Conference of Building Officials.

1.3.14 1997 UBC Standard 21-19, Grout for Masonry, International Conference of Building Officials.

1.3.15 TMS 402/ ACI 530/ ASCE 5, Building Code Requirements for Masonry Structures; Masonry Standards Joint Committee (MSJC)

1.3.16 ASTM A 490, Standard Specification for Heat-Treated Steel Structural Bolts, 150 ksi Minimum Tensile Strength, ASTM International.

1.3.17 ASTM C 55, Standard Specification for Concrete Brick, ASTM International.

1.3.18 ASTM C 62, Standard Specification for Building Brick (Solid Masonry Units Made From Clay or Shale), ASTM International.

1.3.19 ASTM C 90, Standard Specification for Load-bearing Concrete Masonry Units, ASTM International.

1.3.20 ASTM C 129, Standard Specification for Nonload-bearing Concrete Masonry Units, ASTM International.

1.3.21 ASTM C 216, Standard Specification for Facing Brick (Solid Masonry Units Made from Clay or Shale), ASTM International.

1.3.22 ASTM C 270, Standard Specification for Mortar for Unit Masonry, ASTM International.

1.3.23 ASTM C 476, Standard Specification for Grout for Masonry, ASTM International.

1.3.24 ASTM C 652, Standard Specification for Hollow Brick (Hollow Masonry Units Made From Clay or Shale), ASTM International.

1.3.25 ASTM C 1314, Standard Test Method for Compressive Strength of Masonry Prisms, ASTM International.

1.3.26 ASTM E 119, Standard Test Methods for Fire Tests of Building Construction and Materials, ASTM International.

1.3.27 ASTM E 447, Standard Test Method for Compressive Strength of Masonry Prisms, ASTM International.

1.3.28 Standard Method of Cyclic (Reversed) Load Test for Anchors in Concrete or Grouted Masonry, by the Structural Engineers Association of Southern California (SEAOSC); dated August 1, 1996; revised April 17, 1997.

2.0 DEFINITIONS

2.1 Anchor Test Series: A group of identical anchors tested under identical conditions. Identical conditions encompass anchor-type, model, diameter, length, embedment, torque, spacing, edge distance, masonry density/weight, test member thickness and masonry compressive strength.

2.2 Anchor Spacing (s): The measure between anchors, centerline to centerline distance.

2.2.1 Critical Spacing (s_{cr}): The minimum anchor spacing distance at which the full load-bearing capacity of

ACCEPTANCE CRITERIA FOR EXPANSION ANCHORS IN MASONRY ELEMENTS (AC01)

an anchor is obtained without influence of neighboring anchors.

2.2.2 Minimum Spacing (s_{min}): The minimum anchor spacing distance at which the base material will not be damaged when multiple anchors are set, expanded or loaded at service loads.

2.3 Cracked Masonry: Masonry elements cracked by tensile stresses caused by external loads, including loads induced by anchors, or restraint due to deformations induced by temperature or masonry shrinkage. This definition applies to elements with existing cracks and elements with potential for cracking.

2.4 Edge Distance (c): The measure between the anchor centerline and the free edge of the masonry member.

2.4.1 Critical Edge Distance (c_{cr}): The minimum edge distance at which the maximum load capacity of an anchor is obtained.

2.4.2 Minimum Edge Distance (c_{min}): The minimum edge distance at which the component edge does not break away when the anchor is set, expanded or loaded at service loads.

2.5 Expansion Anchor (Anchor): A mechanical fastener placed in assembled masonry, designed to expand in a self-drilled or predrilled hole of a specified size and engage the sides of the hole in one or more locations to develop shear and/or tension resistance to applied loads without grout, adhesive or drypack.

2.5.1 Anchor Types: Type A (Torque-Set): The anchor sleeve is expanded by applying torque to a screw or bolt. Degree of anchorage is controlled by the amount of torque applied.

2.5.2 Type B: The anchor sleeve is expanded by driving in an expansion element. Degree of anchorage is controlled by the length of element travel.

2.5.3 Type C: The anchor sleeve is expanded by driving it onto the expansion element. Degree of anchorage is controlled by the length of sleeve travel. The Type C self-drilling anchor drills the hole itself with the anchor functioning as the drill bit.

2.6 Embedment Depth (h_v): Distance from test member surface to installed end of anchor, measured prior to setting of the anchor.

2.7 New Masonry: Masonry construction with mortar, grout and masonry units that comply with Section 4.0.

2.8 Test Member: The masonry prism receiving anchors to be tested.

2.9 Testing Laboratory: An independent testing laboratory, complying 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, having the personnel, expertise, equipment, and facilities for testing in accordance with this criteria.

2.10 Uncracked Masonry: Masonry elements where analysis indicates no cracking ($f_t < f_r$) due to service loads or deformations. For masonry, f_r is defined in UBC Section 2108.2.4.6 or Section 3.1.8.2 TMS 402/ ACI 530/ ASCE 5 (IBC)

3.0 TEST SPECIMENS AND MISCELLANEOUS INFORMATION

3.1 Anchors used in tests shall be sampled in accordance with Section 3.1 of AC85.

3.2 Anchors shall be described as to:

1. Generic or trade name.
2. Manufacturer's catalog number.
3. Nominal thread size.
4. Nominal anchor or sleeve diameter.
5. Anchor length.
6. Permitted manufacturing tolerances.

7. Basic materials, including physical properties before and after manufacture, i.e., tensile strength, hardness and protective coatings. If the anchor consists of component parts involving different materials, differences must be noted.

8. Appropriate national standard for the materials. Reports of physical properties for materials used in test specimens must be submitted. These reports must be generated by a mill or independent testing agency. Where the actual material strength exceeds the specified strength, test results must be adjusted by the ratio $\frac{F_u \text{ specified}}{F_u \text{ actual}}$ when failure is attributed to the subject anchor material. Where no physical property specifications exist, acceptable properties must be established by physical property tests.

9. Manner of field identification prior to and/or after installation. Each anchor packaging unit shall be marked with the manufacturer's name or insignia; anchor type, diameter and length; the ICC-ES evaluation report number; and the name or logo of the quality control agency. Every anchor, if available in more than one length per anchor diameter, must be marked with a length code, described in Table 1, that is visible and legible after anchor installation.

10. Recommended installation procedures. Manufacturer's published instructions for installation, application, and design must be submitted.

3.3 When anchors are recognized for exterior exposure or damp environments, evidence of durability must be established.

3.4 Special Inspection: Special inspection applies to anchors depending on safety factor selected from Table 7. Special inspection for IBC and IRC shall be in accordance with the Section 1704 of IBC, Section 1701 of the UBC.

4.0 MASONRY

4.1 Masonry units must comply with the appropriate Standard, including:

4.1.1 UBC Standard 21-1 (UBC) or ASTM C 62, ASTM C 216 or ASTM C 652 (IBC or IRC): Building Brick (clay or shale).

4.1.2 UBC Standard 21-3 (UBC) or ASTM C 55 (IBC or IRC): Concrete Building Brick.

ACCEPTANCE CRITERIA FOR EXPANSION ANCHORS IN MASONRY ELEMENTS (AC01)

4.1.3 UBC Standard 21-4 (UBC) or ASTM C 90: Hollow and Solid Load-bearing Concrete Masonry Units (IBC or IRC).

4.1.4 UBC Standard 21-5 (UBC) or ASTM C 129 (IBC or IRC): Nonload-bearing Concrete Masonry Units. The testing agency must verify that masonry units comply with these standards.

4.2 Mortar shall be prepared in accordance with Section 2103 of the UBC or IBC or Section R607 of the IRC and UBC Standard 21-15 (UBC) or ASTM C 270 (IBC or IRC). The testing agency shall report the mortar composition, type, proportions and compliance with the standard.

4.3 Grout shall be prepared in accordance with Section 2103 of the UBC or IBC and Section R609 of the IRC and UBC Standard 21-19 (UBC) or ASTM C 476 (IBC or IRC). The testing agency shall report grout composition, type, proportions and compressive strength.

4.4 Assembled masonry members must be field cured for 28 days with a five-day allowable minus tolerance. Four masonry prism specimens must be prepared and tested in accordance with UBC Standard 21-17 (UBC) or ASTM C 1314 (IBC or IRC). Two prisms are tested during a 24-hour period both immediately preceding and following any anchor test series. The average strength result establishes the compressive strength of the anchor test specimens.

4.5 Reinforcement may only be used to stabilize test members during transportation. Reinforcing elements in masonry test member shall be outside the potential failure region of each test anchor or anchor group. The testing laboratory shall verify location of reinforcing.

5.0 TESTING PROCEDURES

5.1 Anchor Installation:

1. Each diameter anchor to be recognized must be tested.

2. Holes for anchor test specimens are drilled in accordance with the manufacturer's published recommendations, including diameter and depth. Only tools typically used in field installations are permitted. Brand, model number, and size of power tool, and drill-bit type must be reported. Drill bits used in the test program must have bit diameters with allowable tolerances complying with Figure 1 or 2. Drill-bit dimensions and corresponding tolerances must be reported; compliance with applicable standards, such as ANSI B212.15-1994 must be reported when appropriate. Drilling mode (e.g., rotation only or hammering with rotation) shall be reported for each base material. All procedures must be conducted or directly verified by an independent testing agency.

3. Test holes for Type C self-drilling anchors must be drilled with the anchor to be tested.

4. Diameter of each drill bit must be measured before and after drilling each series of anchors (10 anchors maximum). The drill bits must be within the diameter range described in Item 2 of Section 5.1 and Figures 1 and 2. The testing agency must confirm that measured diameters are within allowable tolerances.

5. All test anchors must be installed perpendicular to the surface of the test member with a 6-degree tolerance, in a manner representative of actual field installations.

6. Installation and setting of anchors must comply with published recommendations of the manufacturer. Pertinent data such as anchor embedment, depth, nominal torque, etc., must be observed and noted by the testing laboratory and/or other witnessing agency.

5.2 Proper Functioning Tests:

1. For Type A torque set anchors, additional tests must be conducted on anchors set by using 20 percent of the minimum installation torque. The resulting ultimate tension loads must be at least 80 percent of ultimate loads at installation torque. See Table 2, Series 3, for testing schedule. The masonry compressive-strength class is the lowest strength recommended and verified by Item 3, 4 or 5 of Section 4.0. The anchors are installed at the minimum recommended embedment.

2. Minimum Drill Bit Sizes: To verify proper functioning of anchors installed in holes prepared using the minimum size drill bits described in Figures 1 and 2, tension tests are conducted on anchors installed in masonry having the maximum compressive strength for which recognition is sought. See Table 2, Test Series 1. These tests are conducted at the minimum embedment. Conditions of acceptance:

a. Proper installation determined by completely following recommended installation methods, including application of recommended installation torque.

b. The average ultimate tension loads must meet or exceed loads obtained on anchors tested in accordance with Table 2, Test Series 6.

3. Maximum Drill Bit Sizes: To verify proper functioning of anchors installed in holes prepared using the maximum size drill bits described in Figures 1 and 2, tension tests are conducted on anchors installed in masonry having the minimum compressive strength for which recognition is sought. See Table 2, Test Series 2. These tests are conducted at the minimum embedment.

Conditions of Acceptance: The average ultimate tension loads must be at least 80 percent of loads obtained on anchors tested in accordance with Table 2, Test Series 4.

5.3 Tests for Service Conditions:

1. The service conditions of anchors installed in masonry are determined by testing that investigates the effects of several factors including:

a. Anchor type.

b. Anchor materials.

c. Direction of loading.

d. Masonry strength.

e. Anchor location: spacing and edge distance.

f. Anchor embedment and thicknesses of attached and receiving materials.

2. To determine service conditions, Test Series 4 to 21 shall be performed, as applicable.

ACCEPTANCE CRITERIA FOR EXPANSION ANCHORS IN MASONRY ELEMENTS (AC01)

5.4 Testing and Equipment:

1. Test equipment for pullout and shear loading must be adequate to impose anticipated ultimate loads and must comply with Sections 5 and 6, ASTM E 488. If loading is not carried to failure, the highest value achieved will be considered the ultimate load.

2. Direction of loading for all tensile testing must be coaxial with the embedded anchor.

3. Test equipment can not impose pullout or shear-reaction loadings on the surface or edge of the masonry within a distance "c", as noted in Table 2 of ASTM E 488. Equipment used to apply shear loads must be designed to minimize frictional resistance using a surface finish specified in Section 6.4.4 of ASTM E 488.

4. Displacement due to shear and tension must be recorded for each test specimen. The displacement must be indicated as a function of load and direction of load application. The load-displacement curve must show no fall or plateau until 150 percent of allowable service load is reached. See Section 5.5 of ASTM E 488 for measurement procedures.

5. The testing schedule must comply with Table 2. Characteristics to be evaluated include proper functioning, service conditions, spacing distance and edge distance.

The following parameters will be established by the load test program as they apply to the anchor systems:

- a. Critical edge distance
- b. Minimum edge distance with appropriate load reduction factor
- c. Critical spacing
- d. Minimum spacing with appropriate load reduction factor
- e. Embedment depth(s)

The minimum allowable slab thickness shall be $1\frac{1}{2}$ times h_v , unless other thicknesses are substantiated with acceptable test data.

Section 6.4.1 ASTM E 488 specifies minimum test member thickness. Supplemental anchor test series using varying parameters may be considered to establish anchor efficiency, with appropriate load capacity adjustment factors.

6. Efficiency increases require testing of anchor groups. Recognition will be based on the number, edge distance and spacing of anchors tested. Groups of bolts consist of two to four bolts with an anchor spacing less than four times the embedment. See Table 2 for testing schedule. See Section 5.5.1.2, ASTM E 488 for additional guidelines.

7. Efficiency tests must be conducted on the same nominal size anchors used in shear and pullout tests.

8. All anchors in group efficiency tests must be loaded equally and simultaneously by a common fixture. Shear loads must be collinear with the anchor group.

9. Recognition of test results will be limited to uncracked masonry unless members depict other conditions.

5.5 Static Tests: Static load test procedures for tension and shear must comply with this criteria and Section 8 of ASTM E 488.

5.6 Seismic Tests (optional): Under a simulated seismic test program, tests are performed to determine the seismic tension and shear capacity of anchors. Either Seismic Method 1 or Seismic Method 2 will be required for recognition of anchors for wind or earthquake resistance. See Section 7.5 for limitations.

5.6.1 Seismic Method 1:

5.6.1.1 Procedure: Test procedures shall conform to the Standard Method of Cyclic (Reversed) Load Test for Anchors in Grouted Masonry, by the Structural Engineers Association of Southern California (SEAOSC), dated August 1, 1996, revised April 17, 1997, except Sections 1.2, 2.1, 3.1, 3.7 and 3.10 are not applicable under this criteria.

5.6.1.2 Conditions of Acceptance: The anchor shall demonstrate equivalence to the code-complying anchor for which substitution is proposed, as defined in Section 3.3 of the referenced SEAOSC document.

5.6.2 Seismic Method 2:

5.6.2.1 Procedure: The anchors shall be subjected to a simulated pulsating sinusoidal seismic cycle, detailed in Figure 3, for tension; and a simulated alternating sinusoidal seismic cycle, detailed in Figure 4, for shear loading. The frequency of the loading shall be within the range of 0.1 to 2 Hz. Each seismic cycle test shall consist of at least five anchors. The $\frac{1}{2}$ -inch (12.7 mm) or next-larger size of each anchor type, and the material type (i.e., carbon stainless) to be recognized shall be tested at the shallowest and deepest embedments for which seismic recognition is desired. Where $\frac{1}{2}$ -inch (12.7 mm) diameter is unavailable, the size shall be selected in consultation with ICC-ES staff.

Anchors are installed in accordance with the manufacturer's recommendations. For anchors installed with a tightening torque, anchors are installed at full torque, then the applied torque is reduced to 50 percent of the specified torque before applying the test load cycles, to simulate preload relaxation over time. For anchors installed with "turn of the nut," the installation torque is measured at the specified number of turns for all samples. The anchors are then tightened to a torque that represents one-half of the average measured torque. For anchors with no specified tightening torque, the anchors are set fingertight. For internally threaded anchors, tests are done with a bolt complying with ASTM A 490.

Testing shall be performed on masonry which complies with the strength requirements of Section 4.0. A test series consisting of five anchors, installed in masonry composed of the same constituent materials as that used for the cyclic test anchors, is used to establish the reference ultimate static load values, T_{ref} and V_{ref} , for tension and shear.

After the seismic cycles have been completed, each anchor shall be loaded in tension or shear, as applicable, to ultimate capacity.

5.6.2.2 Tension Procedure: The maximum tension load, N_s , shall be 1.5 times the tension value for which recognition is desired. The value for which

ACCEPTANCE CRITERIA FOR EXPANSION ANCHORS IN MASONRY ELEMENTS (AC01)

recognition is desired shall be no larger than 133.33 percent of the allowable static load assigned to anchors installed under the same conditions (conditions such as masonry strength, embedment and anchor diameter). The minimum load value for each load level shall not be greater than five percent of the ultimate static capacity in same strength masonry. For all tension seismic qualification tests, data recording shall include, at a minimum, the peak values of each load cycle applied to the anchor, together with corresponding anchor displacements in the direction of the load. The load cycle is given in Table 3 and Figure 3.

5.6.2.3 Shear Procedure: The maximum shear test load, V_s , shall be 1.5 times the shear value for which recognition is desired. The value for which recognition is desired shall be no larger than 133.33 percent of the allowable static load assigned to anchors installed under the same conditions (conditions such as masonry strength, embedment and anchor diameter). For shear loading, the load-displacement results must be plotted as hysteretic loops. The load cycle is given in Table 4 and Figure 4. Alternating shear loading may be approximated by the application of two half-sinusoidal load cycles at the desired frequency, connected by a reduced-speed ramped loading, as shown in Figure 5.

5.6.2.4 Conditions of Acceptance:

1. Each anchor shall withstand the loading cycles without failure.
2. The average load in the tests performed on the anchors after the cyclic testing shall be at least 80 percent of the average ultimate static load, T_{ref} or V_{ref} , for anchors installed in the reference masonry.

Exception: Where individual ultimate loads differ more than 15 percent from the average of the results, all ultimate loads shall be at least 80 percent of the average ultimate static load, T_{ref} or V_{ref} .

3. The maximum displacement during all phases of the seismic tests shall satisfy the following equations:

$$\Delta_{ns} = \frac{N_s}{T_{ref}} \leq \Delta_{ult}$$

where:

- T_{ref} = Average ultimate tension load based on tests described in Section 5.6.2.1.
- Δ_{ns} = Measured maximum displacement during seismic tension test (inches or mm).
- Δ_{ult} = Displacement limitation for ultimate tension and shear loads described in Table 5 or 6 (inches or mm).

$$\Delta_{vs} \leq \frac{2V_s}{V_{ref}} \Delta_{ult}$$

where:

- V_{ref} = Average ultimate shear load based on tests described in Section 5.6.2.1.
- Δ_{vs} = Measured maximum displacement during seismic shear test (inches or mm).

5.7 Fire Resistance: Anchors intended for fire-resistant construction must be evaluated for load resistance during fire exposure. General guidelines for fire exposure are in UBC Standard 7-1 (UBC) or ASTM E 119 (IBC or IRC).

6.0 TEST REPORTS AND INTERPRETATIONS

6.1 Test reports must comply with AC85 and include information specified in Section 13 of ASTM E 488 and as follows:

1. Mode of failure for each test (e.g., cracking in masonry, anchor pull-out, anchor shear, ductile steel failure, etc.). Where the anchor and bolt are combined in a single assembly, location of anchor fracture failures must be noted (across major bolt diameter, across thread diameter or through unthreaded reduced diameter portion of bolts, etc.).
2. Photographs of test equipment and typical failure.
3. Report approval by an independent professional engineer.
4. Report of anchor sampling at manufacturer's facilities by independent testing agency. See Section 3.1.

6.2 Report must note when high-tensile bolts, studs, or threaded rods are used in the test program and are not a standard component of the anchor. The bolt, stud, or threaded rod specifications must be noted.

6.3 Testing laboratories shall comply with Section 2.9 of this acceptance criteria.

6.4 A recognized independent testing agency must provide calibration certification of test equipment. The certification must be traceable to NIST and be within one year of test dates.

6.5 The average masonry prism strength test results shall be within 10 percent of the nominal specified strengths.

6.6 Anchors must be tested at the minimum embedment for which recognition is desired. For recognition of variable embedment depths, anchors must be tested at each depth. Where the number of depths is four or more except when four or more depths are to be evaluated, the least, middle, and greatest depth must be tested unless steel failure is obtained. Where the number of depths for an anchor size is an even number, the middle depth shall be considered the minimum embedment in the upper half of the embedment ranges. Values for the untested intermediate depths may then be interpolated from test results. Mathematically, the middle depth is represented by the equation:

$$x = \frac{n}{2} + 1$$

where:

- x = The rank of the middle anchor depth. The depths are ranked in ascending order, i.e., 1 is shallowest depth, etc.
- n = Number of embedment depths for the anchor; an even number.

ACCEPTANCE CRITERIA FOR EXPANSION ANCHORS IN MASONRY ELEMENTS (AC01)

6.7 Extrapolation of test data for additional anchor sizes, embedments and/or masonry strengths is prohibited.

7.0 ALLOWABLE LOADS

7.1 Service Loads: Allowable loads are determined by applying a factor of safety to the average ultimate load. Factors of safety are described in Table 7. When the load test program evaluates the anchor with variations in spacing, edge distance, embedment, and slab thickness, allowable loads may need corresponding adjustments. Test load results can be analyzed by comparing loads to develop appropriate load adjustment factors, which are applied to the optimum allowable anchor load.

When more than one load adjustment factor must be applied, the product of the factors is used to determine design loads. Examples include anchors installed at reduced spacings and reduced edge distances.

7.2 Statistical Method for Service Loads: Calculation based on a “Probabilistic Method” that provides for a factored resistance load called a 5 percent fractile value ($X_{5\%}$). Allowable loads are determined by applying a factor of safety, ν , to the 5 percent fractile of the ultimate test loads. Factors of safety are described in Table 8.

$$\frac{X_{5\%}}{\nu}$$

The 5 percent fractile value is defined as providing a 90 percent confidence level that 95 percent of any anchor tested to ultimate capacity will exceed this value. The 5 percent fractile value is calculated by the equation:

$$X_{5\%} = \bar{X} - ks$$

where:

- \bar{X} is the sample average ultimate load. A sample is five test specimens, minimum.
- k is a constant (k = 2, provided a minimum of 40 specimens are tested for the anchor model line).
- s is the sample standard deviation.

The model line system tests encompass several test samples of anchor test series. These samples are linked by single model line with similar characteristics except for diameter and length differences. The standard deviation is calculated from a model line coefficient of variation by the equation:

$$s = \bar{x} \cdot \overline{CV}_s$$

where:

- CV_s = Model line system coefficient of variation.
- $CV_s = \frac{s}{\bar{x}} = \overline{CV} + 1.282 s_{cv}$
- \overline{CV} = Average coefficient of variation for all samples in the model line.

scv = Standard deviation of all sample coefficient of variations for the model line.

7.3 Combined Loads: Allowable load for anchors subjected to combined shear and tension forces can be determined by the following equation.

$$(P_s/P_t)^{5/3} + (V_s/V_t)^{5/3} \leq 1$$

where:

- P_s = Applied service tension load.
- P_t = Service tension load.
- V_s = Applied service shear load.
- V_t = Service shear load.

7.4 Displacement: Anchor displacement under load is limited by values in Tables 5 and 6.

7.5 Limitations:

1. Evaluation reports shall note that use of anchors in resisting earthquake or wind loads is beyond the scope of the report.

Exception: Recognition for earthquake and wind resistance will be granted when anchors are qualified in accordance with Section 5.6.

2. Allowable static loads may be increased one-third for earthquake or wind resistance when wind or seismic resistance is qualified in accordance with Section 5.6. When using the basic load combinations in accordance with IBC Section 1605.3.1 or UBC Section 1612.3.1, allowable loads are not permitted to be increased for seismic or wind loading. When using the alternative basic load combinations in IBC Section 1605.3.2 or UBC Section 1612.3.2 that include seismic or wind loads, the allowable shear and tension loads for anchors are permitted to be increased by 33 1/3 percent.

8.0 QUALITY CONTROL

8.1 The products 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. The quality control program shall verify continued anchor compliance with specifications in Section 3.2 of this criteria.

8.2 Quality Documentation complying with the ICC-ES Acceptance Criteria for Quality Documentation (AC10) shall be submitted.

9.0 EVALUATION REPORT RECOGNITION

The evaluation report shall include a description of the anchors, allowable loads, installation requirements, special inspection requirements, product identification, and the following findings:

9.1 Fatigue and Shock Loading: Since an ICC-ES acceptance criteria for evaluating data to determine the performance of expansion anchors subjected to fatigue or shock loading is unavailable at this time, the use of these anchors under these conditions is beyond the scope of this report.

9.2 Fire-resistive Construction: (*This version applies to torque-controlled expansion anchors*): Where not

ACCEPTANCE CRITERIA FOR EXPANSION ANCHORS IN MASONRY ELEMENTS (AC01)

otherwise prohibited in the applicable code, anchors are permitted for use with fire-resistance-rated construction provided that at least one of the following conditions is fulfilled:

- Anchors are used to resist wind or seismic forces only.
- Anchors that support fire-resistance-rated construction or gravity load-bearing structural elements are within 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.
- Anchors are used to support nonstructural elements.

(This version applies to displacement-controlled expansion anchors): Anchors are not permitted to support

fire-resistance-rated construction. Where not otherwise prohibited by the applicable code, anchors are permitted for installation in fire-resistance-rated construction provided that at least one of the following conditions is fulfilled:

- Anchors are used to resist wind or seismic forces only.
- Anchors that support gravity load-bearing structural elements are within 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.
- Anchors are used to support nonstructural elements.

9.3 Cracked Masonry: The use of anchors is limited to installation in uncracked masonry. Cracking occurs when $f_t > f_r$ due to service loads or deformations.

TABLE 1—LENGTH CODES

| CODE | | LENGTH OF ANCHOR | |
|------|--------|------------------|-----------|
| | | (inches) | (mm) |
| A | Black | 1 1/2 < 2 | 38 < 51 |
| B | White | 2 < 2 1/2 | 51 < 63 |
| C | Red | 2 1/2 < 3 | 63 < 76 |
| D | Green | 3 < 3 1/2 | 76 < 89 |
| E | Yellow | 3 1/2 < 4 | 89 < 102 |
| F | Blue | 4 < 4 1/2 | 102 < 114 |
| G | Purple | 4 1/2 < 5 | 114 < 127 |
| H | Brown | 5 < 5 1/2 | 127 < 140 |
| I | Orange | 5 1/2 < 6 | 140 < 152 |
| J | N/A | 6 < 6 1/2 | 152 < 165 |
| K | N/A | 6 1/2 < 7 | 165 < 178 |
| L | N/A | 7 < 7 1/2 | 178 < 191 |
| M | N/A | 7 1/2 < 8 | 191 < 203 |

| CODE | LENGTH OF ANCHOR | |
|------|------------------|-----------|
| | (inches) | (mm) |
| N | 8 < 8 1/2 | 203 < 216 |
| O | 8 1/2 < 9 | 216 < 229 |
| P | 9 < 9 1/2 | 229 < 241 |
| Q | 9 1/2 < 10 | 241 < 254 |
| R | 10 < 11 | 254 < 267 |
| S | 11 < 12 | 267 < 305 |
| T | 12 < 13 | 305 < 330 |
| U | 13 < 14 | 330 < 366 |
| V | 14 < 15 | 366 < 381 |
| W | 15 < 16 | 381 < 406 |
| X | 16 < 17 | 406 < 432 |
| Y | 17 < 18 | 432 < 457 |
| Z | 18 < 19 | 457 < 483 |

ACCEPTANCE CRITERIA FOR EXPANSION ANCHORS IN MASONRY ELEMENTS (AC01)

TABLE 2—TESTING SCHEDULE

| TEST SERIES NUMBER | TEST | ASTM E 488 SECTION | ICC-ES ACCEPTANCE CRITERIA SECTION | MASONRY COMPRESSIVE STRENGTH | NUMBER OF TESTS | | | | DRILL SIZE ² | REMARKS ⁴ |
|--|---|--------------------|------------------------------------|------------------------------|-----------------|-------|--------|-------|-------------------------|------------------------------|
| | | | | | All Diameters | Small | Medium | Large | | |
| PROPER FUNCTIONING | | | | | | | | | | |
| 1 | Tolerance of drill holes ⁵ | — | 5.2.2 | Max. | — | 5 | 5 | 5 | Min. | |
| 2 | Tolerance of drill holes ⁵ | — | 5.2.3 | Min. | — | 5 | 5 | 5 | Max. | |
| 3 | Intensity of expansion ⁵ | — | 5.2.1 | Min. | — | 5 | 5 | 5 | Med. | Torque = 20% of normal |
| SERVICE CONDITIONS (Direction of loading: axial tension) | | | | | | | | | | |
| 4 | Single anchors | 8.4.1 | — | Min. | 5 | — | — | — | Med. | ASTM E 488 |
| 5 | Single anchors | 8.4.1 | — | Med. | 5 | — | — | — | Med. | spacing & edge |
| 6 | Single anchors | 8.4.1 | — | Max. | 5 | — | — | — | Med. | distance guidelines |
| 7 | Single anchors, critical edge distance | — | — | Min. | — | 5 | 5 | 5 | Med. | $c = c_{cr}$ |
| 8 | Single anchors, minimum edge distance | — | 5.4.5 | Min. | — | 5 | 5 | 5 | Med. | $c = c_{min}$ |
| 9 | Single anchors, critical edge distance | — | 5.4.5 | Max. | — | 5 | 5 | 5 | Med. | $c = c_{cr}$ |
| 10 | Single anchors, minimum edge distance | — | 5.4.5 | Max. | — | 5 | 5 | 5 | Med. | $c = c_{min}$ |
| 11A | Group of two anchors, critical spacing | — | 5.4.6 | Min. | — | — | 5 | 5 | Med. | $s - s_{cr}$ |
| 11B | Group of 4 anchors, critical spacing distance | — | 5.4.6, .7, .8 | Min. | — | 5 | 5 | 5 | Med. | $s = s_{cr}$ |
| 12A | Group of two anchors, minimum spacing | — | 5.4.6 | Min. | — | 5 | 5 | 5 | Med. | $s - s_{min}$ |
| 12B | Group of 4 anchors, minimum spacing distance | — | 5.4.6, .7, .8 | Min. | — | 5 | 5 | 5 | Med. | $s = s_{min}$ |
| SERVICE CONDITIONS (Direction of loading: shear) | | | | | | | | | | |
| 13 | Single anchors ³ | 8.4.2 | — | Min. | — | — | — | — | Med. | ASTM E488; m |
| 14 | Single anchors, critical edge distance | — | 5.4.5 | Min. | 5 | 5 | 5 | 5 | Med. | $c = c_{cr}$ |
| 15 | Single anchors, minimum edge distance | — | 5.4.5 | Min. | 5 | 5 | 5 | 5 | Med. | $c = c_{min}$ |
| 16 | Single anchors, critical edge distance | — | 5.4.5 | Max. | 5 | 5 | 5 | 5 | Med. | $c = c_{cr}$ |
| 17 | Single anchors, minimum edge distance | — | 5.4.5 | Max. | 5 | 5 | 5 | 5 | Med. | $c = c_{min}$ |
| 18 | Group of 2 anchors critical spacing | — | 5.4.6, .7, .8 | Min. | — | — | 5 | — | Med. | $c = c_{cr}$; $s = s_{cr}$ |
| 19 | Group of 2 anchors minimum spacing | — | 5.4.6, .7, .8 | Min. | — | — | 5 | — | Med. | $c = c_{cr}$; $s = s_{min}$ |
| SERVICE CONDITIONS (Direction of loading: oblique tension 45°) | | | | | | | | | | |
| 20 | Single anchors | — | — | Min. | — | — | — | — | Med. | $c = c_{cr}$ |
| 21 | Single anchors | — | — | Max. | — | — | — | — | Med. | $c = c_{cr}$ |

¹Where anchors are evaluated at more than one masonry strength level, certain tests must be repeated at each masonry strength.

²See Figures 1 and 2 for range of drill bit sizes.

³Tests for "single anchors, critical edge distance (max.)" (No. 14 series) should be tested first. If steel failure occurs, then tests for single anchors (No. 13 series) can be deleted.

⁴ s = spacing, c = edge distance

⁵The displacement limitations in Tables 5 and 6 do not apply to these test series.

ACCEPTANCE CRITERIA FOR EXPANSION ANCHORS IN MASONRY ELEMENTS (AC01)

TABLE 3—TENSION CYCLIC LOAD PROGRAM

| LOAD LEVEL | NUMBER OF CYCLES |
|------------|------------------|
| N_s | 10 |
| N_i | 30 |
| N_m | 100 |

where:

- N_i = A load midway between N_s and N_m .
- N_m = One-fourth the average ultimate tension load, T_{ref} , in masonry of the tested strength.
- N_s = The maximum tension test load.

TABLE 4—SHEAR CYCLIC LOAD PROGRAM

| LOAD LEVEL | NUMBER OF CYCLES |
|------------|------------------|
| $\pm V_s$ | 10 |
| $\pm V_i$ | 30 |
| $\pm V_m$ | 100 |

where:

- V_i = A load midway between V_s and V_m .
- V_m = One-fourth the average ultimate shear load, V_{ref} , in masonry of the tested strength.
- V_s = The maximum shear test load.

TABLE 5—DISPLACEMENT LIMITATIONS (Imperial)

| ANCHOR DIAMETER (inches) | LIMITATION FOR DETERMINING DESIGN LOADS | | LIMITATION FOR DETERMINING ULTIMATE LOADS |
|-----------------------------|--|--------------|--|
| | Tension (inch) | Shear (inch) | Tension and Shear ¹ (inches) |
| $\frac{3}{16}$ | 0.0357 | 0.0625 | 0.188 |
| $\frac{1}{4}$ | 0.0385 | 0.0625 | 0.250 |
| $\frac{5}{16}$ | 0.0417 | 0.0625 | 0.313 |
| $\frac{3}{8}$ | 0.0455 | 0.0714 | 0.375 |
| $\frac{1}{2}$ | 0.0500 | 0.0714 | 0.500 |
| $\frac{5}{8}$ | 0.0556 | 0.0833 | 0.625 |
| $\frac{3}{4}$ | 0.0625 | 0.0833 | 0.750 |
| $\frac{7}{8}$ | 0.0714 | 0.1000 | 0.875 |
| 1 | 0.0833 | 0.1000 | 1.000 |
| $1\frac{1}{8}$ | 0.1000 | 0.1250 | 1.125 |
| $1\frac{1}{4}$ | 0.1250 | 0.1250 | 1.250 |
| $1\frac{3}{8}$ | 0.1250 | 0.1667 | 1.375 |
| $1\frac{1}{2}$ | 0.1250 | 0.1667 | 1.500 |

¹The displacement under shear only applies to the shear deflection equation in Section 5.6.2.4, and is not to be used for establishing an ultimate load.

TABLE 6—DISPLACEMENT LIMITATIONS (Metric)

| ANCHOR DIAMETER (mm) | LIMITATION FOR DETERMINING DESIGN LOADS | | LIMITATION FOR DETERMINING ULTIMATE LOADS |
|-------------------------|--|------------|--|
| | Tension (mm) | Shear (mm) | Tension and Shear ¹ (mm) |
| M6 | 1.0 | 1.6 | 6 |
| M8 | 1.1 | 1.6 | 8 |
| M10 | 1.2 | 1.8 | 10 |
| M12 | 1.3 | 1.8 | 12 |
| M16 | 1.4 | 2.2 | 16 |
| M20 | 1.6 | 2.2 | 20 |
| M22 | 1.8 | 2.6 | 22 |
| M24 | 2.2 | 2.6 | 24 |
| M30 | 3.0 | 3.0 | 30 |

¹The displacement under shear only applies to the shear deflection equation in Section 5.6.2.4, and is not to be used for establishing an ultimate load.

ACCEPTANCE CRITERIA FOR EXPANSION ANCHORS IN MASONRY ELEMENTS (AC01)

TABLE 7—FACTORS OF SAFETY

| MATERIAL | TENSION | | SHEAR | |
|------------------------------------|---------|---------------|-------|---------------|
| | UBC | IBC/IRC | UBC | IBC/IRC |
| Masonry with special inspection | 4 | 5 | 4 | 5 |
| Masonry without special inspection | 8 | Not permitted | 4 | Not permitted |

TABLE 8—FACTORS OF SAFETY, v (STATISTICAL METHOD)

| MATERIAL | | TENSION | | SHEAR | |
|----------|----------------------------|---------|-------------|-------|-------------|
| | | UBC | IBC/IRC | UBC | IBC/IRC |
| Masonry | With special inspection | 3 | 4 | 3 | 4 |
| | Without special inspection | 6 | Not allowed | 3 | Not allowed |

TABLE 9—CROSS REFERENCE OF STANDARD EDITIONS^{1,2}

| STANDARD | 1997 <i>Uniform Building Code</i> TM (UBC) | 2006 <i>International Building Code</i> [®] | 2009 <i>International Building Code</i> [®] | 2006 <i>International Residential Code</i> [®] | 2009 <i>International Residential Code</i> [®] |
|--------------------------------|---|--|--|---|---|
| ASTM A 490 | 1983a | 2004a | 2008b | 2004a | 2008b |
| ASTM C 55 | UBC Standard 21-3 | 2003 | 2006 | 1997 | 2006 |
| ASTM C 62 | UBC Standard 21-1 | 2004 | 2005 | 1997a | 20005 |
| ASTM C 90 | UBC Standard 21-4 | 2003 | 2006b | 1999 | 2006b |
| ASTM C 129 | UBC Standard 21-5 | — | | 2003 | |
| ASTM C 216 | UBC Standard 21-1 | 2004a | 2007 | 1998 | 2007 |
| ASTM C 270 | UBC Standard 21-15 | 2004 | 2007 | 1997 | 2007 |
| ASTM C 330 | 1989 | 2004 | 2005 | — | |
| ASTM C 332 | 1983 | — | | — | |
| ASTM C 476 | UBC Standard 21-19 | 2002 | 2002 | 1999 | 2002 |
| ASTM C 652 | UBC Standard 21-1 | 2004a | 2005 | 1997 | 2005 |
| ASTM C 1314 | — | 2003b | 2007 | — | |
| ASTM E 447 | UBC Standard 21-17 | — | | — | |
| ASTM E 119 | UBC Standard 7-1 | 2000 | 2007 | 1998 | 2007 |
| ASTM E 488 | 1990 | 7996 | 7996 | 1990/19963 | 7996 |
| ACI/530/ ASCE 5/ TMS 402 | — | 2005 | 2008 | 2005 | 2008 |

¹For standards referenced in this criteria, editions of standards applicable to the various codes are summarized in this table.

²Blank entries indicate the standard is not applicable or referenced in the specific code.

ACCEPTANCE CRITERIA FOR EXPANSION ANCHORS IN MASONRY ELEMENTS (AC01)

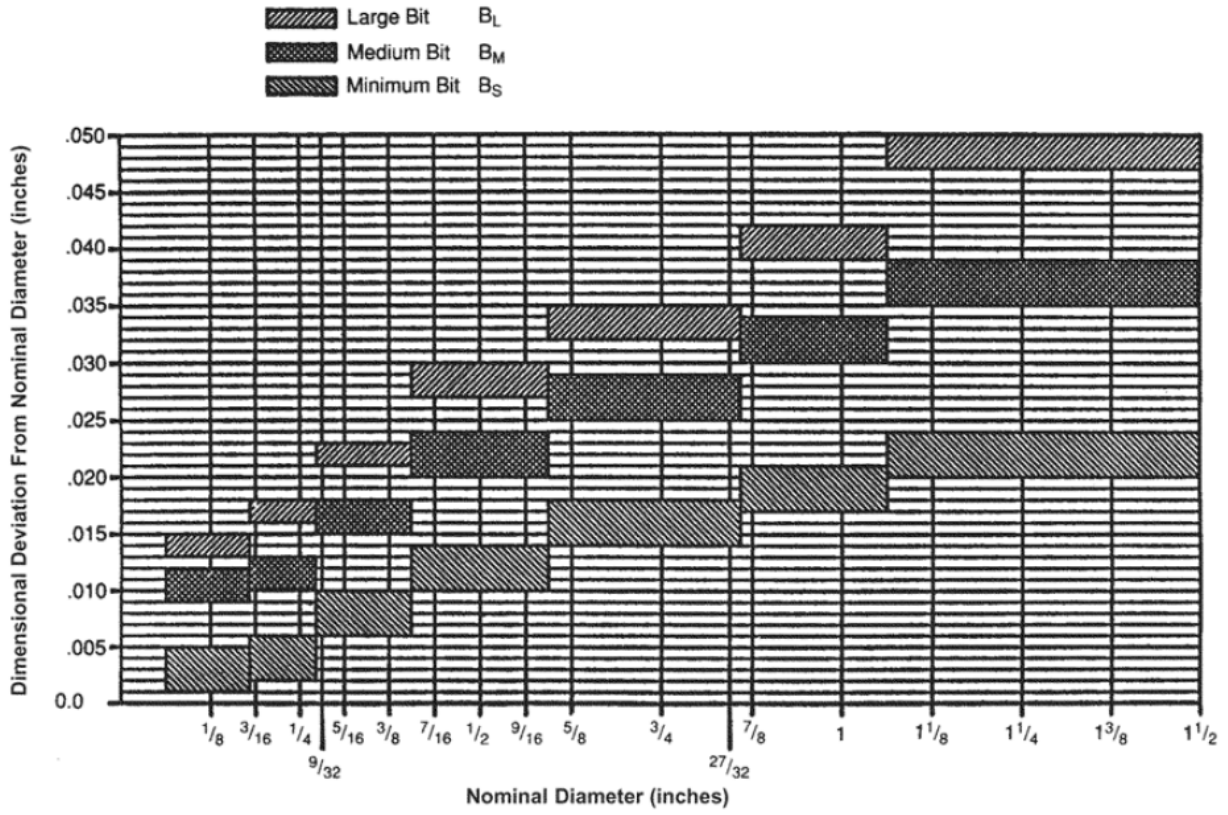


FIGURE 1—CARBIDE-TIPPED DRILL BIT TEST DIAMETER TOLERANCES

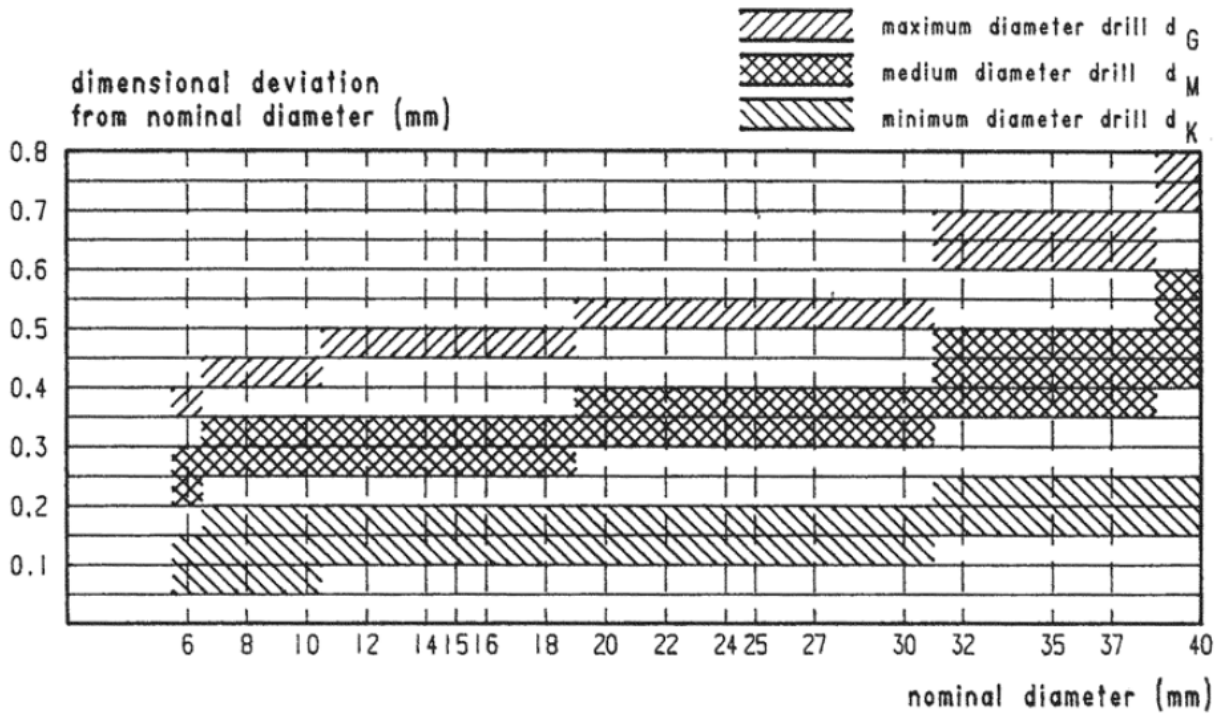


FIGURE 2—CUTTING DIAMETER OF CARBIDE-TIPPED METRIC HAMMER DRILL BITS

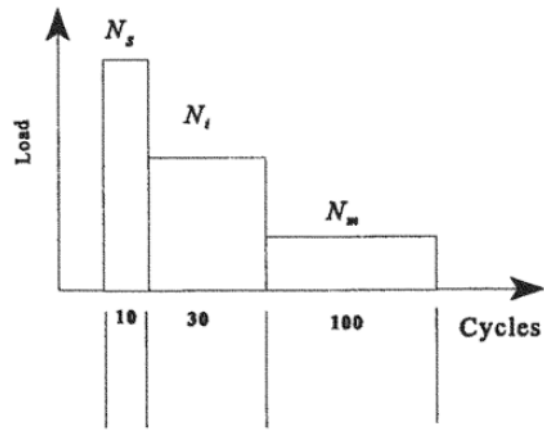


FIGURE 3—SEISMIC TENSION CYCLES

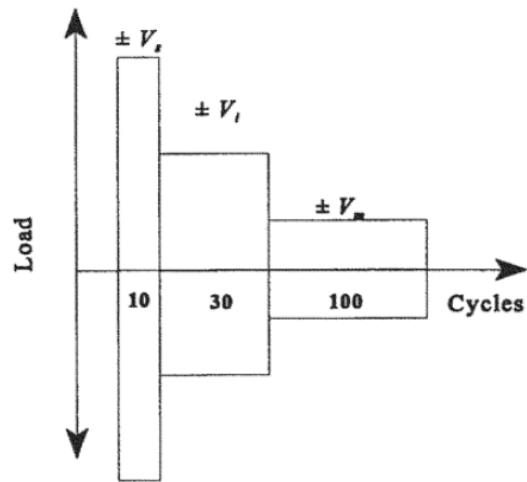


FIGURE 4—SEISMIC SHEAR CYCLE

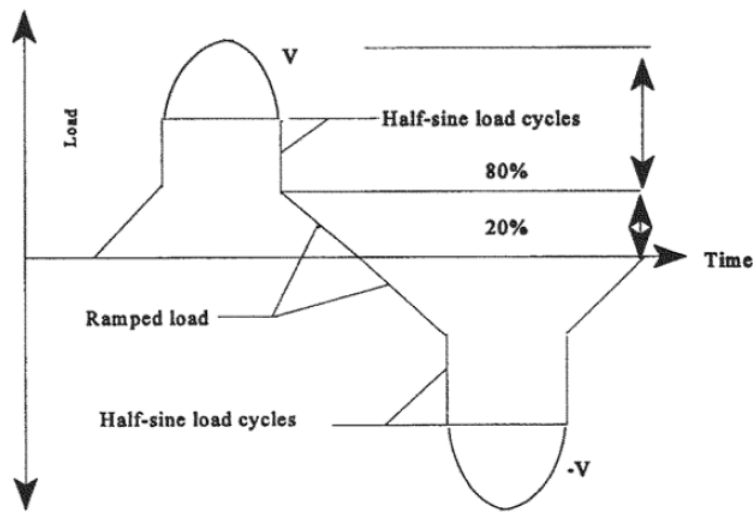


FIGURE 5—APPROXIMATION OF ALTERNATING SHEAR LOADING