ICC EVALUATION SERVICE

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March 10, 2010

TO: **PARTIES INTERESTED IN EVALUATION REPORTS ON PREDRILLED FASTENERS (SCREW ANCHORS) IN MASONRY**

SUBJECT: Proposed Revisions to the Acceptance Criteria for Predrilled Fasteners (Screw Anchors) in Masonry, Subject AC106-0210-R1 (ME/BG)

Dear Madam or Sir:

In February 2010, 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 March 1, 2010, with the following editorial changes to what was initially proposed:

Revise Section 5.2 as: "Quality Documentation complying with the ICC-ES Acceptance Criteria for Quality Documentation (AC10) shall be submitted."

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 Evaluation reports based on a superseded version of an acceptance criteria must be brought into compliance with the most recent edition at the time the reports are reissued.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,

Gary G. Nichols

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

GN/md

Enclosure

cc: Evaluation Committee

ICC EVALUATION SERVICE

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ACCEPTANCE CRITERIA FOR PREDRILLED FASTENERS (SCREW ANCHORS) IN MASONRY

AC106

Approved February 2010

Effective March 1, 2010

Previously approved June 2006, June 2005, February 2005, June 2004, October 2004, September 2002, November 2001

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 (I) 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 purpose of issuing ICC-ES evaluation reports.

ACCEPTANCE CRITERIA FOR PREDRILLED FASTENERS (SCREW ANCHORS) IN MASONRY (AC106)

1.0 INTRODUCTION

1.1 Purpose: The purpose of this criteria is to establish requirements for recognition of predrilled fasteners (screw anchors) in ICC Evaluation Service, Inc. (ICC-ES), evaluation reports under the *2009 International Building Code*® (2009 IBC), the *2009 International Residential Code*® (2009 IRC), the *2006 International Building Code*® (2006 IBC), the *2006 International Residential Code*® (2006 IRC), and the 1997 *Uniform Building Code*™ (UBC). Bases of recognition are IBC Section 104.11, IRC Section 104.11 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: Predrilled fasteners (screw anchors) recognized under this criteria are limited to allowable stress design applications and uncracked masonry as an alternative to Section 2.1.4 of TMS 402/ACI 530/ASCE 5 as referenced in Section 2107.1 of the IBC, Section R301.1.3 of the IRC or Section 2107.1.5 of the UBC. Predrilled fasteners (screw anchors) in concrete shall comply with AC193.

1.3 Codes and Referenced Standards: Where standards are referenced in this criteria, these standards shall be applied consistently with the code (IBC, IRC or UBC) upon which compliance is based. For standards referenced in this criteria and the applicable code, editions of standards applicable to evaluation under the various codes are summarized in Table 9.

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

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

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

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

1.3.5 1997 *Uniform Building Code*™ (UBC).

1.3.6 TMS 402/ACI 530/ASCE 5, Building Code Requirements for Masonry Structures, American Concrete Institute.

1.3.7 ANSI B212.15-1994, Carbide-Tipped Masonry Drills and Blocks for Carbide-Tipped Masonry Drills, American National Standards Institute.

1.3.8 ASTM A 153, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware, ASTM International.

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

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

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

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

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

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

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

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

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

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

1.3.19 ASTM E 488, Standard Test Methods for Strength of Anchors in Concrete and Masonry Elements, ASTM International.

1.4 Definitions:

1.4.1 Anchor Test Series: A group of identical anchors tested under identical conditions. "Identical conditions," for purposes of this criteria, include diameter, length, embedment, spacing, edge distance, masonry density/weight, test member thickness and masonry compressive strength.

1.4.2 Edge Distance:

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

1.4.2.2 Critical Edge Distance (c_{cr}): The least edge distance at which the allowable load capacity of an anchor is applicable without reductions.

1.4.2.3 Minimum Edge Distance (c_{min}): The least edge distance at which the anchors are tested for recognition.

1.4.3 Predrilled Fastener (Anchor): Also known as a screw anchor, the product is a threaded mechanical fastener made of hardened steel placed in assembled masonry with a predrilled hole of lesser size diameter than that of the anchor, designed to develop shear and/or tension resistance to applied loads without grout, adhesive or dry pack.

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

1.4.5 New Masonry: Masonry construction with mortar, grout and masonry units that comply with Section 3.1.

1.4.6 Spacing:

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

1.4.6.2 Critical Spacing (s_{cr}): The least anchor spacing distance at which the allowable load capacity of

an anchor is applicable such that the anchor is not influenced by adjacent anchors.

1.4.6.3 Minimum Spacing (s_{min}): The least anchor spacing at which the anchors are tested for recognition.

1.4.7 Test Member: The masonry assembly receiving the anchors to be tested.

1.4.8 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 TMS 402/ACI 530/ASCE 5 Section 3.1.8.2., or UBC Section 2108.2.4.6.

2.0 BASIC INFORMATION

2.1 Screw Anchors:

2.1.1 Screw anchors 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 pitch.

2.1.1.4 Nominal anchor or sleeve diameter.

2.1.1.5 Anchor length.

2.1.1.6 Permitted manufacturing tolerances.

2.1.1.7 Basic materials, including appropriate physical properties before and after manufacture and protective coatings. If the anchor consists of component parts involving different materials, differences shall be noted.

2.1.1.8 Appropriate national standard for the materials. Reports of physical properties for materials used in test specimens shall be submitted. These reports shall be generated by a mill or testing laboratory. Where no physical property specifications exist, acceptable properties shall be established by physical property tests.

2.1.1.9 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 evaluation report number; and the name or logo of the inspection agency. Every anchor, if available in more than one length per anchor diameter, shall be marked with the actual numerical length, or a length code as described in Table 1, that is visible and legible after anchor installation.

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

2.1.2 When screw anchors are to be recognized for exterior exposure or use in damp environments, evidence of durability shall be established according to the corrosion test procedure in Factory Mutual Research Standard 4450 or 4470.

2.1.3 The applicable specification for the drill bits, such as ANSI B212.15-1994 or manufacturer's specified equivalent shall be provided. Bit diameter tolerances shall comply with medium diameter requirements in Figure 1 or 2, except when testing in accordance with Section 4.2.

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:

2.3.1 Test reports shall comply with AC85 and include information specified in Section 13 of ASTM E 488 and the following:

2.3.1.1 Mode of failure for each test (e.g., substrate cracking, substrate spalling, screw anchor pull-out, screw anchor shear, ductile steel failure, etc.). Location of anchor fracture failures shall be noted (across major screw anchor diameter, across thread diameter, etc.).

2.3.1.2 Photographs of test equipment and typical failure.

2.3.1.3 Report sealed by a registered design professional.

2.3.1.4 Report of screw anchor sampling at manufacturer's facilities by an independent testing agency. See Section 2.4.

2.3.2 Masonry Properties: The test reports shall describe the masonry properties as set forth in Sections 3.1 and 3.2 of this criteria.

2.4 Product Sampling: Screw anchors used in tests shall be sampled in accordance with Section 3.1 of AC85.

2.5 Data Analysis: The documentation containing analysis of data shall be sealed by a registered design professional.

3.0 TEST AND PERFORMANCE REQUIREMENTS

3.1 Masonry:

3.1.1 Masonry test specimens shall be prepared according to the IBC Chapter 21 or UBC Chapter 21, as applicable. Strength is determined according to either the IBC Table 2105.2.2.1.1 or IBC Table 2105.2.2.1.2, or UBC Table 21-D, as applicable, where mortar and grout strength are 110 percent maximum of specified strength. As an alternative, strength is determined using prisms without limitations to unit, mortar and grout strength.

3.1.2 Masonry units shall comply with the appropriate standard:

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

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

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

3.1.2.4 ASTM C 129 (IBC, IRC) or UBC Standard 21-5 (UBC): Non-load bearing Concrete Masonry Units.

3.1.3 Mortar shall be prepared in accordance with the IBC or UBC Section 2103.8 or the IRC Section R607, and ASTM C 270 (IBC, IRC) or UBC Standard 21-15 (UBC). The testing laboratory shall report the mortar composition, type, proportions and compliance with the standard.

3.1.4 Grout shall be prepared in accordance with UBC or IBC Section 2103.12 and IRC Section R609, and

ASTM C 476 (IBC, IRC) or UBC Standard 21-19 (UBC). The testing laboratory shall report grout composition, type, proportions and compressive strength.

3.1.5 Masonry prisms shall be prepared according to ASTM C 1314 (IBC, IRC) or UBC Standard 21-17 (UBC), as applicable. These prisms shall be tested according to ASTM C 1314 (IBC, IRC) or UBC Standard 21-17 (UBC), as applicable, and Section 3.2 of this criteria.

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

3.2 Strength Determination:

3.2.1 Test members shall be aged a minimum of 21 days prior to the beginning of anchor tests.

3.2.2 For masonry where compressive strength is determined according to either IBC Table 2105.2.2.1.1 (clay masonry), IBC Table 2105.2.2.1.2 (concrete masonry), or UBC Table 21-D, masonry unit, mortar and grout tests shall be done at 28 days of age.

3.2.3 For masonry less than 90 days old, two tests of two cylinders, cores or prisms each, prepared according to Section 3.1, shall be tested at the beginning and ending of anchor testing according to Table 2. The beginning test shall be concurrent with the initiation of anchor testing. The beginning and ending strength results shall be averaged (four cylinders, cores or prisms total) to establish the strength of the test members during the anchor test period.

3.2.4 For masonry aged 90 days or more, the compressive strength shall be the average of a single test of three cylinders, cores or prisms determined after at least 90 days and within 30 days of anchor testing.

3.2.5 Reported masonry strength for any anchor test series shall be determined from the tests in this section within the time limitations of Table 2.

3.3 Allowable Loads:

3.3.1 General: The information in Sections, 3.3.2, 3.3.3, 3.3.5, 4.4.4 and 6.6.4 of this criteria shall be applied in determining allowable service loads. The adjustment for seismic or wind load set forth in Section 6.6.4 of this criteria is permitted according to Section 1605.3 of the IBC and Section 1612.3.2 of the UBC if seismic tests described in Section 4.6 of this criteria are conducted.

3.3.2 Allowable Service Load Determination:

3.3.2.1 For tension, if the ultimate load displacement for any test specimen exceeds the displacement limitations set forth in Tables 6 and 7, the ultimate load for that test specimen shall be reduced to an adjusted ultimate load corresponding to the ultimate displacement limitation. For tension and shear, the allowable service load shall be calculated using the average adjusted or unadjusted ultimate load, as applicable, and a factor of safety per Table 8.

3.3.2.2 For tension and shear, the load at the design displacement limitation set forth in Tables 6 and 7 for each test specimen shall be determined, and the average load for each test series shall be calculated.

3.3.2.3 For each test series, the lower of the average loads calculated per Sections 3.3.2.1 and 3.3.2.2 shall be recognized as the allowable service load published in the evaluation report.

3.3.3 Adjustment Factor Considerations:

3.3.3.1 Installation Parameters: 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 shall be applied, the product of the factors is used to determine design loads. Examples include anchors installed at reduced spacings and reduced edge distances.

3.3.3.2 Compressive Strength: Where anchor values are desired in masonry of varying compressive strengths, such values may be derived by interpolation from test results in two strengths of masonry compressive strength, providing the range in mix design strength from one group of tests to another does not exceed 2,000 pounds psi (13.8 MPa).

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

$$(P_s / P_t) + (V_s / V_t) \leq 1$$

where:

P_s = Applied service tension load.

P_t = Service tension load.

V_s = Applied service shear load.

V_t = Service shear load.

The following equation may be used when substantiated by test results from Series 19 and 20:

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

3.3.5 Displacement: Anchor displacement under load is limited by values in Tables 6 and 7.

3.3.6 Spacing and Edge Distance: Where spacings and edge distances have not been established by testing described in Table 3, anchors shall be limited to a minimum anchor spacing and edge distance of 16 times the anchor nominal diameter. Adjustment factors are not permitted unless testing is conducted in accordance with Table 3.

3.3.7 Masonry Test Strength: The average masonry prism strength test results shall be within 10 percent of the nominal specified strengths.

3.3.8 Embedment: Screw anchors shall be tested at the minimum embedment for which recognition is desired. For recognition of variable embedment depths, anchors shall 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 shall 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.

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

4.0 TEST METHODS AND ANALYSIS

4.1 Anchor Installation:

4.1.1 Anchors in each diameter to be recognized shall be tested.

4.1.2 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. The brand, model number, and size of power tool, and drill-bit type shall be reported. Drill bits used in the test program shall have bit diameters with allowable tolerances complying with Figure 1 or 2 for medium bits, except for testing in accordance with Section 4.2, which requires maximum bits. Drill-bit dimensions and corresponding tolerances shall be reported; compliance with applicable standards, such as ANSI B212.15-1994 shall be reported when appropriate. Drilling mode (e.g., rotation only or hammering with rotation) shall be reported for each base material. All procedures shall be conducted or directly verified by the testing laboratory.

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

4.1.4 Installation of anchors shall comply with published recommendations of the manufacturer. Pertinent data such as anchor embedment, depth, nominal torque, etc., shall be observed and reported by the testing laboratory.

4.2 Proper Functioning Tests:

4.2.1 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 3, Test Series A. These tests are conducted at the minimum embedment only. For anchors required to use custom size drill bits supplied by the manufacturer, the drill bit size shall be that of the upper limit supplied.

4.2.2 Conditions of Acceptance: The average ultimate tension loads shall be at least 80 percent of loads obtained on anchors tested in accordance with Table 3, Test Series 1.

4.3 Load Tests for Service Conditions:

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

4.3.1.1 Anchor materials.

4.3.1.2 Direction of loading.

4.3.1.3 Masonry strength.

4.3.1.4 Anchor location: spacing and edge distance.

4.3.1.5 Anchor embedment and thickness of attached and receiving materials. Section 3.3.8 describes embedment qualification criteria.

4.3.2 Table 3 summarizes anchor test requirements for service conditions.

4.4 Testing and Equipment:

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

4.4.2 Direction of loading for all tensile testing shall be coaxial with the embedded anchor.

4.4.3 Test equipment cannot impose pullout or shear-reaction loadings on the surface or edge of the masonry member within the distance specified in Table 2 of ASTM E 488. Equipment used to apply shear loads shall be designed to minimize frictional resistance using a surface finish specified in Section 6.4.3 of ASTM E 488.

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

4.4.5 The testing schedule shall comply with Table 3. Characteristics to be evaluated include service conditions, spacing distance and edge distance. Spacing and edge distance may be established without testing in accordance with Section 3.3.6. The following parameters will be established by the load test program as they apply to the anchor systems:

4.4.5.1 Embedment depth(s).

4.4.5.2 Critical edge distance.

4.4.5.3 Minimum edge distance with appropriate load reduction factor (optional).

4.4.5.4 Critical spacing.

4.4.5.5 Minimum spacing with appropriate load reduction factor (optional).

4.4.6 The minimum allowable wall thickness shall be $1^1/_2$ times h_v, unless other thickness are substantiated with acceptable test data. Section 6.4.1 of 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.

4.4.7 Group tests will establish spacing, except as permitted in Section 3.3.6. Recognition will be based on the number, edge distance and spacing of anchors tested. Groups of bolts consist of two to four anchors with an anchor spacing less than four times the embedment. Table 3 of this criteria and Section 5.5.1.2 of ASTM E 488 contain additional guidelines.

4.4.8 Group tests shall be conducted on the same nominal size anchors used in shear and pullout tests.

4.4.9 All anchors in group tests shall be loaded equally and simultaneously by a common fixture. Shear load shall be collinear with the anchor group.

4.4.10 For anchor tests in masonry, a test program shall be submitted to and accepted by ICC-ES staff before tests are commenced. The program shall consider aspects such as anchor location in test member, (edge distance), anchor location on masonry units (face shells, webs, and unit edges) and anchor location in mortar joints (head joints, bed joints and T-joints).

4.4.11 Where masonry strength is determined according to Section 3.2.2 of this criteria, anchors shall be tested when the test member is 21 to 35 days of age.

4.5 Static Tests: A minimum of five samples per size of anchor is required for tension and shear tests. Static load test procedures for tension and shear shall comply with this criteria and Section 8 of ASTM E 488.

4.6 Seismic and Wind Tests (Optional):

4.6.1 General: Under a simulated seismic test program, tests shall be performed to determine the seismic tension and shear capacity of anchors. This test is required for recognition of anchors for wind or earthquake resistance. Sections 6.3 through 6.6 of this criteria contain additional limitations.

4.6.2 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 median diameter or next-larger diameter of each anchor type, and the material type (i.e., carbon steel, stainless steel, etc.) to be recognized shall be tested at the shallowest and deepest embedments for which seismic recognition is desired.

Anchors shall be installed in accordance with the manufacturer's recommendations and are driven until the anchor just contacts the fixture and the fixture is no longer loose, prior to the testing.

Testing shall be performed on masonry, which shall comply with the strength requirements of Sections 3.1 and 3.2. 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.

4.6.3 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 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 4 and Figure 3.

4.6.4 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 shall be plotted as hysteretic loops. The load cycle is given in Table 5 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.

4.6.5 Conditions of Acceptance:

4.6.5.1 Each anchor shall withstand the loading cycles without failure.

4.6.5.2 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}.

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

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

where:

T_{ref} = Average ultimate tension load based on tests described in Section 4.6.2 or Test Series 1, Table 3, whichever is greater (pounds-force or N).

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 6 or 7 (inches or mm).

N_s = Maximum tension load in seismic tests, described in Section 4.6.3 (pounds-force or N).

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

where:

V_{ref} = Average ultimate shear load based on tests described in Section 4.6.2 or Test Series 12, Table 3, whichever is greater (pounds-force or N).

Δ_{vs} = Measured maximum displacement during seismic shear test (inches or mm).

V_s = Maximum shear load in seismic tests, described in Section 4.6.4 (pounds-force or N).

4.7 Fire Resistance (Optional): Recognition of anchor use in fire-resistive construction shall be evaluated for load resistance during fire exposure. General guidelines for fire exposure are in ASTM E 119 or UBC Standard 7-1.

5.0 QUALITY CONTROL

5.1 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 as otherwise acceptable to ICC-ES. The quality control program shall verify continued anchor compliance with specifications in Section 2.1.

5.2 A quality control manual complying with the ICC-ES Acceptance Criteria for Quality Documentation (AC10) shall be submitted.

6.0 EVALUATION REPORT RECOGNITION

The evaluation report shall include the following:

6.1 Basic information required by Section 2.1, including product description, installation procedures, packaging, and identification.

6.2 Allowable loads for each screw anchor as determined by Section 3.3.

6.3 Exposure: When anchors are recognized for exterior exposure or damp environments, the steel shall be corrosion-resistant, as determined by Section 2.1.2

6.4 Treated Wood: Steel anchoring materials in contact with preservative-treated and fire-retardant-treated wood shall be of hot-dipped zinc-coated steel or stainless steel. The coating weights for zinc-coated steel shall be in accordance with ASTM A 153.

6.5 Special Inspection: Special inspection shall apply to anchors depending on the safety factor selected from Table 8 of this criteria. For the IBC and IRC, special inspection shall conform to Section 1704 of the IBC; for the UBC, special inspection shall be in accordance with Section 1701 of the UBC.

6.6 Evaluation Report Conditions of Use:

6.6.1 Fatigue and Shock Loading: Since an ICC-ES acceptance criteria for evaluating data to determine the performance of screw 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.

6.6.2 Fire-resistance-rated Construction: Where not otherwise prohibited by 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.

6.6.3 Cracked Masonry: Since an ICC-ES acceptance criteria for evaluating the performance of screw anchors in cracked masonry is unavailable at this time, the use of the anchors is limited to installation in uncracked masonry. Cracking occurs when $f_t > f_r$ due to service loads or deformations.

6.6.4 Seismic or Wind Load:

(*This version applies where acceptable test data is supplied under the IBC or the IRC*)

When using the basic load combinations in accordance with IBC Section 1605.3.1.1, 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 that include seismic or wind loads, the allowable shear and tension loads for anchors are permitted to be increased by $33^1/_3$ percent, or the alternative basic load combinations may be reduced by a factor of 0.75.

(*This version applies where acceptable test data is not supplied*:)

Use of the anchors to resist wind or seismic loads is beyond the scope of this report. The allowable loads or load combinations for the anchors shall not be adjusted for anchors subjected to wind or seismic loads.

6.6.4.1 (*This version applies where acceptable test data is supplied under the UBC*)

When using the basic load combinations in accordance with UBC Section 1612.3.1, allowable loads are not permitted to be increased for wind or earthquake loading. When using the alternative basic load combinations in UBC Section 1612.3.2 that include wind or seismic loads, the allowable shear and tension loads for anchors are permitted to be increased by $33^1/_3$ percent.

(*This version applies where acceptable test data is not supplied*:)

Use of the anchors to resist wind or seismic loads is beyond the scope of this report. The allowable loads or load combinations for the anchors shall not be adjusted for anchors subjected to wind or seismic loads.

TABLE 1—LENGTH IDENTIFICATION CODES

CODE		LENGTH (L) OF ANCHOR (inches)
■	N/A	$1 \le L < 1^1/_2$
A	Black	$1^1/_2 \le L < 2$
B	White	$2 \le L < 2^1/_2$
C	Red	$2^1/_2 \le L < 3$
D	Green	$3 \le L < 3^1/_2$
E	Yellow	$3^1/_2 \le L < 4$
F	Blue	$4 \le L < 4^1/_2$
G	Purple	$4^1/_2 \le L < 5$
H	Brown	$5 \le L < 5^1/_2$
I	Orange	$5^1/_2 \le L < 6$
J	N/A	$6 \le L < 6^1/_2$
K	N/A	$6^1/_2 \le L < 7$
L	N/A	$7 \le L < 7^1/_2$
M	N/A	$7^1/_2 \le L < 8$

CODE	LENGTH (L) OF ANCHOR (inches)
N	$8 \le L < 8^1/_2$
O	$8^1/_2 \le L < 9$
P	$9 \le L < 9^1/_2$
Q	$9^1/_2 \le L < 10$
R	$10 \le L < 11$
S	$11 \le L < 12$
T	$12 \le L < 13$
U	$13 \le L < 14$
V	$14 \le L < 15$
W	$15 \le L < 16$
X	$16 \le L < 17$
Y	$17 \le L < 18$
Z	$18 \le L \le 19$
- -	- - - -

For **SI:** 1 inch = 25.4 mm.

TABLE 2—STRENGTH TEST TIME LIMITATIONS

AGE OF MASONRY AT BEGINNING OF ANCHOR TEST	MAXIMUM TIME BETWEEN STRENGTH TESTS (Test Period)	COMMENTS
Less than 21 days	3 days	Per Section 3.2.1 for special tests only
21 - 35 days	7 days	—
36 - 56 days	14 days	—
57 - 90 days	30 days	—
More than 90 days	--	See Section 3.2.3

ACCEPTANCE CRITERIA FOR PREDRILLED FASTENERS (SCREW ANCHORS) IN MASONRY (AC106)

TABLE 3—TESTING SCHEDULE

TEST SERIES NUMBER	TEST	ASTM E 488 CRITERIA SECTION	ICC-ES ACCEPTANCE CRITERIA SECTION	MASONRY COMPRESSIVE STRENGTH[1]	NUMBER OF TESTS				REMARKS[3]
					All Diameters	Small	Medium	Large	
PROPER FUNCTIONING									
A	Tolerance on drill holes[8]	—	4.2	Min.	—	5	5	5	Max. Bit[8]
Service Conditions (Direction of loading: axial tension)									
1	Single anchors	8.4.1	—	Min.	5	—	—	—	Mandatory test
2	Single anchors	8.4.1	—	Med.	5	—	—	—	Optional test
3	Single anchors	8.4.1	—	Max.	5	—	—	—	Optional test
4	Single anchors, critical edge distance	—	3.3.6 & 4.3	Min.	—	5	5	5	Optional test[3]
5	Single anchors, minimum edge distance	—	3.3.6 & 4.3	Min.	—	5	5	5	Optional test[3]
6	Single anchors, critical edge distance	—	3.3.6 & 4.3	Max.	—	5	5	5	Optional test[3]
7	Single anchors, minimum edge distance	—	3.3.6 & 4.3	Max.	—	5	5	5	Optional test[3]
8	Group of 2 anchors, critical spacing distance	—	3.3.6 & 4.3	Min.	—	5	5	5	Optional test[3,5], 9
9	Group of 2 anchors, minimum spacing distance	—	3.3.6 & 4.3	Min.	—	5	5	5	Optional test[3], 10
10	Group of 4 anchors, critical spacing distance	—	3.3.6 & 4.3	Min.	—	5	5	5	Optional test[3,6], 9
11	Group of 4 anchors, minimum spacing distance	—	3.3.6 & 4.3	Min.	—	5	5	5	Optional test[3], 10
Service Conditions (Direction of loading: shear)									
12	Single anchors	8.4.2	—	Min.	5	—	—	—	Mandatory test[2]
13	Single anchors, critical edge distance	—	3.3.6 & 4.3	Min.	—	5	5	5	Optional test[3]
14	Single anchors, minimum edge distance	—	3.3.6 & 4.3	Min.	—	5	5	5	Optional test[3]
15	Single anchors, critical edge distance	—	3.3.6 & 4.3	Max.	—	5	5	5	Optional test[3]
16	Single anchors, minimum edge distance	—	3.3.6 & 4.3	Max.	—	5	5	5	Optional test[3]
17	Group of 2 anchors, critical spacing distance	—	3.3.6 & 4.3	Min.	—	—	5	—	Optional test[3,7]
18	Group of 2 anchors, minimum spacing distance	—	3.3.6 & 4.3	Min.	—		5	—	Optional test[3]
Service Conditions (Direction of loading: oblique tension 45 degrees)									
19	Single anchors	—	3.3.4	Min.	3	—	—	—	Optional test[4]
20	Single anchors	—	3.3.4	Max.	3	—	—	—	Optional test[4]

[1]Where anchors are evaluated at more than one masonry strength level, certain tests shall be repeated at each masonry strength.
[2]Tests for "single anchors, critical edge distance" (No. 13 series) should be tested first. If steel failure occurs, then tests for single anchors (No. 12 series) can be deleted.
[3]Spacings and edge distances are established by acceptable test results. Where acceptable test results are not available, spacings and edge distances shall comply with Section 3.3.6.
[4]Section 3.3.4 describes scope and recognition with and without acceptable test results.
[5]Average ultimate load obtained in this test shall be at least 90% of 2 times the load obtained in test series #4.
[6]Average ultimate load obtained in this test shall be at least 90% of 4 times the load obtained in test series #4.
[7]Average ultimate load obtained in this test shall be at least 90% of 2 times the load obtained in test series #13.
[8]The displacement limitations of Tables 6 & 7 do not apply to this test.
[9] If Test Series 10 (group of four anchors) is conducted, then Test Series 8 (group of two anchors) is considered an optional test.
[10] If Test Series 11 (group of four anchors) is conducted, then Test Series 9 (group of two anchors) is considered an optional test.

TABLE 4—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 5—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 6—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)
$^3/_{16}$	0.0357	0.0625	0.188
$^1/_4$	0.0385	0.0625	0.250
$^5/_{16}$	0.0417	0.0625	0.313
$^3/_8$	0.0455	0.0714	0.375
$^1/_2$	0.0500	0.0714	0.500
$^5/_8$	0.0556	0.0833	0.625
$^3/_4$	0.0625	0.0833	0.750
$^7/_8$	0.0714	0.1000	0.875
1	0.0833	0.1000	1.000
$1^1/_8$	0.1000	0.1250	1.125
$1^1/_4$	0.1250	0.1250	1.250
$1^3/_8$	0.1250	0.1667	1.375
$1^1/_2$	0.1250	0.1667	1.500

[1]The displacement under shear only applies to the shear deflection equation in Section 4.6.5.3, and is not to be used for establishing an ultimate load.

TABLE 7—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

[1]The displacement under shear only applies to the shear deflection equation in Section 4.6.5.3, and is not to be used for establishing an ultimate load.

TABLE 8—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 9—CROSS REFERENCE OF STANDARD EDITIONS[1,2]

STANDARD	1997 *Uniform Building Code*™ (UBC)	2006 *International Building Code*®	2009 *International Building Code*®	2006 *International Residential Code*®	2009 *International Residential Code*®
ASTM C 55	UBC Standard 21-3	2003	2006	1997	2006
ASTM C 62	UBC Standard 21-1	2004	2005	1997a	2005
ASTM C 90	UBC Standard 21-4	2003	2006b	1999	2006b
ASTM C 129	UBC Standard 21-5	2001	2001	2003	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 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 119	UBC Standard 7-1	2000	2007	1998	2007
ASTM E 488	1990	1996	1996	1996	1996
TMS 402/ACI 530/ ASCE 5	—	2005	2008	2005	2008

[1]Editions of standards applicable to the various codes are summarized in this table.
[2]Blank entries indicate the standard is not applicable or referenced in the specific code.

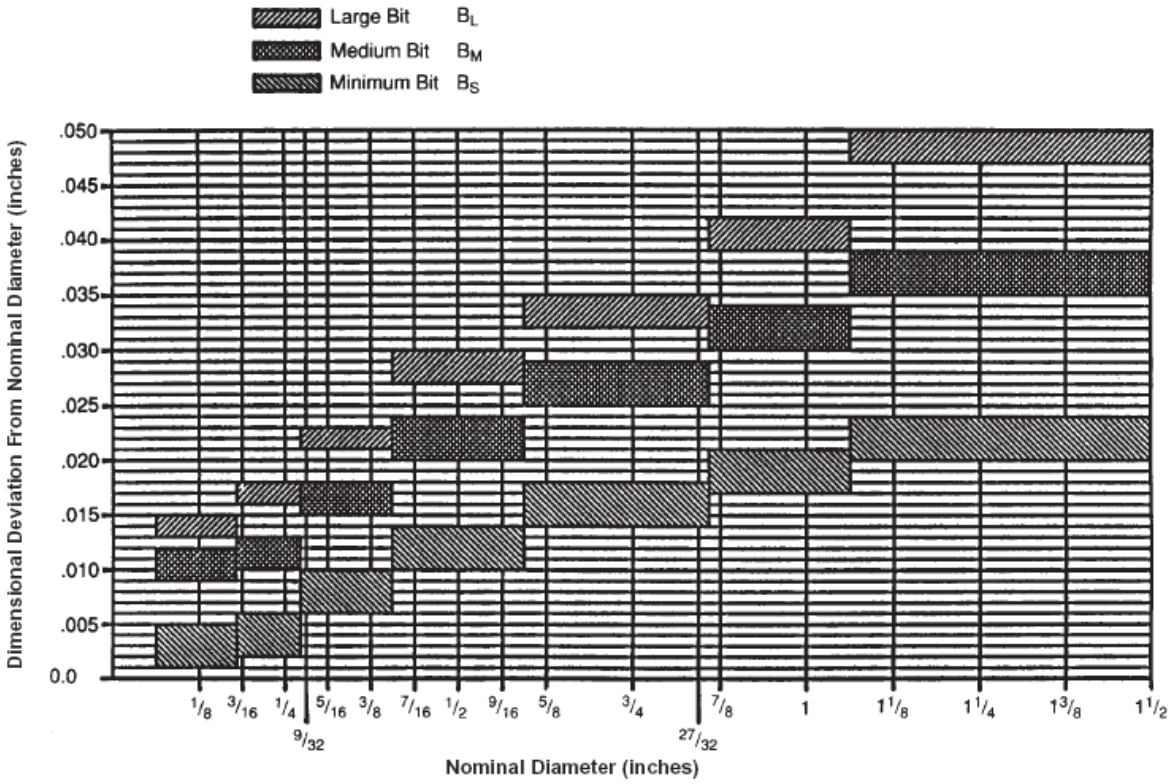

FIGURE 1—CARBIDE-TIPPED DRILL BIT TEST DIAMETER TOLERANCES

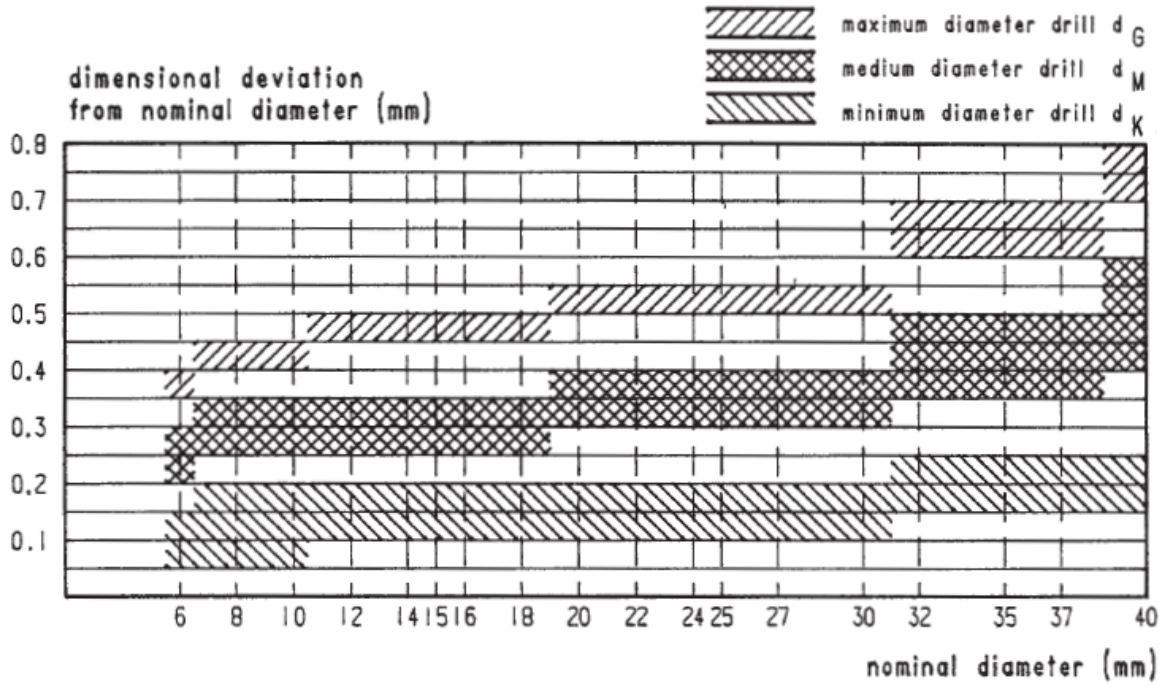

FIGURE 2—CUTTING DIAMETER OF CARBIDE-TIPPED METRIC HAMMER DRILL BITS

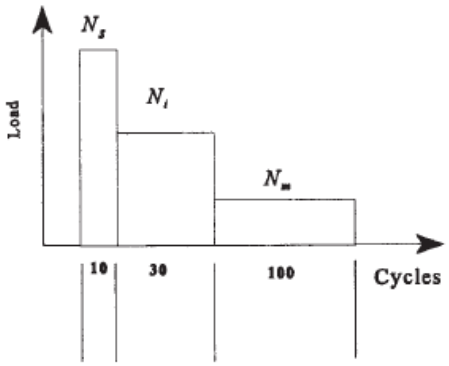

FIGURE 3—SEISMIC TENSION CYCLE

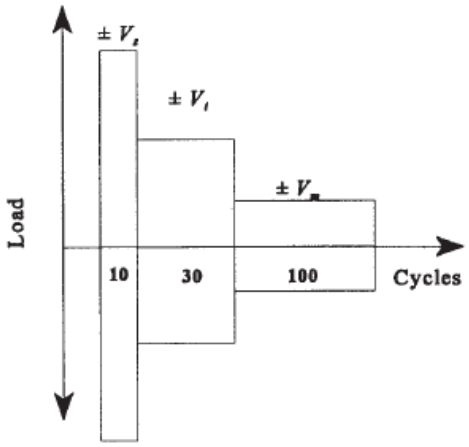

FIGURE 4—SEISMIC SHEAR CYCLE

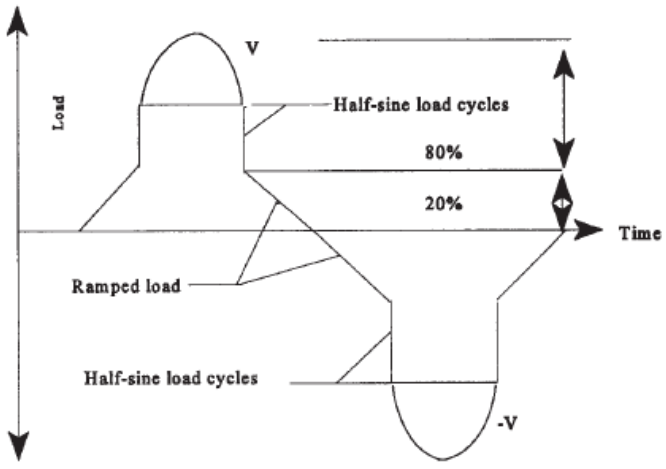

FIGURE 5—APPROXIMATION OF ALTERNATING SHEAR LOADING