ICC EVALUATION SERVICE, INC.
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November 20, 2008

**TO:** **PARTIES INTERESTED IN EVALUATION REPORTS ON CONCRETE REINFORCEMENT**

**SUBJECT:** Acceptance Criteria for Baugrid® Reinforcement, Subject AC403-1008-R1 (BG/RK)

Dear Madam or Sir:

Enclosed is the subject new criteria, which was approved by the ICC-ES Evaluation Committee at the October 22, 2008, hearing. The criteria is effective November 1, 2008.

This acceptance criteria applies to Baugrid® reinforcement, which is intended to be an alternative for providing tie, hoop and stirrup reinforcement in concrete and masonry construction.

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 acceptance 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 Evaluation reports based on a superseded version of an acceptance criteria must be brought into compliance with the most recent edition at the time the reports are reissued.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, applicants should submit data verifying compliance at the time they apply for re-examination.

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

Yours very truly,

Kurt Stochlia, P.E.
Vice President – External Operations

KS/BG/ll

Enclosure

cc: Evaluation Committee

# ACCEPTANCE CRITERIA FOR BAUGRID® REINFORCEMENT

**AC403**

**Approved October 2008**

**Effective November 1, 2008**

## 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 purpose of issuing ICC-ES evaluation reports.***

# ACCEPTANCE CRITERIA FOR BAUGRID® REINFORCEMENT (AC403)

## 1.0 INTRODUCTION

**1.1 Purpose:** The purpose of this acceptance criteria is to establish requirements for BauGrid® reinforcement in structural concrete and masonry to be recognized in an ICC Evaluation Service, Inc. (ICC-ES), evaluation report under the 2006 *International Building Code*® (IBC) and the 1997 *Uniform Building Code*™ (UBC). The bases of recognition are IBC Section 104.11 and UBC Section 104.2.8.

The reason for the development of this criteria is to provide guidelines for evaluating BauGrid® reinforcement as an alternative to code-specified ties, hoops and stirrups for concrete and masonry reinforcement, since the IBC, UBC, ACI 318, and ACI 530 do not specify requirements for acceptance of this alternative product.

**1.2 Scope:** This criteria applies to BauGrid® reinforcement used as an alternative to transverse confinement reinforcement such as code-specified ties, hoops and stirrups, as specified in ACI 318 for reinforced concrete or ACI 530 for reinforced masonry.

BauGrid® reinforcement may be used within lateral force–resisting systems specified in the code, subject to verification of seismic design factors and coefficients based on the design and performance requirements in this criteria and procedures established by ICC-ES.

**1.3 Codes and Referenced Standards:**

**1.3.1** 2006 *International Building Code*® (IBC), International Code Council.

**1.3.2** 1997 *Uniform Building Code* ™ (UBC).

**1.3.3** ASTM A 82-02, Standard Specification for Steel Wire, Plain, for Concrete reinforcement, ASTM International.

**1.3.4** ASTM A 185-02, Standard Specification for Steel Welded Wire reinforcement, Plain, for Concrete, ASTM International.

**1.3.5** ASTM C 31-98, Practice for Making and Curing Concrete Test Specimens in the Field, ASTM International.

**1.3.6** ASTM C 39-03, Test Method for Compressive Strength of Cylindrical Concrete Test Specimens, ASTM International.

**1.3.7** ACI 318-05, Building Code Requirements for Structural Concrete, American Concrete Institute.

**1.3.8** ACI 374.1-05 Acceptance Criteria for Moment Frames Based on Structural Testing and Commentary, American Concrete Institute.

**1.3.9** ACI 530-05, Building Code Requirements and Specification for Masonry Structures, American Concrete Institute.

**1.3.10** SEI/ASCE 7-05, Minimum Design Loads for Buildings and Other Structures, American Society of Civil Engineers.

**1.4 Definitions**

**1.4.1 BauGrid® Reinforcement:** A single-plane reinforcement grid installed in the plane perpendicular to the longitudinal axis of the reinforced concrete or masonry member. The grid is comprised of W11, W20, W31 and W44 plain steel wires complying with ASTM A 82, factory-welded at all wire intersections within the grid in accordance with ASTM A 185 and the approved quality documentation.

**1.4.2 Test Specimen:** Laboratory test specimen representing the characteristics of the structural component being modeled.

**1.4.3 Drift Ratio:** Total lateral deformation of the test specimen divided by the height of the test specimen.

## 2.0 BASIC INFORMATION

**2.1 General:** The following information shall be submitted:

**2.1.1 Product Description:** Information shall be submitted concerning material specifications and manufacturing processes, including production tolerances.

**2.1.2 Installation Instructions:** Installation instructions shall include requirements and limitations for intended use of the product, and a description of the field preparation and assembly; procedures establishing quality control in field installation; and requirements for product handling and storage.

**2.1.3 Packaging and Identification:** The method of packaging shall be specified, and shall include a requirement for labels that bear the names of the evaluation report holder and the authorized manufacturer; product name; wire size and grade; evaluation report number (ICC-ES ER-XXXX); and the name or logo of the inspection agency.

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

**2.3 Test Reports:** The test reports shall comply with AC85 and the requirements detailed in Section 4.2 or 4.3 of this criteria.

**2.4 Product Sampling:** Sampling of the BauGrid® reinforcement product for testing shall comply with Section 3.1 of AC85.

## 3.0 DESIGN AND PERFORMANCE REQUIREMENTS

**3.1 General:** This criteria is to qualify BauGrid® reinforcement as an alternative to ties, hoops and stirrups in concrete and masonry structures, based on analytical and experimental evidence.

The locations of BauGrid® reinforcement as transverse reinforcement in concrete and masonry shall be identified by the evaluation report holder. Locations may include beams, columns, beam-column joints, coupling beams, walls, and shear walls. BauGrid Reinforcement shall not be placed where hinging or buckling is possible, unless the reinforcement is located where plastic hinging will occur within the test specimen and the test results demonstrate acceptable performance.

Acceptance of BauGrid® reinforcement in fully grouted reinforced masonry structures may be based on testing in concrete elements, provided an analysis supporting this relationship in accordance with IBC Section 1604.4 is provided. The analysis shall also reconcile the performance of concrete test specimens with requirements

in ACI 530 and establish pertinent similarities between ACI 318 and ACI 530.

**3.2 BauGrid® Reinforcement Design Procedure:**

**3.2.1 Concrete:** Concrete elements reinforced with BauGrid® reinforcement shall be designed in accordance with the design requirements for conventional transverse reinforcement in Chapters 7 through Chapter 21 of ACI 318 as modified by IBC Section 1908; or Sections 1907 to 1911 of the UBC, as applicable. The value of $f_{yt}$ used in design of transverse reinforcement may exceed 60,000 psi (413 MPa), provided test results prove equivalent elastic and inelastic behavior with code complying elements.

**3.2.2 Masonry:** Masonry elements reinforced with BauGrid® reinforcement shall be designed in accordance with the design requirements for conventional transverse reinforcement in ACI 530 (IBC), as modified by Chapter 21 of the IBC or Chapter 21 of the UBC, as applicable. Seismic design requirements set forth in Section 1.14 of ACI 530 and as modified by IBC Section 2106 shall apply. In areas of seismic risk, design shall also comply with UBC Section 2106.1.12.

**3.2.3 Placement and Detailing:** Placement of BauGrid® reinforcement shall comply with the placement and detailing requirements for conventional transverse confinement reinforcement, including special seismic requirements, as specified in the IBC, UBC, ACI 318 and ACI 530.

**3.3 Structural Testing:** The testing specified in Section 4.2 of this criteria shall be conducted on each concrete member location in the test plan containing BauGrid® reinforcement as set forth in Section 3.1 of this criteria. For adequate comparisons, either testing specified in Section 4.2 of this criteria shall also be conducted on each concrete member location containing conventional transverse reinforcement or published literature exhibiting the corresponding structural systems and relevant performance characteristics shall be submitted. All or part of the tests and literature described in this section, and any additional tests identified for special features of the BauGrid® reinforcement, shall be described in a test plan. The test plan shall demonstrate adequacy of the test program to furnish performance characteristics supporting the intended uses of BauGrid reinforcement. Aspects to be proven in the tests shall include the ability of the test specimens to exhibit the critical limit states or failure modes, the ability to encompass the extremes of intended dimensional, reinforcing, and concrete compressive strength boundaries, and suitability for the intended uses, such as columns, beams, and end use. Rates of applied loads or deformations shall be established and proven as appropriate for the testing. The need for multiple test specimens to establish reliability of the test data shall be addressed. The need for additional tests encompassing special detailing requirements in Chapter 21 of ACI 318 and Section 1.14 of ACI 530 for areas of seismic risk shall be addressed.

**3.4 Conditions of Acceptance:** In addition to specific conditions of acceptance associated with each test set forth in Section 4.2 of this criteria, the test results shall demonstrate that concrete test specimens confined with BauGrid® reinforcement and designed in accordance with this criteria and the provisions of the IBC or UBC for transverse reinforcement, demonstrate the minimum performance as identified in the applicable test method, and provide equivalent structural performance to test results for reinforced concrete test specimens with code-specified ties, hoops and stirrups. Test specimens in this criteria subjected to lateral deformations shall be required to achieve the allowable story drift values specified in Section 12.12-1 of SEI/ASCE 7 for occupancy Category I or II, while supporting gravity loads.

**4.0 TEST METHODS**

**4.1 General:** Reports of tests specified in Sections 4.2 and 4.3 shall be submitted. The test specimens shall be **constructed** under conditions specified by the manufacturer. Tests shall simulate the anticipated loading conditions, load levels, deflections, and ductilities.

**4.2 BauGrid® Reinforcement Performance Tests in Concrete:** Testing under this section shall establish the strength and deformability of concrete elements as identified in Section 3.1, such as walls, shear walls, columns, beams and beam-column joints, based on the performance of test specimens constructed with BauGrid® reinforcement as transverse reinforcement. Similar tests shall also be conducted on test specimens constructed with conventional transverse reinforcement, complying with the code except where published literature is deemed acceptable by the ICC-ES staff.

**4.2.1 Column Test:** Testing under this section shall determine the strength and deformability of cantilever-reinforced concrete columns confined with BauGrid® reinforcement, constructed in accordance with the detailing requirements set forth in the IBC or UBC for transverse reinforcement.

The test specimens shall be tested at full scale, but may have a scale not less than one-third full size provided the test plan substantiates the appropriateness of the reduced scale specimens in replicating the expected performance of the full-scale structure by considering materials, geometry, reinforcement, and load transfer mechanisms. Specimens shall be subjected to concentric compression from 20 percent to 40 percent of their capacities and lateral deformations representative of the drifts expected under earthquake motions, as determined in accordance with SEI/ASCE-7.

**4.2.1.1 Test Specimens:** Column test specimens shall be configured to induce expected limit states or failure modes based on analysis in accordance with Section 3.2. Extremes of dimensional, reinforcing, and strength parameters shall be considered. Column test specimens shall be at least 14 inches (350 mm) square in cross section and a minimum of 94 inches (1370 mm) in height. Additional test specimens of other sizes shall be constructed as deemed necessary to establish equivalency.

BauGrid® reinforcement used in the concrete test specimens shall be investigated by the testing laboratory and comply with material specifications in Sections 5.2.1 to 5.2.6 of this criteria. Actual yield strength of steel reinforcement shall be obtained by testing coupons taken from the same reinforcement heat as used in the test specimens, in accordance with the specifications in Section 3.5 of ACI 318, and shall be reported for each reinforcement type and size. At least two configurations of BauGrid® reinforcement shall be tested, one with one additional central cross wire each way (four-cell grid) and one with two additional cross wires each way (nine-cell grid).

Test specimens shall be constructed using concrete with a minimum 28-day compressive strength of 4,000 psi (30 MPa), poured in two vertical lifts. Additional test specimens with concrete of greater compressive strength shall be constructed as established in the test plan. The compressive strength of concrete shall be determined by testing concrete cylinders prepared in accordance with ASTM C 31 and cured under the same conditions as the test specimen. Cylinder testing shall comply with ASTM C 39 and the applicable requirements of IBC Section 1905.6.

At least three test specimens shall be tested in a cantilever configuration. At least one test specimen shall be tested for each of the axial capacity loading conditions, and at least one test specimen shall be tested for each BauGrid® reinforcement configuration. Similar test specimens using conventional reinforcement shall also be constructed and tested as indicated in the test plan.

Linear variable displacement transformer (LVDT) instrumentation and strain gauges shall be attached to the BauGrid® reinforcement to measure displacement, rotations and strains. To measure horizontal displacement, LVDTs shall be placed at the point of application of the lateral load and just below the loading beam. To measure vertical displacements, LVDTs shall be placed perpendicular to the direction of loading in the critical plastic hinge region predicted by analysis. At least two electrical resistance strain gauges shall be placed on transverse and longitudinal reinforcement to measure the strains in the steel wires.

**4.2.1.2 Testing Method:** The test specimens shall first be subjected to a constant axial load determined by analysis, applied by two 224 kip (1000 kN) capacity actuators; and this load maintained throughout the test. Lateral deformations shall be applied by means of a third actuator positioned horizontally between the steel loading beam and the lateral support system. At least three fully reversed cycles shall be applied at each drift ratio.

The initial drift ratio shall be within the essentially linear elastic response range corresponding to three displacement-controlled elastic cycles of 0.5 percent lateral drift, followed by three cycles of one percent drift. Subsequent drift ratios shall be in one percent increments until the drift ratio equals or exceeds four percent.

Data shall be recorded from all tests, including strains in the BauGrid® reinforcement, to formulate a quantitative interpretation of the performance of the test specimens.

**4.2.1.3 Test Report:** The test report shall contain sufficient evidence for an independent evaluation of all test procedures, assumptions, and the performance of the test specimens, including but not limited to: details of the test specimen design and construction; details of specified material properties; a description of test setup; applied deformation rates; and a description of instrumentation, its locations, and its purpose.

A descriptive and graphical presentation of the data records shall be provided of applied drift ratio sequence versus applied lateral force, and photographs shall be taken that show the condition of the test specimen at the peak displacement and after each testing cycle. The strains exhibited in the BauGrid® reinforcement shall be used to correlate the concrete performance to a means of measuring and assuring BauGrid® reinforcement ductility, described in Section 4.3 of this criteria.

**4.2.1.4 Conditions of Acceptance:** In addition to requirements in Section 3.4 of this criteria, for concrete test specimens constructed with BauGrid® reinforcement as transverse reinforcement and designed in accordance with Section 3.2 of this criteria and the IBC or UBC, conditions of acceptance shall be that the test specimens achieve a minimum drift capacity, measured at a maximum acceptable strength decay rate of 20 percent, of not less than the allowable story drift limitations in the code, as specified in SEI/ASCE-7 Table 12.12-1.

**4.2.2 Beam-column Connection Tests:** Testing shall be conducted in accordance with ACI 374.1. The testing shall investigate and confirm the requirements of ACI 318 Chapter 21 for the weak beam-strong column, using a test specimen incorporating the beam-column connection. BauGrid® reinforcement used in the test specimens shall comply with the detailing requirements set forth in the IBC or UBC for closely spaced transverse reinforcement.

These tests shall be performed on test specimens designed and constructed to represent a beam-column connection of a special moment frame. The test specimens shall have a scale not less than one-third full size and shall be subjected to both gravity and lateral loads.

**4.2.2.1 Test Specimens:** Beam-column joint test specimens shall be configured to induce expected limit states or failure modes based on analysis in accordance with Section 3.2. Extremes of dimensional, reinforcing, and strength parameters shall be considered. Minimum dimensions include column test specimens of at least 12 inches (305 mm) square cross section with a $64^{1}/_{4}$-inch (1632 mm) total height, and beams 8 inches (203 mm) wide by 16 inches (406 mm) deep with a total span of 38.66 inches (982 mm). Additional test specimens of the sizes shall be constructed as deemed necessary to establish equivalency.

The test specimens of the concrete beam-to-column connection shall be constructed using both mild steel reinforcement and BauGrid® reinforcement. BauGrid® reinforcement used in the concrete test specimens shall be investigated and found to comply with material specifications in Sections 5.2.1 to 5.2.6 of this criteria, and the referenced codes. Actual yield strength of steel reinforcement shall be obtained from the same reinforcement heat as used in the test specimens, in accordance with specifications cited in Section 3.5 of ACI 318, and shall be reported for each reinforcement type and size. The configurations of BauGrid® reinforcement to be tested in the column shall include a square dimension with two additional central cross wires each way (nine-cell grid). In the beams, two configurations shall be used: one rectangular and one H-shaped to accommodate the trough design of the beam.

Test specimens shall be constructed using concrete with minimum 28-day compressive design strength of 6,000 psi (41.37 MPa). Additional test specimens with concrete of greater compressive strength shall be constructed as established in the test plan. The compressive strength of concrete shall be determined by testing concrete cylinders cured under the same conditions as the test specimen. Cylinder testing shall comply with ASTM C 39 and the applicable requirements of IBC Section 1903.6.

At least three test specimens shall be tested. Each test specimen shall be tested under the same simulated gravity loading conditions and lateral deformations, and vary only in the amount and type of mild steel reinforcement in the beams. Similar test specimens using conventional reinforcement shall also be constructed and tested as indicated in the test plan..

**4.2.2.2 Testing Method:** The test specimens shall be first subjected to simulated gravity loads taken from the moment frame design analysis. The minimum dead and live loads maintained as constant throughout the test shall be 4.49 kips (20 kN) and shall be applied perpendicular to the beam approximately $3^1/_2$ inches (89 mm) from the face of the column. These loads shall be required to ensure that the beam member and the column member of the test specimen reinforced with BauGrid® reinforcement have sufficient shear resistance to both shear and gravity loads.

Lateral deformations shall be applied horizontally by a load cell at the end of the beam. Three fully reversed cycles shall be applied at each drift ratio.

The basic loading history shall consist of three cycles at the predetermined initial drift ratio followed by an elastic cycle of approximately 30 percent of the peak load in the subsequent cycles. The first initial drift ratio shall be within the linear elastic response range and be at least 0.001. Subsequent drift ratios shall be in increments of 1.25 to 1.50 times greater than the subsequent cycle until the drift ratio equals or exceeds 0.035.

Data shall be recorded from all tests to formulate a quantitative interpretation of the performance of the test specimens.

**4.2.2.3 Test Report:** The test report shall contain sufficient evidence for an independent evaluation of all test procedures, assumptions, and the performance of the test specimens, including but not limited to details of the test module design and construction; details of specified material properties applied deformation or load rates; and a description of test setup.

A descriptive and graphical presentation of the data records shall be provided as test applied drift ratio sequence versus applied lateral force, and photographs shall be taken that show the condition of the test specimen at the peak displacement and after each key testing cycle.

**4.2.2.4 Conditions of Acceptance:** In addition to requirements in Section 3.4 of this criteria, for the beam-column test specimen constructed with BauGrid® reinforcement as transverse reinforcement and designed in accordance with Section 3.2 of this criteria, the conditions of acceptance shall be that performance of the test specimen is equivalent to the performance of a beam-column connection test specimen with code-specified transverse reinforcement. Equivalency comparisons shall consider the quantities illustrated in Figure R9.1 of ACI 374.1.

**4.2.3 BauGrid® Reinforcement in Boundary Elements of Shear Walls:** Testing in accordance with this section shall investigate and confirm the strength and deformability of reinforced concrete shear wall boundary elements confined with BauGrid® reinforcement, constructed in accordance with the detailing requirements set forth in the IBC or UBC for transverse reinforcement. Where intended applications include masonry shear walls, the test plan shall demonstrate how the testing complies with requirements in Section 3.3.6.10 of ACI 530.

Tests shall be performed on a minimum of three test specimens, designed and constructed to represent part of a shear wall boundary element. To represent fully the complexities and behavior of actual construction, the test specimens shall be designed as full-scale portions of the boundary elements and shall be subjected to a low rate of cyclic loading. The test plan shall demonstrate the specimens' structural compatibility with the intended shear walls.

**4.2.3.1 Test Specimens:** Column test specimens shall be configured to induce expected limit states or failure modes based on analysis in accordance with Section 3.2. Extremes of dimensional, reinforcing, and strength parameters shall be considered. Three concrete test specimens a minimum of 5.5 inches (150 mm) wide, 18 inches (450 mm) long in plan, and 56 inches (1422 mm) tall shall be constructed using BauGrid® reinforcement as transverse confinement reinforcement to model boundary elements of uniform width shear walls with aspect ratios from 4.8 to 7.4. Testing shall be conducted under increasing cycles of axial load reversals replicating tension and compression cycles experienced in boundary elements during flexural response of shear walls subjected to strong ground motion.

BauGrid® reinforcement used in the concrete test specimens shall be investigated and found to comply with material specifications in Sections 5.2.1 to 5.2.6 of this criteria and the IBC or UBC. Actual yield strength of steel reinforcement shall be obtained by testing coupons taken from the same reinforcement heat as used in the test specimens, in accordance with the ASTM specifications cited in Section 3.5 of ACI 318. BauGrid® reinforcement used in the test shall have a rectangular dimension with two additional central cross wires (three-cell grid) in the long direction. Similar test specimens using code-specified transverse reinforcement shall be constructed as indicated in the test plan.

Test specimens shall be constructed using concrete with a minimum 28-day compressive strength of 4,000 psi (30 MPa) poured in two lifts. Additional test specimens with concrete of greater compressive strength shall be constructed as established in the test plan. The compressive strength of concrete shall be determined by testing concrete cylinders prepared in accordance with ASTM C 31 and cured under the same conditions as the test specimen. Cylinder testing shall comply with the applicable requirements of IBC Section 1905.6.

Direct current displacement transformer (DCDT) instrumentation and strain gauges attached to the BauGrid® reinforcement shall be used to measure displacement, rotations and strains. To measure axial deformation, DCDTs shall be placed on rods embedded in the concrete perpendicular to the longitudinal axis of the test specimen.

**4.2.3.2 Testing Method:** The test specimens shall be first subjected to a compression load applied by a vertical 1,000 kips (4448 kN) capacity actuator, and then cycled through tension and compression at a low rate of monotonic loading.

The compression load in the first cycle shall be applied until a local strain of approximately 0.006 is attained and then reversed, and tension loading applied

until a strain of 0.06 is attained. The cycles shall be repeated to incrementally greater strains until failure.

**4.2.3.3 Test Report:** The test report shall contain sufficient evidence for an independent evaluation of all test procedures, assumptions, and the performance of the test specimens, including but not limited to details of the test module design and construction; details of specified material properties; a description of the test setup; and a description of instrumentation, its locations, and its purpose.

A description and graphical presentation shall be provided of applied load sequence as well as a description of observed performance and the condition of each test specimen at the conclusion of the test. Photographic documentation shall also be provided.

**4.2.3.4 Conditions of Acceptance:** In addition to requirements in Section 3.4 of this criteria, for BauGrid® reinforcement designed in accordance with Section 3.2 of this criteria and the referenced codes, the condition of acceptance shall be that the test specimens shall exhibit stable mechanical behavior up to strains of 0.02.

**4.3 BauGrid® Reinforcement Performance Tests:** Testing in accordance with this section shall establish the strength and deformability of BauGrid® reinforcement as identified in Section 4.2, above.

**4.3.1 BauTech® Ductility Tests:** Testing under this section shall establish the correlation between the material strain experienced in BauGrid® reinforcement in the reinforced concrete test specimens in accordance with Section 4.2 of this criteria, and material properties of exposed BauGrid® reinforcement to create a standardized material test to confirm the ductility and elongation characteristics of BauGrid® reinforcement. This test shall supplement the materials tests described in Sections 5.2.1 through 5.2.6 of this criteria.

**4.3.2 Test specimens:** Test specimens shall be obtained from the same reinforcement heat as used for the concrete test specimens described in Section 4.2.1.1 of this criteria, and tested to determine compliance with material specifications in Sections 5.2.1 to 5.2.6 of this criteria. Tests shall be conducted on each reinforcement size used in BauGrid® reinforcement.

Two configurations of BauGrid® reinforcement with each wire size shall be tested, each with a square out-to-out dimension of 11.5 inches (292 mm): one with one additional central cross wire each way (four-cell grid) and one with two additional cross wires each way (nine-cell grid). At least three test specimens shall be tested for each configuration.

Linear variable displacement transformer (LVDT) instrumentation and strain gauges shall be attached to the BauGrid® reinforcement to measure displacement, rotations and strains.

**4.3.2.1 Test Method:** The BauGrid® reinforcement test specimens shall be subjected to diagonal tension by means of hinged loading pins along one of the diagonals while the specimens are restrained against contraction in the orthogonal diagonal direction by means of restraining rods. Elongation measurements shall be taken in the direction of loading by an LVDT placed between the two loading pins. Loading shall be applied under monotonically increasing tensile force until failure. The load rate shall be in accordance with ASTM A 370 or as documented in the test plan.

**4.3.2.2 Test Report:** The test report shall contain sufficient evidence for an independent evaluation of all test procedures, assumptions, and the performance of the test specimens, including but not limited to details of the test; details of specified material properties; a description of test setup; and a description of instrumentation, its locations, and its purpose.

The results of this test shall be used to establish conditions of acceptance for a standardized test protocol for quality control as detailed in Section 5.2.6 of this criteria. The test report shall identify relevant performance criteria for ongoing quality assurance, by expressing the limits for elongation capacity in terms of percent elongation along the diagonal to achieve the elongation corresponding to twice the strain experienced in the material for the allowable story drift ratio referenced in Section 4.2.1 of this criteria.

Data shall be recorded from all tests such that a quantitative interpretation can be made regarding the performance of the test specimens. A record shall be made of both strain and displacement versus applied load, and photographs shall be taken that show the condition of the test specimens in concrete and corresponding condition of the exposed reinforcement of the test specimen.

**4.3.2.3 Conditions of Acceptance:** Inelastic deformability shall be equated to and expressed in terms of diagonal elongation of the grid, and acceptable values shall be determined by correlation with the strains recorded in the BauGrid® reinforcement in the concrete test specimens described in Section 4.2.1 of this criteria

## 5.0 QUALITY CONTROL

**5.1 General:** BauGrid® reinforcement shall be manufactured under a quality control program described in quality documentation complying with the ICC-ES Acceptance Criteria of Quality Documentation (AC10). Such documentation shall be submitted for each manufacturing facility. The chain of certification and control shall ensure quality control is consistent and ongoing. Certification and test results in accordance with ASTM 82 shall be furnished by the steel wire producer or supplier.. Tests performed by the BauGrid® reinforcement manufacturing facility shall be conducted in accordance with the quality documentation, which shall reproduce the pertinent material tests to provide a chain of certification. The manufacturing facility shall perform additional specific product tests during manufacture as identified in the quality documentation.

**5.2 BauGrid® Reinforcement Material Tests:** Testing in accordance with this section shall demonstrate that the facilities manufacturing BauGrid® reinforcement comply with the approved quality control program and the quality documentation.

The initial approval of a BauGrid® reinforcement manufacturing facility shall require testing of three samples provided for each wire size on each machine. The initial approval test report shall include the tests described in Sections 5.2.1 through 5.2.6 of this criteria. The test report shall include documentation, in the form of certification from the producer or supplier or test reports, of the actual physical properties of the wire. The physical

properties of the wire shall comply with the properties specified in ASTM A 82 for plain wire.

Testing in accordance with this section of this criteria shall also be used to demonstrate ongoing compliance with the quality control measures as specified in the quality documentation for all products manufactured in each manufacturing facility, including compliance with ASTM A 82 and ASTM A 185, as outlined in Sections 5.2.1 to 5.2.6.

**5.2.1 Reduction of Area Tests:** Sampling frequency and test procedures for the reduction of area tests on the plain wire used in BauGrid® reinforcement shall be conducted by the material supplier in accordance with Section 10 of ASTM A 185. For quality control, two samples cut from the BauGrid® reinforcement shall be tested by the manufacturer at each change of shift, for each machine, in accordance with the quality documentation and the test procedures for the reduction of area tests on the plain wire set forth in Section 7 of ASTM Standard A 185. The results of all tests shall comply with the conditions of acceptance specified in ASTM A 82.

**5.2.2 Tensile Tests:** Sampling frequency for the tensile tests on the plain wire shall be conducted in accordance with Section 10 of ASTM A 185, and the quality documentation. The test procedures for tensile tests on the plain wire shall be conducted in accordance with Section 7 of ASTM Standard A 185 on wire cut from the BauGrid® reinforcement. The results of the tests shall demonstrate compliance with ASTM A 82, except a minimum yield strength of 75,000 psi (515 MPa) and a minimum tensile strength of 85,000 psi (585 MPa) shall be achieved for all wire sizes.

**5.2.3 Weld Shear Tests:** The sampling frequency and test procedures for weld shear tests on the BauGrid® reinforcement manufactured with plain wire shall be conducted in accordance with Sections 7 and 10 of ASTM A 185 and the quality documentation. The results of all tests shall comply with the conditions of acceptance specified in Section 7 of ASTM A 185.

**5.2.4 Tension Tests:** Sampling frequency and test procedures for tension tests on the incoming plain wire shall be conducted by the producer, supplier, or testing laboratory in accordance with Section 10 of ASTM A 82. The actual physical properties of the plain wire shall be documented by test reports or mill certificates. The conditions of acceptance are that the minimum yield strength shall be 75,000 psi (515 MPa)and the minimum tensile strength shall be 85,000 psi (585 MPa).

**5.2.5 Bend Tests:** Sampling frequency and test procedures for bend tests on the incoming plain wire shall be conducted in accordance with ASTM A 82. The actual results for the wire shall be documented by test reports conducted by the producer, supplier or testing laboratory. The conditions for acceptance are that material subjected to the bend test conforms to requirements in ASTM A 82.

**5.2.6 Ductility Tests:** The test method and conditions of acceptance for ductility testing shall reflect the results of the experimental testing outlined in Section 4.3 of this criteria, with the elongation capacity expressed in terms of percent elongation along the diagonal of a square grid. The sampling frequency for ductility testing of the BauGrid® reinforcement with plain wire shall be two samples of single-cell grids of approximately 10-inch (254 mm) square dimensions to be tested by the manufacturing facility at each change of shift for each machine, in accordance with the quality documentation. Test procedures and the results of all tests shall comply with the conditions of acceptance, in terms of minimum elongation along the diagonal, set forth in the quality documentation, related to the performance of the BauGrid® reinforcement used in the tests of Section 4.0 of this criteria.

## 6.0 EVALUATION REPORT RECOGNITION

**6.1** The evaluation report shall indicate that special inspections shall be provided at the jobsite as required by the IBC or UBC for transverse reinforcement.

**6.2** The evaluation report shall provide basic information required in Section 2.1, including a product description, installation instructions and packaging and labeling information.

**6.3** The evaluation report shall include a condition that the BauGrid® reinforcement shall be designed and installed in accordance with the IBC or UBC, as applicable, except as specifically modified in the evaluation report.

**6.4** The evaluation report shall include a statement as to whether reinforced concrete or masonry systems containing BauGrid® reinforcement, recognized under this acceptance criteria can be used in lateral force–resisting systems.■