



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

May 13, 2010

**TO: PARTIES INTERESTED IN EVALUATION REPORTS ON CONCRETE WITH VIRGIN CELLOLOSE FIBERS**

**SUBJECT: Proposed Revisions to the Acceptance Criteria for Concrete with Virgin Cellulose Fibers, Subject AC217-0610-R1 (MO/ME)**

**Hearing Information:**

Tuesday, June 15, 2010

8:00 a.m.

**DoubleTree Hotel**

808 South 20<sup>th</sup> Street

Birmingham, Alabama 35205

(800) 222-8733

Dear Madam or Sir:

The subject acceptance criteria will be on the agenda for the Evaluation Committee noted above for discussion of proposed revisions. The virgin cellulose fibers are added to concrete to reduce plastic shrinkage cracking of reinforced concrete and structural plain concrete and/or to reduce shrinkage and temperature cracking in structural plain concrete slabs on grade.

The proponent has proposed a revision to Section A7.0 of Annex A to change the conditions of acceptance for the plastic shrinkage crack testing, from a minimum crack reduction of 50 percent to a reduction of 40 percent. The proponent refers to the ICC-ES Acceptance Criteria for Concrete with Synthetic Fibers (AC32), Section A7.0, as using 40 percent as the minimum for synthetic fibers. **Staff Comment:** The reason AC217 requires 50 percent whereas AC32 requires 40 percent is because cellular fiber properties may be affected by the source; even if the source is the same, wood properties may change each year. Therefore, as a safety factor, better performance from wood fibers is expected as compared to synthetic fibers, which have the same properties at all times.

References to the 2009 *International Building Code*<sup>®</sup> (IBC) and the 2009 the *International Residential Code*<sup>®</sup> (IRC) were added to Sections 1.1 and 1.3.1, with appropriate editions of test standards revised in Table 1.

The proposed revisions will not affect the existing evaluation report issued under this criteria.

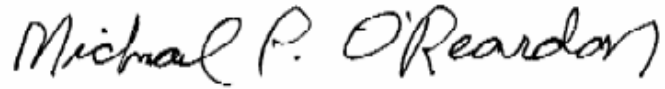
You are cordially invited to submit written comments on agenda items, or to attend the Evaluation Committee hearing and present verbal comments. If you wish to contribute to the hearing, please note the following:

1. Written comments that are received by the Los Angeles business/regional office by **June 1, 2010**, will be forwarded to the committee prior to the hearing, and will be posted on the ICC-ES web site shortly after the comment deadline.
2. Written comments received up to ten days before the meeting, and staff memos responding to comments, will be posted to the web site on **June 10, 2010**.
3. ICC-ES is no longer providing printed copies at the meeting of proposed acceptance criteria, staff memos or public comments. These documents will be available on a limited number of CDs at the meeting, for uploading to computers; and ICC-ES will make arrangements with the hotel business center to have hard copies available for photocopying.
4. Written comments that miss the deadline noted in item (1), above, will only be available at the meeting if you provide 35 copies, collated, stapled, and three-hole punched, either at the meeting itself or to the Los Angeles business/regional office by **June 10, 2010**.
5. If you plan to speak for more than 15 minutes, or offer a visual presentation lasting longer, you should notify ICC-ES staff as far as possible in advance. There will be a computer, projector, and screen available at the meeting for anyone wishing to make a visual presentation, and presentations in most cases will need to be in PowerPoint format. Also, ICC-ES will need to be provided with your presentation at least a half-hour before the start of the relevant meeting session (morning or afternoon) on either a CD or a flash card.
6. If you have any special needs related to a presentation, you should contact ICC-ES staff well in advance of the meeting.
7. Any visual aids for viewing at committee meetings (charts, overhead transparencies, slides, videos, electronic presentations, etc.) will be permitted only if a copy is provided to ICC-ES, before the presentation, in a medium that can be retained with other records of the meeting.
8. Any materials submitted for committee consideration are considered nonconfidential and available for public discussion, as noted in Section 2.7 of the ICC-ES Rules of Procedure for the Evaluation Committee.
9. Prior to the meeting, you should refrain from trying to communicate directly with committee members about agenda items, either verbally or in writing. Committee members reserve the right to refuse such communications.

Your cooperation with these guidelines is much appreciated, as is your interest in the deliberations of the Evaluation Committee. If you have any question, please contact the

undersigned at (800) 423-6587, extension 5685, or Mahmut Ekenel, P.E., Staff Engineer, at extension 3253. You may also reach us by e-mail at [es@icc-es.org](mailto:es@icc-es.org).

Yours very truly,

A handwritten signature in black ink that reads "Michael P. O'Reardon". The signature is written in a cursive, slightly slanted style.

Michael O'Reardon, P.E.  
Regional Manager

MPO/raf

Enclosures

cc: Evaluation Committee

# BUCKEYE

1001 TILLMAN, P.O. BOX 80407  
MEMPHIS, TENNESSEE 38108 0407  
TEL 901.320.8100 FAX 901.320.8204

January 6, 2010

Michael O'Reardon, P.E., C.B.O., M.C.P.  
Regional Manager  
ICC Evaluation Service, Inc.  
Birmingham Regional Office  
900 Montclair Road, Suite A  
Birmingham, AL 35213

RE: Proposed Change to AC 217 – Acceptance Criteria for Concrete with Virgin Cellulose Fibers

Dear Mr. O'Reardon:

I am writing in regard to Acceptance Criteria AC 217 for Cellulose fibers for concrete reinforcement. Buckeye Technologies would like to petition ICC to amend AC 217 in regard to the Plastic Shrinkage Crack requirement. AC 217 currently requires a minimum crack reduction of 50% for cellulose fibers in the Plastic Shrinkage Crack test. Acceptance Criteria AC 32 for Synthetic fibers for concrete reinforcement requires a minimum crack reduction of 40% in the Plastic Shrinkage Crack test. Buckeye Technologies would like to petition ICC to amend the minimum crack reduction for AC 217 from 50% minimum to 40% minimum. This change would make the required plastic shrinkage crack reduction consistent with AC 32 requirement.

Both cellulose fibers and synthetic fibers are used by the concrete industry for the same purpose - crack reduction. The difference in the requirement for crack reduction for the two types of fibers has been a source of confusion by both the end users and specifiers. This difference in required crack reduction has also provided manufacturers of synthetic fibers an unfair marketing advantage vs. cellulose fibers by allowing a lower dosage rate of synthetic fibers to meet the lower crack reduction level of 40%.

In order to make this amendment the only change required is to Section A7.0 of Annex A of AC 217. A7.0 is the Conditions for Acceptance for the Plastic Shrinkage Crack Test. The amendment would be to change the minimum crack reduction from 50% to 40%.

This amendment would not affect the performance level of concrete in the field. A minimum crack reduction of 40% is already allowed in the concrete industry by AC 32.

We thank you in advance for your assistance in this request.

Regards,

  
Michael J. Schultz, P.E.  
Product Development Engineer

BUCKEYE TECHNOLOGIES INC.



## ICC EVALUATION SERVICE, INC., RULES OF PROCEDURE FOR THE EVALUATION COMMITTEE

### 1.0 PURPOSE

The purpose of the Evaluation Committee is to monitor the work of ICC-ES, in issuing evaluation reports; to evaluate and approve acceptance criteria on which evaluation reports may be based; and to sponsor related changes in the applicable codes.

### 2.0 MEETINGS

**2.1** The Evaluation Committee shall schedule meetings that are open to the public in discharging its duties under Section 1, subject to Section 3.

**2.2** All scheduled meetings shall be publicly announced.

**2.3** Two-thirds ( $\frac{2}{3}$ ) of the voting Evaluation Committee members shall constitute a quorum. A majority vote of members present is required on any action.

**2.4** In the absence of the nonvoting 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.

**2.5** Minutes of the meetings shall be kept.

**2.6** An electronic audio record of meetings shall be made by ICC-ES; no other audio, video, electronic or stenographic recordings of the meetings will be permitted. Visual aids (including, but not limited to, charts, overhead transparencies, slides, videos, or presentation software) viewed at meetings shall be permitted only if the presenter provides ICC-ES before 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. A copy of the ICC-ES recording of the meeting and such visual aids, if any, will be available to interested parties upon written request made to ICC-ES together with a payment as required by ICC-ES to cover costs of preparation and duplication of the copy. These materials will be available beginning five days after the conclusion of the meeting but will no longer be available after one year from the conclusion of the meeting.

**2.7** 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 should be delivered to ICC-ES. All such written communications and submissions shall be considered nonconfidential and available for discussion in open session of an Evaluation Committee meeting, and shall be delivered at least ten days before the scheduled Evaluation Committee meeting if they are to be forwarded to the committee. Materials delivered to ICC-ES at least ten

days before the scheduled meeting will be posted on the ICC-ES web site ([www.icc-es.org](http://www.icc-es.org)) prior to the meeting. After this time, parties wishing to submit materials for consideration by the Evaluation Committee must deliver a sufficient number of copies as directed by ICC-ES. Consideration of materials not received by ICC-ES at least ten days before the meeting is at the discretion of the Evaluation Committee. Following the meeting, ICC-ES will make all materials considered by the Evaluation Committee available on the web site for a maximum period of one year following the meeting. The committee reserves the right to refuse recognition of communications which do not comply with the provisions of this section.

### 3.0 CLOSED SESSIONS

Evaluation Committee meetings shall be open except that the chairman may call for a closed session to seek advice of counsel.

### 4.0 ACCEPTANCE CRITERIA

**4.1** 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, method of construction, or service. 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 Evaluation Committee.

#### 4.2 Procedure:

**4.2.1** 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 5.0 of these rules.

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

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

**4.2.4** 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.

**4.3** Approval of acceptance criteria shall be as specified in Section 2.3 of these rules.

**4.4** Actions of the Evaluation Committee may be

**ICC EVALUATION SERVICE, INC., RULES OF PROCEDURE FOR THE EVALUATION COMMITTEE**

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.

**5.0 COMMITTEE BALLOTING FOR ACCEPTANCE CRITERIA**

**5.1** Acceptance criteria may be issued without a public hearing following a 30-day public comment period and a majority vote for approval by the Evaluation Committee when, in the opinion of ICC-ES staff, one or more of the following conditions have been met:

1. The subject is nonstructural, does not involve life safety, and is addressed in nationally recognized standards or generally accepted industry standards.
2. The subject is a revision to an existing acceptance criteria that requires a formal action by the Evaluation Committee, and public comments raised were resolved by staff with commenters fully informed.
3. Other acceptance criteria and/or the code provide precedence for the revised criteria.

**5.2** 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 a public hearings.* The committee member requests additional input from other committee members, staff or industry.

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

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

**6.0 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:

**6.1** Committee members receiving an electronic ballot should respond only to the sender (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.

**6.2** 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. ■

***Effective March 18, 2008***

## PROPOSED REVISIONS TO THE ACCEPTANCE CRITERIA FOR CONCRETE WITH VIRGIN CELLULOSE FIBERS

AC217

Proposed May 2010

Previously approved June 2007, July 2003

### 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.

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 proposed in this document, and otherwise meet the applicable performance requirements of the codes. Notwithstanding that a product, material, or type or method of construction meets the requirements of the criteria proposed in this document, or that it can be demonstrated that valid alternate criteria are equivalent to the criteria in this document and otherwise meet the applicable performance requirements 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 malfunctioning is apt to cause unreasonable property damage or personal injury or sickness relative to the benefits to be achieved by the use of the product, material, or type or method of construction.

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

# PROPOSED REVISIONS TO THE ACCEPTANCE CRITERIA FOR CONCRETE WITH VIRGIN CELLULOSE FIBERS

## 1.0 INTRODUCTION

**1.1 Purpose:** The purpose of this acceptance criteria is to establish requirements for virgin cellulose fibers to be recognized in an ICC Evaluation Service, Inc. (ICC-ES), evaluation report under the 2009 and 2006 International Building Code<sup>®</sup> (IBC), the 2009 and 2006 International Residential Code<sup>®</sup> (IRC), the BOCA<sup>®</sup> National Building Code/1999 (NBC), the 1999 Standard Building Code<sup>®</sup> (SBC), and the 1997 Uniform Building Code<sup>™</sup> (UBC). The bases of recognition are IBC Section 104.11, IRC Section R104.11, NBC Section 106.4, SBC Section 103.7 and UBC Section 104.2.8. Applicable code sections are IBC Sections 1909 (Structural Plain Concrete) and 1910 (Minimum Slab Provisions), and IRC Table R402.2 (Minimum Specified Compressive Strength of Concrete) and Section R506 [Concrete Floors (On Ground)]. Applicable code sections in the NBC are Sections 1901.0, 1902.0, and 1905; in the SBC are Sections 1901 and 1909; and in the UBC are Sections 1907.12, 1922 and 1922.3.

The reason for the development of this criteria is to set requirements for evaluation of virgin cellulose fibers for use in concrete, since the code does not provide requirements for evaluation of virgin cellulose fibers for use in concrete.

**1.2 Scope:** Virgin cellulose fibers are added to concrete to reduce plastic shrinkage cracking of reinforced concrete and structural plain concrete and/or to reduce shrinkage and temperature cracking in structural plain concrete slabs on grade.

**1.2.1** Consideration shall be given to the volume, size and type of cellulose fibers used. Extrapolation to other volumes, sizes and types of fibers shall be documented in accordance with this acceptance criteria or by an engineering evaluation, signed, sealed and dated by a registered design professional.

**1.2.2** The fibers are regarded as an admixture and are used in addition to any structural reinforcement, shrinkage and temperature reinforcement and joints required in the applicable code.

**1.2.3** The cellulose fibers may be used in concrete over steel deck construction.

**1.2.4** The cellulose fibers may be used in fire-resistive construction.

**1.2.5** Cellulose fibers when used in concrete slabs exposed to abrasive and impact traffic conditions (e.g., forklifts), shall be used only for reduction of plastic shrinkage cracking.

**1.3 Reference Standards:** Where standards are referenced in this criteria, these standards shall be applied consistently with the code upon which compliance is based. Standard editions applicable to each code are summarized in Table 1.

### 1.3.1 Codes:

**1.3.1.1** 2009 International Building Code<sup>®</sup> (2009 IBC), International Code Council.

**1.3.1.2** 2006 International Building Code<sup>®</sup> (2006 IBC), International Code Council.

**1.3.1.3** 2009 International Residential Code<sup>®</sup> (2009 IRC), International Code Council.

**1.3.1.4** 2006 International Residential Code<sup>®</sup> (2006 IRC), International Code Council.

**1.3.1.5** BOCA<sup>®</sup> National Building Code/1999 (NBC).

**1.3.1.6** 1999 Standard Building Code<sup>®</sup> (SBC).

**1.3.1.7** 1997 Uniform Building Code<sup>™</sup> (UBC).

### 1.3.2 ASTM International Standards:

**1.3.2.1** ASTM C 31 [see Table 1], Standard Practice for Method of Making and Curing Concrete Test Specimens in the Field.

**1.3.2.2** ASTM C 39 [see Table 1], Test Method for Compressive Strength of Cylindrical Concrete Specimens.

**1.3.2.3** ASTM C 78-02, Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading).

**1.3.2.4** ASTM C 94 [see Table 1], Standard Specification for Ready-Mixed Concrete.

**1.3.2.5** ASTM C 172 [see Table 1], Standard Practice for Sampling Freshly Mixed Concrete.

**1.3.2.6** ASTM C 192 [see Table 1], Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory.

**1.3.2.7** ASTM C 234-91a, Test Method for Bond Strength<sup>1</sup>.

**1.3.2.8** ASTM C 403-06, Standard Test Method for Time of Setting of Concrete Mixtures by Penetration Resistance.

**1.3.2.9** ASTM C 494-05a, Standard Specification for Chemical Admixtures for Concrete.

**1.3.2.10** ASTM C 470-02a, Standard Specification for Molds for Forming Concrete Test Cylinders Vertically.

**1.3.2.11** ASTM C 666-03, Test Method for Resistance of Concrete to Rapid Freezing and Thawing.

**1.3.2.12** ASTM C 1018-97, Test Method for Flexural Toughness and First-Crack Strength of Fiber-Reinforced Concrete (Using Beam with Third-Point Loading).

**1.3.2.13** ASTM C 1116-06 Specification for Fiber-Reinforced Concrete and Shotcrete.

**1.3.2.14** ASTM D 698-00ae1, Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort.

**1.3.2.15** ASTM D 1557 [see Table 1], Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort.

**1.3.2.16** ASTM D 1695-96 (2001), Standard Terminology of Cellulose and Cellulose Derivatives.

**1.3.2.17** ASTM D 6942-03, Standard Test Method for Stability of Cellulose Fibers in Alkaline Environments

**1.3.2.18** ASTM E 119 [see Table 1], Test Methods for Fire Tests of Building Construction Materials.

## PROPOSED REVISIONS TO THE ACCEPTANCE CRITERIA FOR CONCRETE WITH VIRGIN CELLULOSE FIBERS (AC217)

**1.3.2.19** ASTM E 136 [see Table 1], Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750 C.

### **1.3.3 American Concrete Institute (ACI) Committee Reports:**

**1.3.3.1** ACI 305R-99, Specification on Hot Weather Concreting.

**1.3.3.2** ACI 318- (-08, 2009 IBC; -05, 2006 IBC and IRC; -95, NBC, SBC and UBC), Building Code Requirements for Structural Concrete.

**1.3.3.3** ACI 544.2R-89 (1999), Measurement of Properties of Fiber-reinforced Concrete.

**1.3.3.4** ACI 544.1R-96, State-of-the-Art Report on Fiber Reinforced Concrete.

**1.3.4** ANSI/ASCE 3-91, Standard for the Structural Design of Composite Slabs, American Society of Civil Engineers.

### **1.4 Definitions:**

**1.4.1 Admixture:** Admixture is material other than water, aggregate, or hydraulic cement used as an ingredient of concrete and added to concrete before or during its mixing to modify its properties.

**1.4.2 Plastic Shrinkage Cracking:** Plastic shrinkage cracking is cracking that occurs in the surface of fresh concrete soon after it is placed and while it is still plastic.

**1.4.3 Reinforced Concrete:** Reinforced concrete is defined in Section 2.2 of ACI 318.

**1.4.4 Structural Plain Concrete:** Structural plain concrete is defined in ACI 318.

**1.4.5 Shrinkage and Temperature Cracking:** Shrinkage and temperature cracking is cracking in tension due to a decrease in length or volume.

**1.4.6 Virgin Cellulose Fibers:** Virgin cellulose fibers are fibers composed partly or completely of cellulose. Cellulose is a naturally occurring organic polymer. The term "virgin" means that the fibers have been manufactured from the original natural raw material (i.e., trees, etc.) and are being used for the first time in a final product for consumer/commercial use and are not post-consumer recycled cellulose fiber. For more definitions of these and related words, ASTM D 1695, "Standard Terminology of Cellulose and Cellulose Derivatives," shall be referenced.

## **2.0 BASIC INFORMATION**

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

**2.1.1 Product Description:** Complete information concerning material specifications, cellulose fiber type and source, size and fiber tensile strength as measured by zero-span tensile method.

**2.1.2 Installation Instructions:** Printed instructions for mixing and dosage rates as provided with the packaging of the product.

**2.1.3 Packaging and Identification:** A description of the method of packaging and field identification of product. Identification provisions shall include the evaluation report number.

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

**2.3 Test Reports:** Test reports shall comply with AC85.

**2.3.1** Test reports shall include the following:

**2.3.2** Description of type and source of cellulose fiber (e.g. hardwood, softwood, grass, hemp, cotton).

**2.3.3** Description of test procedure.

**2.3.4** Statement on passing or failing, where applicable.

**2.4 Product Sampling:** Products shall be sampled in accordance with Section 3.0 of AC85.

## **3.0 TEST AND PERFORMANCE REQUIREMENTS**

**3.1 General:** Consideration must be given to the volume ratio, size and type of fibers used. Extrapolation to other volumes, sizes and types of cellulose fibers shall be justified. Recognition in evaluation reports of cellulose fibers in concrete are divided into the following categories:

**3.1.1** Where cellulose fibers are used in controlling plastic shrinkage cracking of reinforced concrete and structural plainconcrete, the fibers are regarded as an admixture and are used in addition to any structural reinforcement, and to any shrinkage and temperature reinforcement required in Section 1907.12 of the IBC, or joints required in Section 1909.3 of the IBC.

**3.1.2** Where cellulose fibers are used to help reduce shrinkage and temperature cracking in structural plain concrete slabs on grade, the fibers are used in addition to joints required in Section 1909.3 of the IBC.

**3.1.3** Cellulose fibers used in concrete over steel deck construction. Refer to Section 4.9.

**3.1.4** Cellulose fibers used in fire-resistive concrete over steel deck construction. Refer to Section 4.10.

### **3.2 Test Requirements:**

**3.2.1** For recognition under Section 3.1.1, results of tests conducted in accordance with Sections 4.1 through 4.6, inclusive, are required.

**3.2.2** For recognition under Section 3.1.2, results of tests conducted in accordance with Sections 4.1 through 4.7, inclusive, are required.

**3.2.3** For recognition under Section 3.1.3, results of tests conducted in accordance with Sections 4.1 to 4.9, inclusive, are required. For noncomposite concrete placement over steel deck, compliance with Section 4.9 may be omitted.

**3.2.4** For recognition under Section 3.1.4, results of tests conducted in accordance with Sections 4.1 to 4.10, inclusive, are required. For noncomposite concrete placement over steel deck, compliance with Section 4.9 may be omitted.

## **4.0 TEST METHODS**

All tests shall be conducted using appropriate sections of the reference mix outlined in Sections 11 through 15 of ASTM C 494.

**4.1 Concrete Flexural Strength:** Purpose of the test is to evaluate whether the addition of cellulose fibers to a

## PROPOSED REVISIONS TO THE ACCEPTANCE CRITERIA FOR CONCRETE WITH VIRGIN CELLULOSE FIBERS (AC217)

concrete mix adversely affects the flexural strength of concrete.

**4.1.1** Comparative tests shall be conducted in accordance with ASTM C 78.

**4.1.2** Sampling and conditioning shall comply with ASTM C 31 and ASTM C 192 as referenced in Section 7.2 of ASTM C 1018.

**4.1.3** Tests shall be conducted on three specimens with proprietary fibers in the concrete mix and three specimens without fibers (control).

**4.1.4 Conditions of Acceptance:** The average flexural strength of the three specimens with fibers shall be at least equal to the average flexural strength of the control specimens, at 28 days. Slight deviations, due to variations in testing, may be considered.

**4.2 Concrete Compressive Strength:** Purpose of the test is to evaluate whether the addition of cellulose fibers to a concrete mix adversely affects the compressive strength.

**4.2.1** Comparative tests shall be conducted in accordance with ASTM C 39.

**4.2.2** Tests shall be conducted on three concrete specimens with proprietary fibers and three specimens without fibers (control).

**4.2.3 Conditions of Acceptance:**

**4.2.3.1** The average compressive strength of the three specimens with the fibers shall be at least equal to the average compressive strength of the control specimens at 28 days. Slight deviations, due to variations in testing, may be considered.

**4.3 Freeze-thaw Durability:** Purpose of the test is to evaluate whether the addition of cellulose fibers to a concrete mix adversely affects the freeze-thaw durability of the concrete.

**4.3.1** Comparative tests shall be conducted in accordance with Procedure A of ASTM C 666.

**4.3.2** Tests shall be conducted on three concrete specimens with proprietary fibers and three specimens without fibers (control). Air content of each mixture shall be as specified in Section 12.2.2 of ASTM C 494.

**4.3.3 Conditions of Acceptance:** The average durability factor of the three specimens containing the fibers shall be at least equal to the average durability factor of the control specimens. The number of cycles should be 300 or until the average relative dynamic modulus of elasticity (MOE) of the fiber specimens or the control specimens reaches 60 percent of the respective initial modulus, whichever occurs first.

**4.3.4** In lieu of providing test information in accordance with ASTM C 666, a proven record of freeze-thaw performance in accordance with Section 21.4 of ASTM C 1116 may be provided. The field test report shall be prepared by a recognized independent agency, and include the size, quantity, trade name and type of fiber along with the concrete mix design. Test reports from at least three separate locations are required.

**4.4 Effect on Reinforcement Bond Strength:** (May be omitted if use of fibers is limited to plain concrete slabs on grade.) Purpose of the test is to determine whether the addition of cellulose fibers to a concrete mix adversely

affects the bond strength between the reinforcement and concrete.

**4.4.1** Comparative tests shall be conducted in accordance with ASTM C 234. Steel reinforcement shall be evaluated horizontally in accordance with Section 4.3 of ASTM C 234. Concrete shall be cured a minimum of 28 days.

**4.4.2** Tests shall be conducted on three concrete specimens with cellulose fibers and three specimens without fibers (control).

**4.4.3 Conditions of Acceptance:** The average bond strength for the steel reinforcement embedded in the concrete with the fibers shall be equal to or exceed the average bond strength for the steel reinforcement embedded in the control specimen. Slight deviations, due to variations in testing, may be considered.

**4.5 Plastic Shrinkage Cracking:** Purpose of the test is to show that cellulose fibers decrease the plastic shrinkage cracking of concrete. Test must be conducted in accordance with Annex A. Conditions of acceptance are noted in Annex A.

**4.6 Compatibility with Concrete:** The purpose of the test is to evaluate the long-term resistance of the cellulose fiber to deterioration when in contact with moisture and alkalis present in cement paste or the substances present in air-entraining and chemical admixtures.

**4.6.1 Alkaline Stability Test Procedure:** This test is conducted in accordance with ASTM D 6942.

**4.6.2 Test Conditions:** ASTM D 6942 shall be run at time intervals of 1, 3, 7, 14, 21, 28 and 35 days, treating the fibers with saturated calcium hydroxide and 1N sodium hydroxide in open containers. For each sample, the zero-span tensile value shall be the average from testing eight strips cut from four handsheets.

**4.6.3 Conditions of Acceptance:** The Average Zero-Span Stability Ratio (ZSSR) reported from ASTM D 6942 shall not fall below 90 percent for both alkali environments tested.

**4.7 Post-crack Integrity:**

**4.7.1 General:** The Impact test is used to evaluate the integrity of concrete with cellulose fibers after cracking:

**4.7.2 Impact Resistance:** This test compares the impact resistance of concrete with and without cellulose fibers. The test must be conducted in accordance with the procedure outlined in Annex B.

**4.7.3 Conditions of Acceptance:** The number of blows to ultimate failure for fiber concrete specimens shall exceed the blows to plain concrete specimens by 40 percent at seven days and 40 percent at 28 days.

**4.8 Noncombustible Building Material (Optional):**

**4.8.1 General:** Concrete with virgin cellulose fibers used in building construction required to be noncombustible in accordance with the applicable code shall be tested in accordance with ASTM E 136.

**4.8.2 Conditions of Acceptance:** The specimens of concrete with virgin cellulose fibers shall satisfy the requirements set forth in ASTM E 136.

**4.9 Concrete over Steel Deck Composite Construction Test:**

**PROPOSED REVISIONS TO THE ACCEPTANCE CRITERIA FOR CONCRETE WITH VIRGIN CELLULOSE FIBERS (AC217)**

**4.9.1 General:** The purpose of the tests is to evaluate whether the addition of fibers to a concrete mix placed over steel deck adversely affects the shear bond between the concrete and steel deck construction.

Results of full-scale superimposed load tests providing comparative load capacity and deflection information, shall be submitted. A minimum of two decks for each reinforcement method shall be tested. Consideration shall be given to the volume, type and size of fibers used. Testing shall be conducted using No. 20 gage [0.0359 inch (0.91 mm)] steel deck (ASTM A 653 Structural Grade 33), 3 inches (76 mm) deep with 12-inch (304.8 mm) rib spacing, designed for composite use and filled with 2 1/2 inches (63.5 mm) of concrete fill having a specified compressive strength of 3,000 psi (20.7 MPa). Specimens shall include:

1. One set of specimens shall contain concrete fill with 6 x 6-W1.4 x W1.4 (WWF), 1 inch (25.4 mm) below the top of the slab.
2. One set of specimens shall contain concrete fill with cellulose fibers.

**4.9.2 Test Procedure:** Concrete with virgin cellulose fibers used in composite steel deck construction shall be evaluated in accordance with one of the following procedures:

**4.9.2.1** Testing and conditions of acceptance in accordance with Section 4.8.2 of AC32.

**4.9.2.2** Testing and evaluation of test results in accordance with Section 3.2 of ANSI/ASCE 3-91.

**4.10 Fire-resistance-rated Construction Test:**

**4.10.1** The purpose of the test is to evaluate whether the addition of the virgin cellulose fibers in a concrete mix will adversely affect the fire-resistance-rating of concrete-filled steel deck assemblies.

Consideration shall be given to the volume ratio, type and size of fiber used.

Testing shall be conducted in accordance with ASTM E 119 (UBC Standard 7-1).

**4.10.2 Conditions of Acceptance:** The conditions of acceptance shall be in accordance with ASTM E 119. The

assembly shall be rated for a minimum of 1 hour. The fire-resistance-rated assembly shall be detailed in the evaluation report.

**5.0 QUALITY CONTROL**

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

**5.2** Third-party follow-up inspections are not required under this acceptance criteria.

**5.3** The quality documentation shall identify that the cellulose fibers are original natural fibers, "virgin." Also refer to section 1.4.6.

**6.0 EVALUATION REPORT RECOGNITION**

**6.1** If the applicant/holder of an evaluation report purchases the fibers from a fiber manufacturer, evidence is needed of an agreement between the fiber manufacturer and the applicant/holder indicating that the manufacturer will inform the applicant/holder of any changes to the fiber. The applicant/holder shall then notify ICC-ES.

**6.2** The evaluation report shall include the condition that use of the fibers is approved by the project engineer or architect.

**6.3** For structural plain concrete, the evaluation report shall indicate that control joints, as required by Section 1909.3 of the IBC, are to be provided.

**6.4** For reinforced concrete, the evaluation report must indicate that structural reinforcement and shrinkage and temperature reinforcement in accordance with Section 1907.12 of the IBC are to be provided.

**6.5** A batch ticket, signed by a ready-mix representative, shall be available to the code official upon request. The delivery ticket shall include, in addition to the items noted in Section 16.1 of ASTM C 94, the type and amount of fibers added to the concrete mix.

**6.6** If recognition for other types of concrete, such as lightweight, is desired, results of tests conducted in accordance with this criteria shall be submitted for each type. ■

**TABLE 1**

ASTM	DATE OF STANDARD						
	2009 IBC	2006 IBC	2009 IRC	2006 IRC	BNBC	SBC	UBC
C 31	-06	-98	-	-03a	-98	-91	-91
C 39	-	-96	-	-03	-96	-93a	-93a
C 94	-07	-04	-07	-04	-98b	-94	-94
C 172	-04	-04	-	-04	-97	-90	-90
C 192	-	-02	-	-02	90a	-90a	-90a
D 1557	-02e01	-02	-	-02	91	-91	-91
E 119	-07	-00	-07	-00	-98	-95a	-83 (UBC 7-1)
E 136	-04	-99e1	-04	-99e01	-98e1	-94a	-79 (UBC 2-1)

**ANNEX A**  
**TEST METHOD FOR EVALUATING PLASTIC SHRINKAGE CRACKING OR**  
**RESTRAINED CONCRETE WITH CELLULOSE FIBERS**

**A1.0 INTRODUCTION**

This test method compares the surface cracking of a concrete panel containing cellulose fiber with the surface cracking of a control concrete panel without fibers. Both concretes are subjected to prescribed conditions of moisture loss severe enough to produce cracking. Both concretes can also be subjected to anticipated job conditions of temperature and humidity to obtain the difference between the cracking potentials of plain concrete and concrete with cellulose fibers in the field.

Shrinkage cracking is quantified by computing the area of surface cracks in each panel specimen to obtain a value in square inches, which represents the assumed total area of crack opening on the surface of the concrete panels.

The effect of fibers on the development of shrinkage cracking is determined by expressing the cracking value for the concrete with cellulose fibers as a percentage of the value for the control concrete (without fibers) when subjected to the identical and simultaneous drying conditions.

Values of shrinkage cracking stated in square inches are regarded as the standard. This method attempts to control or duplicate atmospheric variables to quantify the performance of the fiber variable in a given concrete mixture. Since many other variables such as cement fineness, aggregate gradation and surface finishes also influence cracking potential and cannot be precisely duplicated, this method may not be suitable for interlaboratory evaluations.

**A2.0 SUMMARY OF METHOD**

Following casting and screeding, the surfaces of concrete test panels with and without fibers are subjected to airflow produced by a fan or fans. The use of a fan box is a method for producing a uniform airflow over the panel surface (see Figure A1). A clear cover over the specimen in conjunction with the fan box will aid in obtaining uniform airflow and allow for specimen observation.

The test is conducted using a method shown in Figure A1, by exposing the panels to an evaporation rate of 0.2 pound of water per square foot of surface per hour (0.975 kg/m<sup>2</sup>/h) or more. (See ACI 305.)

Referring to the evaporation graph in ACI 305R, evaporative variables are set in the laboratory for the comparison test to obtain a minimum of the critical rate, i.e., 0.2 pound of water per square foot of surface per hour (0.975 kg/m<sup>2</sup>/h). The evaporation rate is monitored by a 1-square-foot (0.0929 m<sup>2</sup>) pan of water that is weighed initially and thereafter periodically until the termination of the test to determine the evaporation rate (Annex Note 1).

**Annex Note 1:** A principal determinant in this method is evaporative water loss that is controlled by the atmospheric environment of the test specimens. Since the concrete specimens will not always provide the same rate of free water evaporation as is available from the pan of water, the rate of evaporation from the pan of water is the standard for this test.

The drying conditions are intended to induce shrinkage in cracking which will occur due to internal or external restraints on volume reduction. End of test shall be determined when final set of the concrete is reached. Final set will be determined according to ASTM C 403.

The specimens should be uncovered and exposed to the same conditions. The total area of crack opening at the end of the test is computed for each test panel. The shrinkage of the concrete is expressed as the total area of crack opening for the panel in square inches.

During the setting stage, from initial through final set, "plastic" shrinkage cracks occur. Because it is difficult to measure cracks in the plastic state, all cracks are measured after the termination of the test period.

The test specimens and monitoring pan are inserted into an environmental chamber designed for this purpose (see Figures A1 and A2). The atmospheric variables set, achieve the minimum prescribed evaporation rate, are not critical in the comparison test because the average evaporative rate is the determining factor of the test.

Before casting of the concrete panels, it is expeditious to check the atmospheric variables in the laboratory test facility to determine that the necessary conditions can be achieved.

Cracking values are determined by counting the number of cracks in each panel and recording the approximate length and width of each crack. The accumulated crack area is computed based on these measurements to determine the cracking value for each test panel. The ratio of the cracking values for fiber reinforced versus control panels is the fiber effectiveness ratio expressed as a percentage. Refer to Section A6.0, Quantification of Cracking.

**A3.0 APPARATUS**

**Molds:** A mold with a depth of 4 inches (102 mm), a minimum surface area of 1.75 square feet (0.16 m<sup>2</sup>) and rectangular dimensions of 14 inches by 22 inches (356 mm by 559 mm), with internal restraint and stress risers as shown in the figure. The mold may be fabricated from metal, plastic or plyform (Annex Note 2). Fabricate the internal restraints and stress riser for a separate sheet metal piece. This sheet metal piece shall seat snugly at the bottom of the mold (see Figure A2).

**Annex Note 2:** The use of plyform, with very little absorption, is appropriate for constructing lightweight, stiff molds.

**Restraint:** Two 1.25-inch (31.7 mm) risers, placed 4 inches (102 mm) inward from each end of the mold, provide restraint to the concrete. The center 2.5-inch (63.5 mm) stress riser serves as an initiation point for plastic shrinkage cracking.

## PROPOSED REVISIONS TO THE ACCEPTANCE CRITERIA FOR CONCRETE WITH VIRGIN CELLULOSE FIBERS (AC217)

The sheet metal stress riser insert is lightly oiled to provide appropriate debonding of the concrete from the bottom of the sheet. The insert is considered to be properly oiled when the entire surface is coated and all excess oil has been removed. The sides of the mold are oiled in the same manner as the insert.

**Fan(s):** Adjustable-speed fan(s) capable of achieving a minimum 10 mph (16.1 km/h) airflow over the entire test specimen surface area.

**Sensors:** Temperature, humidity, air velocity sensor means of recording ambient air and concrete temperatures to the nearest 1°F (0.5°C) and relative humidity to the nearest 1 percent near the test specimen surface during testing. An anemometer capable of measuring air velocity to the nearest 1 mph (1.61 km/h) shall be used.

**Vibrating Platform:** Any device that can fully consolidate the test panels within 12 seconds and that meets minimum frequency requirements for an external vibrator is suitable.

**Monitoring Pan:** A pan suitable for holding water in the air stream between the concrete test panels. The sides of the pan shall be vertical and shall expose precisely 1 square foot (0.0929 m<sup>2</sup>) of water ±1 percent to the atmosphere. This size of pan will expedite the calculation of evaporation rate. The exposed lip of the pan shall not extend more than 1/8 inch (3.2 mm) above the water level at the start of the test. A 12-inch-by-

12-inch-by-1-inch (305 mm by 305 mm by 25 mm) or 8-inch-by-18-inch-by-1-inch (203 mm by 457 mm by 25 mm) configuration is appropriate.

**Scale:** A balance or scale for weighing the monitoring pan shall have a capacity of at least 5 pounds (2.2 kg) and accurate to within 0.1 percent of its capacity.

**Optional:** A scale for weighing the test panels shall have a capacity of at least 200 pounds (90.7 kg) and accurate to within 1 percent of the test load.

### A4.0 SAMPLING, TEST SPECIMENS AND TEST UNITS

**General Requirements:** The preferred specimen depth for concrete is 4 inches (102 mm). Maximum coarse aggregate size when using stress risers is 3/4 inch (19 mm).

**Test Specimens:** The specimens are cast in the laboratory in accordance with the applicable provisions of ASTM C 192.

**Test Units:** A test unit is at least six test specimens. Three are control specimens without fibers. The other specimens are identical except they contain specified amounts and types of fiber. Control concrete specimens may be compared to more than one series of fiber-reinforced concrete specimens.

### A5.0 PROCEDURE

The molds are filled with concrete and subjected to a source of external vibration until the concrete is consolidated and approximately level with the top of the mold. Each specimen is then screeded three times with an angle iron screed. The total vibration time is limited to 12 seconds, to avoid material segregation.

**Optional:** The molds are weighed prior to filling the concrete. Following removal of any waste concrete adhering to the outside of the mold, each specimen while in the mold is weighed prior to testing so that evaporation in the form of water loss during testing may be determined at the end of the test by subsequent weighing.

After vibration and screeding, the surface of the concrete is floated with a magnesium float to embed the aggregate and compact the surface. The number of passes shall be determined for each mixture and material source used during testing. Float specimens of the same mixture and material using equal number of passes.

The fiber reinforced and control specimens are placed in the selected exposure area downstream from the fan(s). (See arrangement in Figure A1.)

The fan(s), preset to achieve a minimum airflow velocity of 10 mph (16.1 km/h) are turned on, and the time of day is recorded. Simultaneously, the specimens are exposed to identical drying conditions. The evaluation of cracking commences at this time.

Air and concrete temperatures, relative humidity and airflow velocity, at a location 4 inches (102 mm) above the specimen, are recorded at the start and at 30 minute intervals. The time at which cracking is first observed is also recorded for each specimen.

Observations are continued at 30-minute intervals until final set or for a minimum of three hours. Measurement of cracking commences only at the completion of the drying period.

The evaporation rate is determined by initially weighing the full monitoring pan at the start of the test and at 30-minute intervals thereafter. The weight loss in pounds is recorded to the nearest 0.01 pound (4.53 g) at each weighing in the air stream to prevent an interruption in evaporation losses.

**Annex Note 3:** Adjustments should be made if necessary to maintain the standard evaporation rate at the prescribed level. It is suggested that the monitoring pan be placed on a scale in the air stream for continuous monitoring without periodic removal during testing.

After final set, or a minimum of three hours under the test conditions, atmospheric variables are recorded, and the fans are stopped, the total water loss from the monitoring pan is determined. The test is not valid if the total standard evaporation rate was less than 0.2 pound of water per square foot of surface per hour (0.975 kg/m<sup>2</sup>/h).

**Optional:** If mass loss of test panels is desired, test panels are weighed at this time.

## PROPOSED REVISIONS TO THE ACCEPTANCE CRITERIA FOR CONCRETE WITH VIRGIN CELLULOSE FIBERS (AC217)

### A6.0 QUANTIFICATION OF CRACKING

Cracks are quantified by computing the crack opening area at the surface of the panels. The unit of measurement is square inches ( $\text{mm}^2$ ).

Measurement of cracks commences after the end of drying. Each crack is identified and measured in a progressive order from one side of the panel to the other. As each crack is measured, it shall be identified with a bright, felt-tipped pen to prevent duplication. The approximate length of a crack is determined by laying a string along its length and subsequently recording the straight-line distance of string from end to end. It is important to use the same care and measuring methodology on each specimen. Average crack width is computed by recording and averaging widths measured along the crack at a minimum of 1-inch (25.4 mm) intervals (Annex Note 4). When all measurements have been taken and all cracks have been marked, this step is complete.

**Annex Note 4:** A crack comparator or crack microscope available from many sources is required to determine the width of the cracks.

It is very important to use the same care and measuring methodology on each specimen. The cracking values of each panel are computed by multiplying crack lengths by their associated average widths and accumulating these products to determine the specimen's total cracking value.

### A7.0 CONDITIONS OF ACCEPTANCE

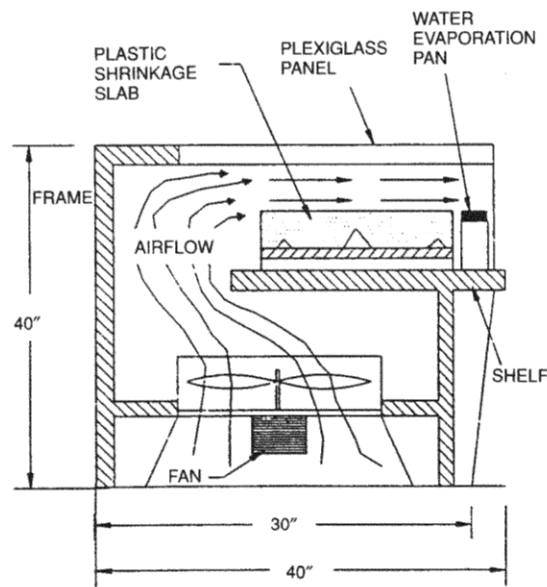
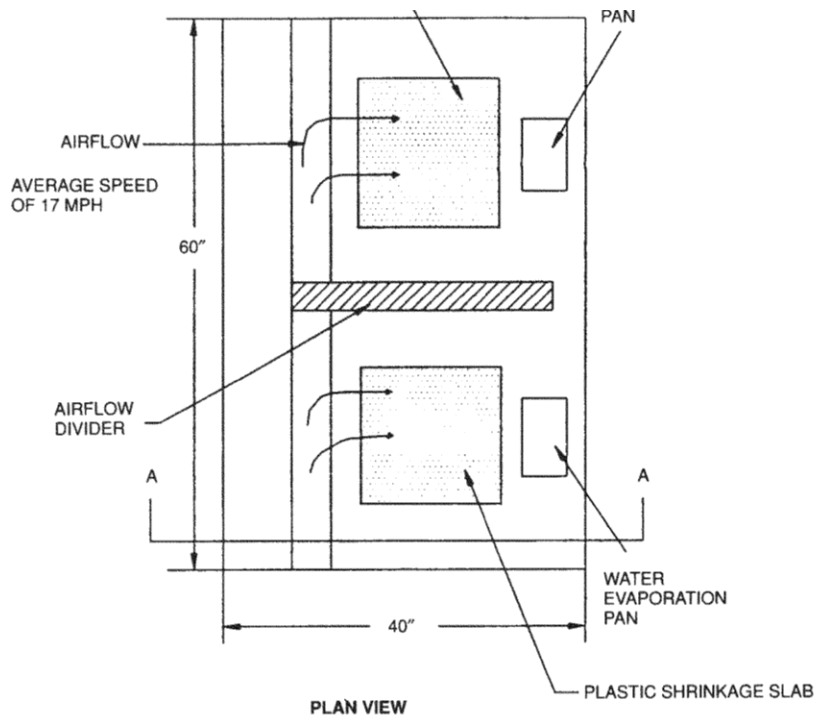
The results should be evaluated on the basis of averaging the test results and any peculiar individual test results should be noted.

The minimum accepted for the final results should be that cellulose fibers decrease the plastic shrinkage cracking of concrete by 40 percent ~~50 percent~~.

### A8.0 REPORT

The report shall include the following:

- Concrete strength, unit weight, and the amount of air entrainment (if applicable).
- The amount in  $\text{lb./yd}^3$  ( $\text{kg/m}^3$ ) of water, aggregates with aggregate gradation and fibers; admixture in  $\text{fluid oz./yd}^3$  ( $\text{mL/m}^3$ ); water-cement ratio and slump for each concrete mixture evaluated.
- The fiber volume percentage (%) and type of fiber in each concrete mixture evaluated.
- Depth and dimensions of specimens.
- Cracking value of each specimen determined in square inches ( $\text{mm}^2$ ).
- Total the measured rate of moisture loss in pounds per square foot ( $\text{kg/m}^2$ ).
- Cracking ratio relative to control without fibers:  
Cracking value (FRC)/Cracking value (control) X 100%
- Mass loss of specimens (optional)
- Calculated moisture loss of each panel in pounds of water per square foot ( $\text{kg/m}^2$ ) of surface (optional).

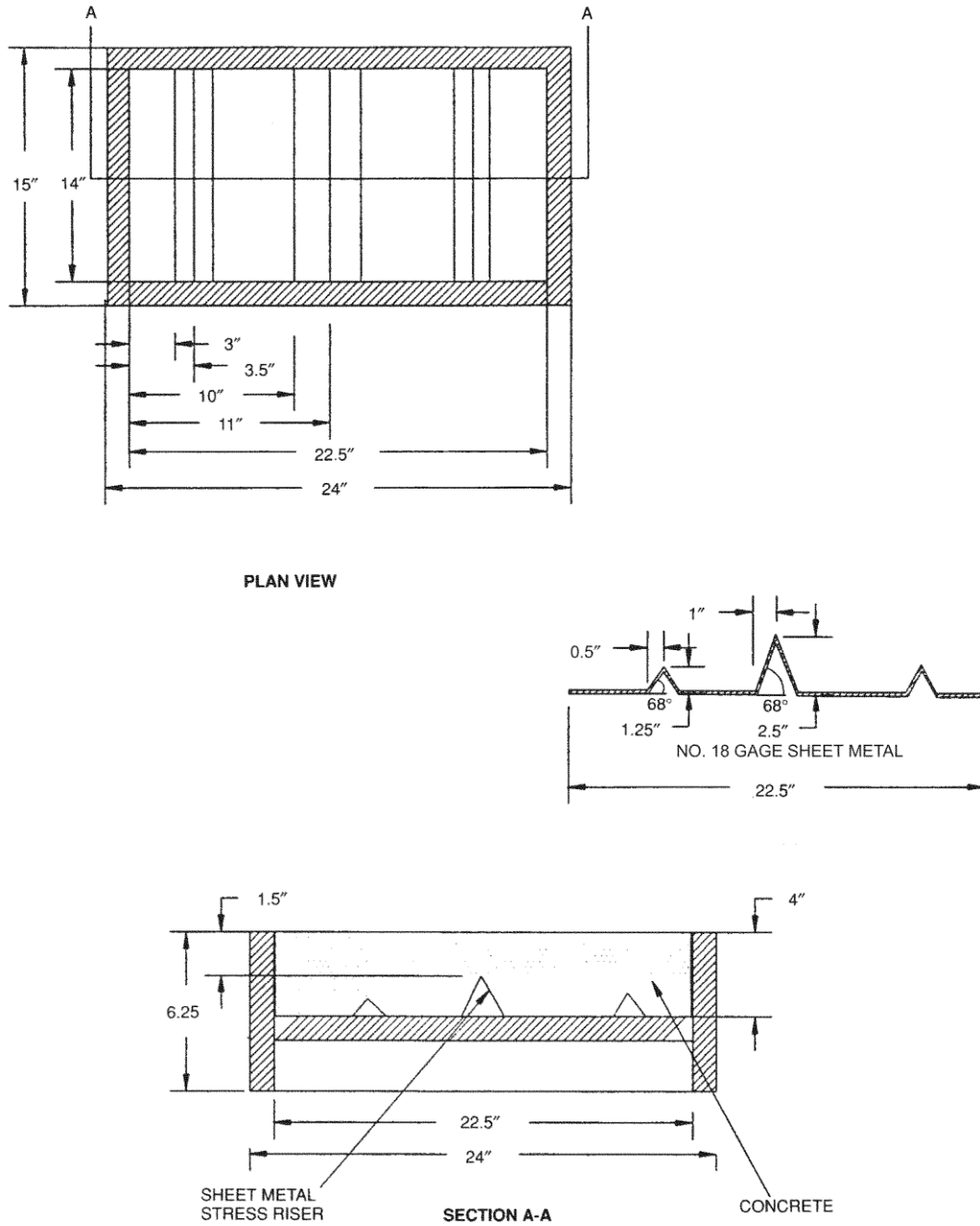


For SI: 1 inch = 25.4 mm.

(FIGURE NOT TO SCALE)

FIGURE A1—SCHEMATIC OF FAN BOX USED WITH PLASTIC SHRINKAGE SLAB TO TEST FIBERS

PROPOSED REVISIONS TO THE ACCEPTANCE CRITERIA FOR CONCRETE WITH VIRGIN CELLULOSE FIBERS (AC217)



(FIGURE NOT TO SCALE)

For SI: 1 inch = 25.4 mm.

FIGURE A2—SCHEMATIC OF PLASTIC SHRINKAGE MOLD USED FOR FIBER TESTS

**ANNEX B  
TEST METHOD FOR EVALUATING IMPACT RESISTANCE  
OF CONCRETE WITH CELLULOSE FIBERS**

**B1.0 SCOPE**

The test method compares the impact resistance of concrete with and without cellulose fibers. Impact resistance is characterized by the measure of: (a) the energy consumed to fracture a specimen; (b) the number of blows in a “repeated impact” test to achieve a prescribed level of distress, and (c) the extent of damage.

**B2.0 APPARATUS**

The equipment for the drop weight impact test consists of:

**B2.1** A standard, manually or mechanically operated 10-pound (4.54 kg) compaction hammer with an 18 inches (457 mm) drop as specified in ASTM D 698 or ASTM D 1557.

**B2.2** A 2<sup>1</sup>/<sub>2</sub>-inch-diameter (63.5 mm) hardened steel ball.

**B2.3** A flat base plate with four lugs welded to it (refer to Figures B1 and B2).

**B2.4** Molds to cast 6-inch-diameter (152 mm) by 2<sup>1</sup>/<sub>2</sub>-inch (63.5 mm) ±<sup>1</sup>/<sub>8</sub>-inch (±3 mm) concrete specimens. This is accomplished with molds complying with ASTM C 31 or C 470.

**B3.0 TEST PROCEDURE**

The 2<sup>1</sup>/<sub>2</sub>-inch-thick-by-6-inch-diameter (63.5 mm by 152 mm) concrete samples are prepared using external vibration. The method, frequency, amplitude and time of vibration shall be recorded. Test specimens of 2<sup>1</sup>/<sub>2</sub> inch (63.5mm) thickness are cast in a single layer to avoid fiber orientation and fiber-free planes. The molds are filled partially to the 2<sup>1</sup>/<sub>2</sub>-inch (63.5 mm) depth and float finished.

The specimens are tested at 7 and 28 days of age. Specimen thickness is recorded to the nearest <sup>1</sup>/<sub>16</sub> inch (1.6 mm). The reported thickness is determined by averaging the measured thickness at the center and each edge of the specimen along any diameter across the top surface. The samples are coated on the bottom with a thin layer of petroleum jelly or a heavy grease and placed on the base plate within the positioning lugs with the finished face up. The base plate shall be bolted to a rigid base such as a concrete floor or cast concrete block. The hardened steel ball is placed on top of the specimen within the bracket. Foamed elastomer pieces are placed between the specimen and positioning lugs to restrict movement of the specimen during testing to first visible crack.

The drop hammer is placed with its base upon the steel ball and held there with enough down pressure to keep it from bouncing off the ball during the test. The hammer is repeatedly dropped 18 inches (457 mm), and the number of blows required to cause the first visible crack on the top and to cause ultimate failure are both recorded. The foam elastomer is removed after the first visible crack is observed. Ultimate failure occurs when the test specimen comes in contact with three of the four lugs welded to the base plate. Illustrative details are in Figures B1 and B2.

**B4.0 SAMPLING, TEST SPECIMENS AND TEST UNITS**

**B4.1 Sampling:** Five specimens are molded for each test age and test condition. Specimens involving a given variable can be made on any given day. When it is possible to make at least one specimen for each variable on a given day, the mixing of the entire series of specimens must be completed in as few days as possible, and one of the mixtures must be repeated each day as a standard comparison.

**B4.2 Test Specimens:** The test specimens are cast in accordance with ASTM C 192, the Standard Method for Making and Curing Concrete Test Specimens in the Laboratory.

**B4.3 Test Units:** A test unit is at least five test specimens of each variation. One unit is the control concrete without fibers. The other units are the same concrete mixture with specified amounts and types of fiber.

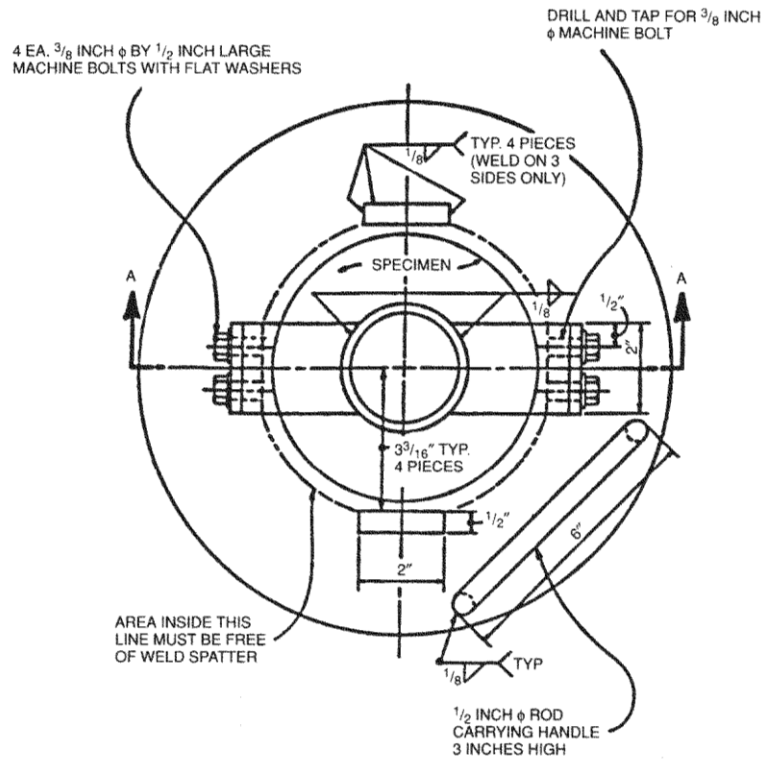
**B5.0 CONDITIONS OF ACCEPTANCE**

The results are evaluated on the basis of averaging the test results. Any individual peculiarities among test results shall be noted. The minimum acceptance for the final results is that the cellulose fibers increased the impact of concrete by 40 percent at 7 days and 40 percent at 28 days.

**B6.0 REPORT**

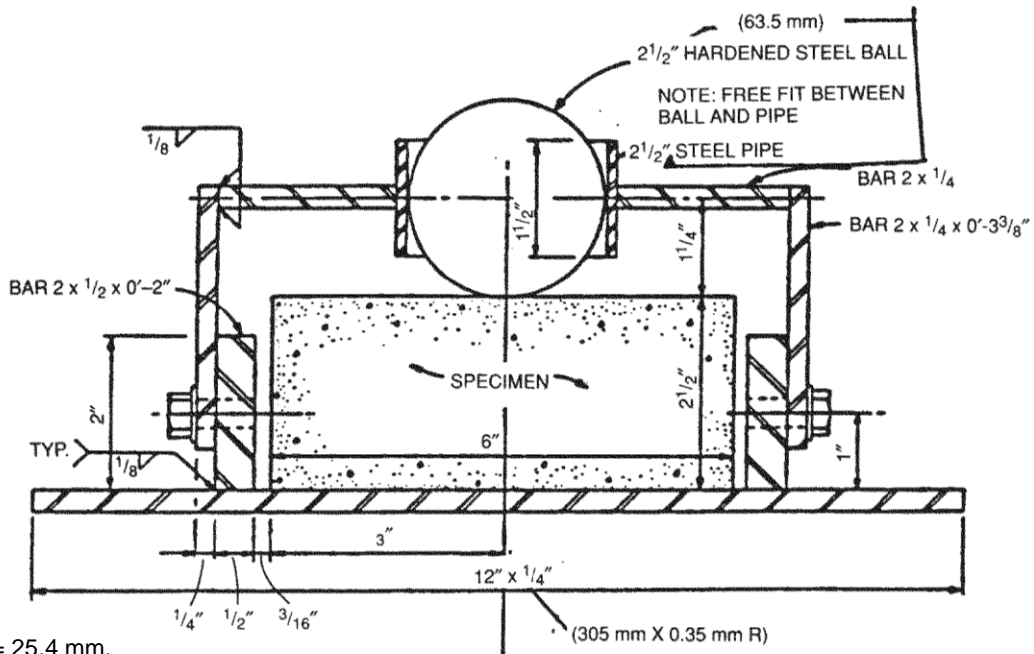
In addition to the requirements of AC85, the report shall include the following:

- The concrete design mix for all variations.
- Fiber dosage for each set of specimens, by weight.
- Fiber length for each of set specimens.
- Thickness and dimension of specimen.
- Height of hammer drop.
- Number of blows to first visible crack.
- Number of blows to ultimate failure.



For SI: 1 inch = 25.4 mm.

FIGURE B1—PLAN VIEW OF TEST DEVICE



For SI: 1 inch = 25.4 mm.

FIGURE B2—SECTIONAL VIEW A-A OF TEST DEVICE