ICC EVALUATION SERVICE

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August 18, 2020

TO: **PARTIES INTERESTED IN PROPOSED ACCEPTANCE CRITERIA FOR FIBER–REINFORCED POLYMER (FRP) BARS AND MESHES FOR INTERNAL REINFORCEMENT OF NON-STRUCTURAL CONCRETE MEMBERS (AC521)**

SUBJECT: Proposed Acceptance Criteria for Fiber-Reinforced Polymer (FRP) Bars and Meshes for Internal Reinforcement of Non-Structural Concrete Members, AC521-1020-R1 (ME/MC)

Hearing Information:
WebEx Event Meetings
Tuesday, October 6, 2020
Wednesday, October 7, 2020
8:00 am Central Daylight Time
Click each date above to register.
Please register for *both* days

Dear Colleague:

You are invited to comment on proposed new acceptance criteria for Fiber-Reinforced Polymer (FRP) Bars and Meshes for Internal Reinforcement of Non-Structural Concrete Members, AC521, which will be discussed at the Evaluation Committee hearing noted above. The proponent of the proposed acceptance criteria is Lite-Form Technologies, LLC.

This acceptance criteria applies to solid circular cross-section glass or basalt fiber-reinforced polymer (FRP) bars or meshes that are used as secondary reinforcement for cracking, temperature and shrinkage control in non-structural concrete members. Items evaluated include physical, and mechanical properties.

This acceptance criteria applies to FRP bars and meshes used as an alternative to the shrinkage and temperature reinforcement specified in Section 24.4 of ACI 318 for plain

concrete footings and for plain concrete slabs (as defined by ACI 360) supported directly on the ground. This criteria does not eliminate the requirement for joints specified in Section 14.3.4 of ACI 318 (IBC and IRC).

FRP bars and meshes are also used as an alternative to horizontal temperature and shrinkage reinforcement in structural plain concrete walls covered in IBC Section 1906, IRC Sections R404.1.3 and R608.1, and ACI 332 Sections 8.2.1 and 8.2.7, excluding walls where vertical reinforcement is required.

You are invited to submit written comments on this or any other agenda item, or to attend the Evaluation Committee hearing and present your views during the Webex Event meeting. If you wish to contribute to the discussion, please note the following:

1. Regarding written comments and presentations:

   a. You should submit these via e-mail to es@icc-es.org or by U.S. mail to the Eastern Regional (Birmingham) office to be received by the applicable due date.

   b. Comments are to be received by **September 10, 2020.** These written comments will be forwarded to the committee before the meeting, and will also be posted on the ICC-ES web site shortly after the deadline for submission. Written comments that are not submitted by this deadline will not be considered at the meeting.

   c. Rebuttal comments, from the proponent noted in this letter, are to be received by **September 22, 2020**. They will be forwarded to the committee before the meeting, and will also be posted on the ICC-ES web site shortly after the deadline for submission. Written rebuttal comments that are not submitted by the deadline will not be considered at the meeting.

   d. If you want to make a visual presentation at the hearing, it must be received in PowerPoint format. The presentation is to be received by **September 22, 2020.** These will be forwarded to the committee before the meeting, and will also be posted on the ICC-ES web site after the deadline for submission. Presentations that are not submitted by the deadline cannot be presented at the meeting. **Note:** Videos will not be posted on the web site.

      Presentations will be retained with other records of the meeting.

   e. ICC-ES will post to the web site, on **October 2, 2020**, memos by the ICC-ES staff, responding to the previously received public comments.

   f. If you miss the deadlines for submission of written comments and visual presentations, your verbal comments can be presented at the Webex Event meeting.

   g. Proposed criteria, written public comments, visual presentations, and responses by ICC-ES staff for this agenda item are all available on our website.

2. Regarding verbal comments and presentations:

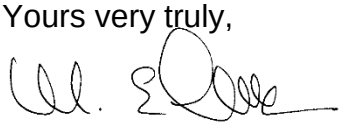
   Please plan to speak for not more than ten minutes. As noted above, visuals are to be in PowerPoint format and will be shown during the Webex Event meeting.

3. Keep in mind that all materials submitted for committee consideration are part of the public record and will not be treated as confidential. It is the presenter's responsibility to certify to ICC-ES staff that no materials infringe copyright.

4. Please do not communicate with committee members before the meeting about any items on the agenda.

We appreciate your interest in the work of the Evaluation Committee. If you have any questions, please contact me at (800) 423-6587, extension 3253, or Manuel Chan, P.E., S.E., at extension 3288. You may also reach us by e-mail at es@icc-es.org.

Yours very truly,



Mahmut Ekenel, Ph.D., P.E.
Senior Staff Engineer

ME/MC/ls

Encl.

cc: Evaluation Committee

ICC EVALUATION SERVICE, LLC, RULES OF PROCEDURE FOR THE EVALUATION COMMITTEE

1.0 PURPOSE

The purpose of the Evaluation Committee is to review and approve acceptance criteria on which evaluation reports may be based.

2.0 MEMBERSHIP

2.1 The Evaluation Committee has a membership of not fewer than nine, with one of the members named by the ICC-ES president each year to serve as the chairman–moderator.

2.2 All members of the committee shall be representatives of a body enforcing regulations related to the built environment.

2.3 Persons are appointed to the committee by the ICC-ES president, from among individuals who have formally applied for membership.

2.4 The ICC-ES Board of Managers, using simple majority vote, shall ratify the nominations of the president.

2.5 Committee membership is for one year, coinciding with the calendar year. Members may be renominated and reappointed, but no person shall serve for more than five consecutive terms.

2.6 In the event that a member is unable to attend a committee meeting or complete a term on the committee, the ICC-ES president may appoint a replacement to fill in at the meeting or for the remainder of the member's term. Any replacement appointed for only one meeting must have prior experience as a member of the Evaluation Committee. Appointments under this section (Section 2.6) are subject to ratification as noted in Section 2.4.

3.0 MEETINGS

3.1 The Evaluation Committee shall schedule meetings that are open to the public in discharging its duties under Section 1.0, subject to Section 3.0.

3.2 All scheduled meetings shall be publicly announced. There shall be three meetings per year.

3.3 More than half of the Evaluation Committee members, counting the chairman, shall constitute a quorum. A majority vote of members present is required on any action. To avoid any tie vote, the chairman may choose to exercise or not exercise, as necessary, his or her right to vote.

3.4 In the absence of the chairman–moderator, Evaluation Committee members present shall elect an alternate chairman from the committee for that meeting. The alternate chairman shall be counted as a voting committee member for purposes of maintaining a committee quorum and to cast a tie-breaking vote of the committee.

3.5 Minutes shall be kept and shall be the official record of each meeting.

3.6 An electronic record of meetings may be made by ICC-ES if deemed necessary; no other audio, video, electronic recordings of the meetings will be permitted. Visual aids (including, but not limited to, charts, slides, videos, or presentation software) viewed at meetings shall be permitted only if the presenter provides ICC-ES before the presentation with a copy of the visual aid in a medium which can be retained by ICC-ES with its record of the meeting and which can also be provided to interested parties requesting a copy.

3.7 Parties interested in the deliberations of the committee should refrain from communicating, whether in writing or verbally, with committee members regarding agenda items. All written communications and submissions regarding agenda items must be delivered to ICC-ES and shall be considered nonconfidential and available for discussion in open session of an Evaluation Committee meeting. Such materials will be posted on the ICC-ES web site (www.icc-es.org) prior to the meeting. Comments and submissions not meeting the following deadlines will not be considered at the meeting:

- Initial comments on agenda items shall be submitted at least 28 days before the scheduled meeting.
- A rebuttal comment period shall follow, whereby rebuttal comments to the initial comments may be submitted by the proponent at least 21 days before the scheduled meeting.
- Those planning on giving a visual presentation at the meeting must submit their presentation, in PowerPoint format only, at least 10 days before the scheduled meeting.

The committee reserves the right to refuse recognition of communications which do not comply with the provisions of this section.

4.0 CLOSED SESSIONS

Evaluation Committee meetings shall be open except that at the discretion of the chairman, staff counsel may be necessary. Also, matters related to clients or potential clients covered by confidentiality requirements of ICC-ES Rules of Procedure for Evaluation Reports are discussed only during closed meetings.

5.0 ACCEPTANCE CRITERIA

5.1 Acceptance criteria are established by the committee to provide a basis for issuing ICC-ES evaluation reports on products and systems under codes referenced in Section 2.0 of the Rules of Procedure for Evaluation Reports. They also clarify conditions of acceptance for products and systems specifically regulated by the codes.

Acceptance criteria may involve a product, material, or method of construction. Consideration of any acceptance criteria must be in conjunction with a current and valid application for an ICC-ES evaluation report, an existing ICC-ES evaluation report, or as otherwise determined by the ICC-ES President.

EXCEPTIONS: The following acceptance criteria are controlled by the ICC-ES executive staff and are not subject to committee approval:

- The Acceptance Criteria for Quality Documentation (AC10)
- The Acceptance Criteria for Test Reports (AC85)
- The Acceptance Criteria for Inspections and Inspection Agencies (AC304)

5.2 Procedure:

5.2.1 Proposed acceptance criteria shall be developed by the ICC-ES staff and discussed in open session with the Evaluation Committee during a scheduled meeting, except as permitted in Section 4.0 of these rules.

5.2.2 Proposed acceptance criteria shall be available to interested parties at least 30 days before discussion at the committee meeting.

5.2.3 The committee shall be informed of all pertinent written communications received by ICC-ES.

5.2.4 Attendees at Evaluation Committee meetings shall have the opportunity to speak on acceptance criteria listed on the meeting agenda, to provide information to committee members. In the interest of fairness, each person requesting to testify on a proposed acceptance criteria or proposed changes to an existing acceptance criteria will be given the same amount of time. The following time limits are established:

a. For entities offering their first testimony on any item, a 10-minute limit applies. This time limit applies to both verbal testimony and/or visual presentations.

b. Each person offering testimony may return to the microphone for one five-minute period to offer additional testimony and/or to rebut testimony given by others.

c. Each person offering testimony on the staff recommendation, on each criteria, is allowed one, two-minute trip to the microphone.

Time limits do not include time needed to answer questions from the staff and/or committee members. The chairman–moderator shall have limited authority to modify time limitations on testimony. The chairman–moderator shall also have the authority to adjust time limits as necessary in order to get through the hearing agenda.

Keeping of time for testimony by an individual will be by an automatic timing device. The time remaining shall be evident to the person testifying. Interruptions during testimony will not be tolerated. It is the responsibility of the chairman–moderator to maintain decorum and order during all testimony.

5.3 Approval of any action on an acceptance criteria shall be as specified in Section 3.3 of these rules. Possible actions made by the Evaluation Committee include: Approval; Approval with Revisions; Disapproval; or Further Study. The Evaluation Committee must give the reason(s) for any Disapproval or Further Study actions with specific recommendations.

5.4 Actions of the Evaluation Committee may be appealed in accordance with the ICC-ES Rules of Procedure for Appeal of Acceptance Criteria or the ICC-ES Rules of Procedure for Appeals of Evaluation Committee Technical Decisions.

6.0 COMMITTEE BALLOTING FOR ACCEPTANCE CRITERIA

6.1 Acceptance criteria may be revised without a public hearing following a 30-day public comment period and a majority vote for approval by the Evaluation Committee, when at the discretion of the ICC-ES executive staff, the subject is a revision that requires formal action by the Evaluation Committee.

6.2 Negative votes must be based upon one or more of the following, for the ballots to be considered valid and require resolution:

a. *Lack of clarity*: There is insufficient explanation of the scope of the acceptance criteria or insufficient description of the intended use of the product or system; or the acceptance criteria is so unclear as to be unacceptable. (The areas where greater clarity is required must be specifically identified.)

b. *Insufficiency*: The criteria is insufficient for proper evaluation of the product or system. (The provisions of the criteria that are in question must be specifically identified.)

c. *The subject of the acceptance criteria is not within the scope of the applicable codes*: A report issued by ICC-ES is intended to provide a basis for approval under the codes. If the subject of the acceptance criteria is not regulated by the codes, there is no basis for issuing a report, or a criteria. (Specifics must be provided concerning the inapplicability of the code.)

d. *The subject of the acceptance criteria needs to be discussed in public hearings*. The committee member requests additional input from other committee members, staff or industry.

6.3 An Evaluation Committee member, in voting on an acceptance criteria, may only cast the following ballots:

- Approved
- Approved with Comments
- Negative: Do Not Proceed

7.0 COMMITTEE COMMUNICATION

Direct communication between committee members, and between committee members and an applicant or concerned party, with regard to the processing of a particular acceptance criteria or evaluation report, shall take place only in a public hearing of the Evaluation Committee. Accordingly:

7.1 Committee members receiving an electronic ballot should respond only to the sender (ICC-ES staff). Committee members who wish to discuss a particular matter with other committee members, before reaching a decision, should ballot accordingly and bring the matter to

the attention of ICC-ES staff, so the issue can be placed on the agenda of a future committee meeting.

7.2 Committee members who are contacted by an applicant or concerned party on a particular matter that will be brought to the committee will refrain from private communication and will encourage the applicant or concerned party to forward their concerns through the ICC-ES staff in writing, and/or make their concerns known by addressing the committee at a public hearing, so that their concerns can receive the attention of all committee members.■

Revised August 2020

ICC EVALUATION SERVICE

www.icc-es.org | (800) 423-6587 | (562) 699-0543 *A Subsidiary of the International Code Council®*

PROPOSED ACCEPTANCE CRITERIA FOR FIBER–REINFORCED POLYMER (FRP) BARS AND MESHES FOR INTERNAL REINFORCEMENT OF NON-STRUCTURAL CONCRETE MEMBERS

AC521

Proposed August 2020

PREFACE

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

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

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

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

PROPOSED ACCEPTANCE CRITERIA FOR FIBER–REINFORCED POLYMER (FRP) BARS AND MESHES FOR INTERNAL REINFORCEMENT OF NON-STRUCTURAL CONCRETE MEMBERS

1.0 INTRODUCTION

1.1 Purpose: The purpose of this acceptance criteria is to establish requirements for glass or basalt fiber–reinforced polymer (FRP) bars and meshes (also referred to as mats) to be recognized in an ICC Evaluation Service, LLC (ICC-ES), evaluation report under the 2018 and 2015 *International Building Code*® (IBC) and the 2018 and 2015 *International Residential Code*® (IRC). Bases of recognition are IBC Section 104.11 and IRC Section R104.11.

The reason for the development of this criteria is to provide guidelines for the evaluation of glass or basalt fiber–reinforced polymer (FRP) as temperature and shrinkage reinforcement for non-structural concrete members, where the codes do not provide usage provisions, or requirements for testing and determination of physical and mechanical properties of this type of reinforcement products.

Scope: This acceptance criteria applies to glass or basalt fiber-reinforced polymer (FRP) bars or meshes, in cut lengths that are solid and have continuous uninterrupted circular cross-sections, where the mesh may be manufactured using bars. Items evaluated include physical and mechanical properties.

This acceptance criteria applies to FRP bars and meshes used as an alternative to the shrinkage and temperature reinforcement specified in Section 24.4 of ACI 318 for plain concrete footings and for plain concrete slabs (as defined by ACI 360) supported directly

on the ground. This criteria does not eliminate the requirement for joints specified in Section 14.3.4 of ACI 318 (IBC and IRC).

FRP bars and meshes are also used as an alternative to horizontal temperature and shrinkage reinforcement in structural plain concrete walls covered in IBC Section 1906, IRC Sections R404.1.3 and R608.1, and ACI 332 Sections 8.2.1 and 8.2.7, excluding walls where vertical reinforcement is required.

1.2 Codes and Referenced Standards:

1.2.1 2018 and 2015 *International Building Code*® (IBC), International Code Council.

1.2.2 2018 and 2015 *International Residential Code*® (IRC), International Code Council.

1.2.3 ACI 318-14 (2018 and 2015 IBC), Building Code Requirements for Structural Concrete and Commentary, American Concrete Institute.

1.2.4 ASTM A1064 – 18A, Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete, ASTM International.

1.2.5 ASTM C39 - 20, Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens, ASTM International.

1.2.6 ASTM C904-01 (2012), Standard Terminology Relating to Chemical-Resistant Nonmetallic Materials, ASTM International.

1.2.7 ASTM C1579, Standard Test Method for Evaluating Plastic Shrinkage Cracking of Restrained Fiber Reinforced Concrete (Using a Steel Form Insert), ASTM International.

1.2.8 ASTM D570-98 (2010)e1, Standard Test Method for Water Absorption of Plastics, ASTM International.

1.2.9 ASTM D792-13, Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement, ASTM International.

1.2.10 ASTM D2584-11, Test Method for Ignition Loss of Cured Reinforced Resins, ASTM International.

1.2.11 ASTM D4475-02(2008), Standard Test Method for Apparent Horizontal Shear Strength of Pultruded Reinforced Plastic Rods by the Short-Beam Method, ASTM International.

1.2.12 ASTM D5229/D5229M-14 Standard Test Method for Moisture Absorption Properties and Equilibrium Conditioning of Polymer Matrix Composite Materials, ASTM International.

1.2.13 ASTM D7205/D7205M-06 (2011), Standard Test Method for Tensile Properties of Fiber–Reinforced Polymer Matrix Composite Bars, ASTM International.

1.2.14 ASTM D7617/D7617M-11, Standard Test Method for Transverse Shear Strength of Fiber–Reinforced Polymer Matrix Composite Bars, ASTM International.

1.2.15 ASTM D7913/D7913M-14(2020), Test Method for Bond Strength of Fiber-Reinforced Polymer Matrix Composite Bars to Concrete by Pullout Testing, ASTM International.

1.2.16 ASTM D7957/D7957M-17, Standard Specification for Solid Round Glass Fiber Reinforced Polymer Bars for Concrete Reinforcement, ASTM International.

1.2.17 ASTM E1356-08 (2014), Standard Test Method for Assignment of the Glass Transition Temperatures by Differential Scanning Calorimetry, ASTM International

1.2.18 ASTM E1640-13, Standard Test Method for Assignment of the Glass Transition Temperature by Dynamic Mechanical Analysis, ASTM International.

1.2.19 ASTM E2160–04 (Reapproved 2012), Standard Test Method for Heat of Reaction of Thermally Reactive Materials by Differential Scanning Calorimetry, ASTM International.

1.3 Reference guides and reports:

1.3.1 ACI 332-14, Residential Code Requirements for Structural Concrete and Commentary, American Concrete Institute.

1.3.2 ACI 360R-10, Design of Slabs on Ground, American Concrete Institute.

1.3.3 ACI 440.5R-08, Specification for Construction with Fiber–Reinforced Polymer Reinforcing Bars, American Concrete Institute.

1.3.4 ACI 408R-03 (reapproved 2012), Bond and Development of Straight Reinforcing Bars in Tension, American Concrete Institute.

1.3.5 ACI 440.1R-15, Guide for the Design and Construction of Structural Concrete Reinforced with FRP Bars, American Concrete Institute.

2.0 DEFINITIONS

For definitions of terms used in this criteria, refer to ASTM C904. Additional specific terms are defined as follows:

2.1 Production Lot:

FRP bar or mesh produced from start to finish with the same constituent materials used in the same proportions without changing any production parameter, such as cure temperature or line speed.

2.2 Guaranteed Property:

Characteristic value no greater than the mean minus three standard deviations of at least the required number of samples tested according to a specific test method. This definition is applicable to the transverse shear strength, bond strength, and ultimate tensile force of the FRP bars and meshes, in accordance with this criteria.

2.3 Mean Property:

A value no greater than the mean of at least the required number of samples tested according to this criteria. This definition is applicable to the glass transition temperature, degree of cure, total enthalpy of polymerization measured cross-sectional area, tensile modulus of elasticity, horizontal shear strength, ultimate tensile strain, shear strength of mesh intersection (mesh only) and moisture absorption.

2.4 Surface Enhancement:

Protrusions, lugs, sand coatings, deformations or any additional surface treatment for purposes of inhibiting longitudinal movement of the bar or mesh relative to the concrete surrounding the bar in construction. The lugs, protrusions, sand coating and other enhancements are included in the measured cross-sectional area and affect the cross-sectional area of the FRP bar or mesh.

2.5 Measured Cross-Sectional Area:

The measured cross-sectional area of a bar or mesh element including surface enhancement shall be determined in accordance with Section 4.1.5 of this criteria. The term “measured” reflects a true measured value as opposed to the term “nominal,” defined in Section 2.6 of this criteria, which indicates an equivalency.

2.6 Nominal Properties:

The nominal properties are used for the purpose of classification and design.

2.6.1 Nominal Cross-Sectional Area:

The nominal cross-sectional area of the FRP bar or mesh is determined based on the measured cross-sectional area within a tolerance range as specified in Table 3 of ASTM D7957 for FRP bars, and Tables 2 and Table 3 of this criteria for FRP meshes. This tolerance accommodates any enhancing surface treatment.

2.6.2 Nominal Diameter:

The nominal bar diameter is the standard diameter as specified in Table 3 of ASTM D7957 for FRP bars, or Table 2 of this criteria for FRP meshes irrespective of the manufactured bar shape and form.

2.6.3 Nominal Bar Designation:

Admissible nominal bar designation number that corresponds to the nominal diameter between 0.25 inch to 0.75 inch (6.3 to 19.1 mm) in increments of $^1/_8$ inch. (3.2 mm) for bars.

2.6.4 Nominal Mesh Designation:

Admissible nominal mesh designation corresponds to the value of the nominal cross-sectional area in square inches multiplied by 100 for US units, or the nominal cross-sectional area in millimeters squared. For sizes other than those provided in Table 2, the mesh designation shall be the number of one hundredths of a square inch in the nominal area of the mesh cross-section for US units or the number of square millimeters in the nominal area of the mesh cross section for SI units. Other mesh sizes to those reported in Table 2 may be acceptable in increments of 0.0015 in.^{2} (1.00 mm^2).

2.6.5 Nominal Guaranteed Tensile Strength:

The nominal guaranteed tensile strength is the ratio of the guaranteed tensile force and the nominal cross-sectional area.

2.7 Materials and Manufacture:

2.7.1 Fibers:

Fibers shall be in the form of uni-directional glass or basalt fiber rovings of a given size and mass. Fiber sizing and coupling agents shall be compatible with the resin system used to impregnate the fibers. The fiber type and the fiber volume determine the physical and mechanical properties of the FRP bar or mesh.

2.7.2 Matrix Resin:

- Thermo-set resin systems, or their blending, and thermoplastic resin systems are permitted provided the finished product meets the physical and mechanical requirements of this criteria.
- The amount of styrene, as a mass percentage of the matrix resin, added during processing (if any) shall be reported.

2.7.3 Fillers and Additives:

- Only inorganic fillers, such as but not limited to, kaolin clay, calcium carbonate, and alumina trihydrate, are permitted to be added to the matrix resin, and shall not exceed 20 percent by mass of the matrix resin.
- Only additives and process aids, such as release agents, low-profile shrink additives, initiators, promoters, hardeners, catalysts, pigments, fire retardants, and ultraviolet inhibitors, are permitted to be added to the matrix resin.

2.7.4 Manufacturing Process:

- FRP bars and meshes under this criteria are to be manufactured using variations of the pultrusion process.
- FRP elements of meshes shall be securely connected at every intersection in the longitudinal and transvers directions, having

substantially square or rectangular openings assuring a consistent spacing and alignment of the finish product.

- The manufacturer shall document the process used and report the date of production and the production lot size.

2.7.5 As-Produced FRP Bar or Mesh:

Bars or meshes that are manufacturer ready for commercial use, after going through all manufacturing steps including addition of surface deformations and quality control.

3.0 REQUIRED INFORMATION

3.1 General: The following information shall be submitted to ICC-ES for evaluation:

3.1.1 Product Description: Identification shall include:

1. If applicable, restrictions or limitations on use.

2. Element identifiers for each bar or mech size, including (but not limited to) the following:

- Name of the FRP material (manufacturer’s description);
- Fiber and resin type;
- Measured bar or mesh area;
- Nominal area, nominal diameter, and bar or mesh designation as defined in Section 2.6.3 and 2.6.4 of this acceptance criteria;
- Mesh spacing in the longitudinal and transverse directions;

3.1.2 Installation Instructions: Installation instructions shall include the following items:

- Description of how the bar or mesh will be used or installed in the field;
- Applicable procedures establishing quality control in the field installation;
- Requirements for product handling and storage of the bar or mesh, including the permitted method/s for cutting.
- Requirements for placement of the bar or mesh, including the type of supports and ties used, and were mesh reinforcement is permitted to extend through a contraction joint;
- Definition of a cut, defect or damage (other than at the ends) of a bar or mesh and statement of the remedy for such defined damage portion/segment of the bar or mesh.
- ACI 440.5-08 guideline may be considered by the manufacturer for construction using fiber-reinforced polymer reinforcing bars in the field.

3.1.3 Packaging and Identification: A description of the method of packaging for purposes of shipping/transportation and field identification of glass and basalt FRP bars and meshes in the form of cut lengths or mesh areal size, or rolled length and spacing configuration shall be submitted. Product identification shall be in

accordance with the product identification provisions of the ICC-ES Rules of Procedure for Evaluation Reports and shall include the bar or mesh size.

3.2 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.

3.3 Test Reports: Test reports shall comply with AC85.

3.4 Product Sampling: Sampling of the FRP bars for tests under this criteria shall comply with Section 3.1 and 3.3 of AC85.

3.5 Qualification Test Plan: A qualification test plan shall be submitted to and approved by ICC-ES staff prior to any testing being conducted**.**

4.0 TEST AND PERFORMANCE REQUIREMENTS OF FRP BARS AND MESHES

This section consists of the following sub-sections addressing evaluation/testing requirements and conditions of acceptance:

Section 4.1: Physical properties of FRP bars and meshes including fiber content, mean glass transition temperature, mean total enthalpy of polymerization (total heat of reaction), mean degree of cure, mean cross-sectional area, and mean moisture absorption.

Section 4.2: Mechanical properties of straight FRP bars and meshes including guaranteed tensile force, mean tensile modulus of elasticity, guaranteed transverse shear strength, mean horizontal shear strength, mean ultimate tensile strain, guaranteed bond strength (bars only), mean shear strength of mesh intersection (mesh only), and/or shrinkage cracking.

Section 4.3: Required number of specimen test repetitions and lot sampling for all properties listed in this criteria.

4.1 Physical Properties:

4.1.1 Fiber Content:

The fiber content shall be measured in accordance with ASTM D2584. The fiber content shall be derived from tests with the number of specimens indicated in Section 4.3 of this criteria. The individual test results shall be reported for each specimen. Testing of all bar and mesh sizes is required.

Conditions of Acceptance: The fiber content of as-produced FRP bars and meshes shall meet the property limits as specified in Table 2 of ASTM D7957 for all test specimens.

4.1.2 Mean Glass Transition Temperature:

The mean glass transition temperature (T_g) of the FRP bars and meshes shall be measured on a coupon, slice or segment cut from the as-produced bar or mesh using either dynamic mechanical analysis (DMA) method as specified in ASTM E1640 or differential scanning calorimetry (DSC) method in ASTM E1356. When using DMA for bars, the coupons shall be extracted from the exterior ring of the bar having a thickness up to one third of the bar diameter (i.e., the center core of the bar shall not be used for this test); for mesh, a segment of the bar element can be used. The mean T_g shall be derived from tests with the number of specimens indicated in Section 4.3 of this criteria.

The individual test results shall be reported for each specimen. Testing shall be conducted for the smallest, medium, and largest bar and mesh size to be evaluated.

Conditions of Acceptance: The mean T_g shall meet the property limits as specified in Table 1 of ASTM D7957 when using DSC method, or be equal to or greater than 230°F (110°C) when using DMA method.

4.1.3 Mean Total Enthalpy of Polymerization:

The total enthalpy of polymerization (total heat of reaction) testing shall be performed in accordance with ASTM E2160 on the unreacted (neat) resin system used for the manufacturing of the FRP bars and meshes. The mean total enthalpy test result shall be reported and be used to determine the degree of cure (fraction reacted) in Section 4.1.4 of this criteria and for fingerprinting the material. The mean total enthalpy shall be derived from tests conducted on the neat resin with the number of specimens indicated in Section 4.3 of this criteria.

4.1.4 Mean Degree of Cure (Fraction Reacted):

The degree of cure (fraction reacted) of as-produced bar or mesh shall be determined in accordance with ASTM E2160 as a percentage of the total polymerization enthalpy of the neat resin. The mean degree of cure shall be derived from tests conducted on samples extracted from segment of a slice of the cross-section of the solid bar or mesh with the number of specimens indicated in Section 4.3 of this criteria. The individual test results shall be reported for each specimen. Testing of all bar and mesh sizes is required.

Conditions of Acceptance: The mean degree of cure of as-produced FRP bars and meshes shall meet the property limits as specified in Table 1 of ASTM D7957.

4.1.5 Mean Measured Cross-sectional Area:

The measured cross-sectional area of the FRP bar or mesh element shall be obtained in accordance with Section 11.2.5.1 of ASTM D7205 and ASTM D792, Test Method A (volume of water displacement), accounting for any surface treatments. The specimen length shall be, at a minimum the smaller of twice the nominal diameter or 1.0 in. (25 mm). The mean measured area shall be derived from tests with the number of specimens indicated in Section 4.3. The individual test results shall be reported for each specimen. Testing of all bar or mesh sizes is required.

Conditions of Acceptance: For as-produced FRP bars, the mean measured cross-sectional area shall meet the property limits as specified in Table 3 of ASTM D7957. For mesh elements, the mean measured cross-sectional area shall meet the property limits as specified within Table 2 of this acceptance criteria. These sizes represent standard sizes and other mesh sizes may be available by manufactures that can produce meshes in increments of approximately 0.0015 in^2 (1.00 mm^2).

4.1.6 Permissible Variation in Diameter (Mesh only):

The permissible variation of the mesh diameter shall be measured with a calibrated micrometer, where a minimum of three diameter measurements along the length of a 12 in. (305 mm) mesh segment shall constitute one reading. This reading shall be compared to the nominal diameter to determine the variation. The permissible variation shall be

conducted in the number of specimens indicated in Section 4.3 of this criteria. The individual test results shall be reported for each specimen. Testing of all mesh sizes is required.

Conditions of Acceptance: For mesh only, the as-produced permissible variation (plus and minus) in diameter shall not exceed the tolerances listed in Table 3 of this acceptance criteria.

4.2 Mechanical Properties:

The deviation of any strength value obtained from any single test in Section 4.2.1 through 4.2.7, shall not vary from the average value from all tests by greater than 15 percent. If such deviation exceeds 15 percent, then additional sets of tests shall be performed until the deviation of any test does not exceed 15 percent from the average of all tested, or a minimum of 15 additional tests have been performed.

4.2.1 Guaranteed Ultimate Tensile Force:

The ultimate tensile force shall be measured according to ASTM D7205 with the number of test specimens as indicated in Section 4.3 of this criteria. The individual test results shall be reported for each specimen. Testing of all bar and mesh sizes is required.

Conditions of Acceptance: The guaranteed ultimate tensile force shall be calculated in accordance with Section 2.2 of this criteria using ultimate tensile force values obtained in accordance with this section. The minimum guaranteed tensile load shall meet the property requirement values listed in Table 3 as specified in ASTM D7957 for bar

designations No. 2 (M6) through No. 6 (M19). Other designations are outside the scope of this criteria.

For mesh, the minimum guaranteed ultimate tensile force shall be equal to or greater than the resulting guaranteed ultimate tensile strength of 135.0 ksi (931 MPa) using the nominal area to compute the equivalent tensile force, as reflected in Table 2 of this criteria.

4.2.2 Mean Tensile Modulus of Elasticity:

The tensile modulus of elasticity shall be derived from specimens tested in accordance with ASTM D7205 with the number of specimens as indicated in Section 4.3 of this criteria. The individual test results shall be reported for each specimen. Testing of all bar and mesh sizes is required.

Conditions of Acceptance: The mean tensile modulus of elasticity of as-produced FRP bars and mesh shall be equal to or greater than 6.5 ksi (44.8 GPa).

4.2.3 Guaranteed Transverse Shear Strength (Perpendicular to the Bar or Mesh Element):

The transverse ultimate shear strength shall be determined in accordance with ASTM D7617. The guaranteed transverse ultimate shear strength is determined with the number of specimens as indicated in Section 4.3 of this criteria. The individual test results shall be reported for each specimen. Testing of all bar and mesh sizes is required.

Condition of Acceptance: The guaranteed transverse shear strength of as-produced FRP bars and meshes shall meet the property limits as specified in Table 1 of ASTM D7957.

4.2.4 Mean Ultimate Tensile Strain:

Based upon the assumption that the stress-strain behavior is linear-elastic, the mean ultimate tensile strain shall be calculated by dividing the tensile force by the product of mean tensile modulus of elasticity and nominal cross-sectional area. The calculated mean ultimate tensile strain obtained by this procedure shall be reported for each individual specimen and for all bar and mesh sizes.

4.2.5 Guaranteed Bond Strength (Bars only):

The bond strength of FRP bars shall be determined as per ASTM D7913 with the number of specimens as indicated in Section 4.3 of this criteria. The guaranteed bond strength shall be calculated for a surface area based on the nominal bar diameter. The individual test results shall be reported for each specimen, together with the method used for casting the test specimens and concrete strength in accordance with ASTM C39. Testing shall be conducted for the smallest, medium, and largest bar and mesh size to be evaluated.

Conditions of Acceptance: The guaranteed bond strength shall meet the property limits as specified in Table 1 of ASTM D7957. Any FRP bar that shows failure by full separation of the surface enhancement from the load bearing portion of the FRP bar shall be discarded.

4.2.6 Mean Shear Strength of Mesh Intersection (Mesh only):

The intersection between the longitudinal and transverse bar elements of the mesh can contribute to the bond an anchorage in concrete. The shear strength between the longitudinal and transverse bar elements of the mesh shall be tested as described in Section 9.0 of ASTM A1064, where the test rate shall result in failure occurring between 1 and 10 minutes, with the number of specimens as indicated in Section 4.3 of this criteria. The mean shear strength value in pound-force and/or kilonewtons shall be reported for fingerprinting purposes. Testing of all mesh sizes is required.

4.2.7 Mean Moisture Absorption:

Specimens shall be tested in accordance with Sections 7.1 and 7.4 of ASTM D570 or Procedure B of ASTM D5229, submerged in water at 122°F (50°C) until saturation with the number of specimens as indicated in Section 4.3 of this criteria. The moisture absorption obtained by these procedures shall be reported for each individual specimen. Testing of all bar and mesh sizes is required.

Conditions of Acceptance: After 24 hours, or until saturation is achieved, the mean moisture absorption of as-produced FRP bars and meshes shall meet the property limits as specified in Tables 1 and 2 of ASTM D7957, respectively.

4.2.8 Shrinkage Cracking:

The purpose of the shrinkage cracking test is to demonstrate that FRP bars and meshes in concrete have equivalent temperature and shrinkage cracking resistance when compared to conventional steel temperature and shrinkage reinforcement in concrete.

Testing shall be in accordance with the general guidelines of ASTM C1579 on two control specimens using conventional steel temperature and shrinkage reinforcement, and two test specimens with equal amount of FRP bars or meshes per nominal area. FRP bars and meshes shall be tested separately. Using ASTM C1579 guidelines, surface cracking of concrete panels reinforced with FRP bars or meshes shall be compared with the surface cracking of control concrete panels. The panels shall be subjected to prescribed conditions of restraint and moisture loss that are severe enough to produce cracking before final setting of the concrete.

The bars or meshes shall be supported with chairs so that the clear concrete cover is 0.75 in. (19 mm) regardless of the type of reinforcement. In order to achieve an acceptable comparison, average crack width calculated for the control specimens shall not be zero.

Conditions of Acceptance: Average crack width of two specimens shall be calculated in accordance with ASTM C1579 for both FRP bar and mesh test specimens. The average crack width value obtained from FRP bar or mesh test specimens shall be equal or less than the average crack width value obtained for control specimens. In addition, size and spacing of both FRP bars/meshes and steel reinforcing used in testing must be reported in the test report.

4.3 Lot Sampling and Number of Specimens:

The number of test specimens are summarized in Table 1 of this acceptance criteria. Mechanical tests exhibiting failure modes influenced by the test methodology, such as failures that occur within or just outside of any anchor or grip shall be disregarded.

4.3.1 For the determination of fiber content, measured cross-sectional area, permissible variation in diameter (mesh only), tensile properties, transverse and horizontal shear strengths and mean shear strength of mesh intersection (mesh only); at least 24 samples shall be obtained in groups of eight from three different production lots for each bar or mesh size, as applicable.

4.3.2 For total enthalpy of polymerization (resin) only three tests are needed from a representative sample of the neat resin.

4.3.3 For the degree of cure and shrinkage cracking (excluding any control specimens), at least 9 samples shall be obtained in groups of three from three different production lots for each bar or mesh size.

4.3.4 For T_g and bond strength (bar only), at least five tests shall be conducted for each of the smallest, medium, and largest bar and mesh size produced, from any given production lot for each bar size.

5.0 QUALITY CONTROL

5.1 Quality documentation complying with the ICC-ES Acceptance Criteria for Quality Documentation (AC10) shall be submitted for each facility manufacturing or labeling products that are to be addressed in the ICC-ES evaluation report.

5.2 FRP bars or meshes and shall be manufactured under an approved quality control program with inspections by an inspection agency approved by ICC-ES.

5.3 A qualifying inspection shall be conducted at each manufacturing facility in accordance with the requirements of the ICC-ES Acceptance Criteria for Inspections and Inspection Agencies (AC304)**.**

6.0 EVALUATION REPORT RECOGNITION

The evaluation report shall include the following information:

6.1 A statement indicating that the installation of FRP bars or meshes used as temperature and shrinkage reinforcement for plain concrete footings, plain concrete slabs, and plain concrete walls where vertical reinforcement is not required must be in accordance with the evaluation report, the report holder's Installation Manual, and the IBC and IRC.

6.2 A statement showing the test installation details of Section 4.8 of this criteria, such as: "Minimum FRP bar designation No. (mesh designation no.) of ... and maximum spacing of … in. (… mm) can be used as an alternative to conventional temperature and shrinkage reinforcement with maximum bar designation no. …. and maximum spacing of … in. (… mm).

6.3 A statement indicating that complete construction documents, including plans and calculations verifying compliance with the evaluation report, must be submitted to the code official for each project at the time of permit application. The construction documents must be prepared and sealed by a registered design professional where required by the statutes of the jurisdiction in which the project is to be constructed.

6.4 A statement indicating that FRP bars or meshes shall be stored and protected during storage in accordance with the guidelines given in ACI 440.5-08.

6.5 A statement indicating that special inspection as required by Table 1705.3 of the IBC for steel-reinforced concrete construction, is also applicable to FRP bar or mesh reinforced concrete construction under this criteria.

6.6 A statement indicating that the use of FRP bars or meshes does not eliminate the requirement for joints specified in Section 14.3.4 of ACI 318 (IBC and IRC). ■

431 **TABLE 1 — SUMMARY OF REQUIRED TESTS**
432 **FOR FRP BARS AND MESHES**

PROPERTY TO REPORT	TEST OR CALCULATION METHOD	NUMBER OF TEST SPECIMENS
Physical		
Fiber Content	ASTM D2584	For each bar/mesh size: total 24 (8 from 3 separate lots)
Mean Glass Transition Temperature	ASTM E1640 (DMA) ASTM E1356 (DSC)	Total 15: 5 from smallest, median and largest bar/mesh size each
Mean Total Enthalpy of Polymerization (Resin)	ASTM E2160	For the neat resin system: total 3
Mean Degree of Cure	ASTM E2160	For each bar/mesh size: total 9 (3 from 3 separate lots)
Mean Measured Cross-Sectional Area	ASTM D7205 ASTM D792	For each bar/mesh size: total 24 (8 from 3 separate lots)
Permissible Variation in Diameter (Mesh only)	Section 4.1.6	For each mesh size: total 24 (8 from 3 separate lots)
Mean Moisture Absorption to Saturation	ASTM D570 or ASTM D5229	For each bar/mesh size: total 24 (8 from 3 separate lots)
Mechanical		
Guaranteed Ultimate Tensile Force	ASTM D7205	For each bar/mesh size: total 24 (8 from 3 separate lots)
Mean Tensile Modulus of Elasticity	ASTM D7205	
Guaranteed Transverse Shear Strength (⊥ to the Bar)	ASTM D7617	
Mean Horizontal (Inter-laminar) Shear Strength	ASTM D4475	
Mean Ultimate Tensile Strain	Tensile Strength to Modulus of Elasticity Ratio	
Guaranteed Bond Strength (Bar only)	ASTM D7913	Total 15 (5 from smallest, median and largest bar size each)
Mean Shear Strength of Mesh Intersection (Mesh only)	ASTM A1064	For each mesh size: total 24 (8 from 3 separate lots)
Shrinkage Cracking	ASTM C1579	For each bar/mesh size: total 9 (3 from 3 separate lots)

433

434 **TABLE 2 (a) — REQUIREMENTS FOR FRP MESHES (US Units)**

Mesh Designation Size Number*	Nominal Diameter		Nominal Area		Nominal Minimum Guaranteed Ultimate Tensile Force[A]	
US	in.	mm	$in.^2$	mm^2	kip	kN
0.5	0.080	2.03	0.005	3.24	0.68	3.02
1.1	0.119	3.02	0.011	7.17	1.50	6.68
1.2	0.124	3.15	0.012	7.79	1.63	7.25
1.4	0.134	3.40	0.014	9.09	1.90	8.46
2	0.160	4.06	0.020	12.97	2.71	12.07
2.5	0.178	4.52	0.025	16.05	3.36	14.94
2.9	0.192	4.88	0.029	18.67	3.91	17.38
3.1	0.200	5.08	0.031	20.26	4.24	18.86
3.5	0.211	5.36	0.035	22.55	4.72	20.99
4.0	0.226	5.74	0.040	25.87	5.41	24.08

435 *The designation number indicates the nominal cross-sectional area mesh in square inches multiplied by 100. For
436 sizes other than those shown above, the Mesh Designation Size Number shall be the number of one hundredths of a
437 square inch in the nominal area of the mesh cross section. Other mesh sizes may be available and may be produced
438 in 0.0015 $in.^2$ increments. Interpolation between the Nominal Minimum Guaranteed Ultimate Tensile Force is
439 permitted for intermediate Mesh Designation Size Numbers.
440 [A] Computed assuming a Minimum Guaranteed Ultimate Strength of 135 ksi using the nominal area.

441 **TABLE 2 (b) — REQUIREMENTS FOR FRP MESHES (SI Units)**

Mesh Designation Size Number*	Nominal Diameter		Nominal Area		Nominal Minimum Guaranteed Ultimate Tensile Force[A]	
SI	mm	in.	mm^2	$in.^2$	kN	kip
3.5	2.11	0.083	3.5	0.005	3.26	0.73
5.0	2.52	0.099	5.0	0.008	4.66	1.05
7.5	3.09	0.122	7.5	0.012	6.98	1.57
10.0	3.57	0.141	10.0	0.016	9.31	2.09
12.5	3.99	0.157	12.5	0.019	11.64	2.62
15.0	4.37	0.172	15.0	0.023	13.97	3.14
17.5	4.72	0.186	17.5	0.027	16.29	3.66
20.0	5.05	0.199	20.0	0.031	18.62	4.19
22.5	5.35	0.211	22.5	0.035	20.95	4.71
27.5	5.92	0.233	27.5	0.043	25.60	5.76

442 *The designation number indicates the nominal cross-sectional area of the mesh in square millimeters. For sizes
443 other than those shown above, the Mesh Designation Size Number shall be the number of square millimeters in the
444 nominal area of the mesh cross section. Other mesh sizes may be available and may be produced in 1.00 mm^2
445 increments. Interpolation between the Nominal Minimum Guaranteed Ultimate Tensile Force is permitted for
446 intermediate Mesh Designation Size Numbers.
447 [A] Computed assuming a Minimum Guaranteed Ultimate Strength of 931 MPa using the nominal area.

448 **TABLE 3 – PERMISSIBLE VARIATION OF MESH ELEMENT DIAMETER**
449

Size Number			Permissible Variation (plus and minus)	
	US	**SI**	**in.**	**mm**
Smaller than	0.5	3.5	0.015	0.381
Between (incl.)	0.5 to 2.5	3.5 to 16	0.025	0.635
Over	2.5	16	0.035	0.889

450