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February 05, 2009

**TO: PARTIES INTERESTED IN EVALUATION REPORTS ON
PROPOSED ACCEPTANCE CRITERIA FOR STRUCTURAL
CONCRETE WITH LIGHTWEIGHT SYNTHETIC PARTICLES**

**SUBJECT: Acceptance Criteria for Structural Concrete with Lightweight
Synthetic Particles, Subject AC408-0209-R1 (ME/KS)**

Dear Madam or Sir:

Enclosed is a copy of the subject new acceptance criteria approved by the ICC-ES Evaluation Committee on February 5, 2009, effective March 1, 2009.

The purpose of this acceptance criteria is to establish requirements for structural concrete with lightweight synthetic particles to be recognized in an ICC-ES evaluation report under the 2006 International Building Code[®] (IBC) and the 2006 International Residential Code[®] (IRC). The proposed acceptance criteria is intended to address requirements for concrete with lightweight synthetic particles that are added to concrete as a partial replacement of conventional fine or coarse aggregate to create structural concrete while maintaining mechanical and durability characteristics defined by the applicable codes.

During the meeting, Evaluation Committee approved all the revisions proposed in the Staff Memo, dated January 29, 2009.

Based on the discussions during the meeting, the following revisions were also approved by the committee

1. Revise Section 4.9.3 as: "Conditions of Acceptance: The average bond strength for the steel reinforcement embedded in the concrete with the lightweight synthetic particles shall be at least equal to, or better than the average bond strength for the steel reinforcement embedded in the control specimens."
2. Add the following sentences to the end of Section 6.4 as: "Concrete shall be designed as structural lightweight concrete."

3. Add a new evaluation report recognition as: "For applications where computed deflections contain long-term deflections due to sustained loads, creep effects shall be considered based on creep test results."

ICC-ES evaluation reports issued on or after the effective date noted above, both new reports and conversions of legacy reports, must comply with this criteria if they fall within its scope.

If you have any questions, please contact Mahmut Ekenel, Ph.D., P.E., Staff Engineer, at (800) 423-6587, extension 3260. You may also reach us by e-mail at es@icc-es.org.

Yours very truly,

A handwritten signature in black ink, appearing to read "Kurt Stochlia". The signature is written in a cursive, flowing style.

Kurt Stochlia, P.E.
Vice President

KS/gh:raf

Enclosure

cc: Evaluation Committee

ACCEPTANCE CRITERIA FOR STRUCTURAL CONCRETE WITH LIGHTWEIGHT SYNTHETIC PARTICLES

AC408

Approved February 2009

Effective March 1, 2009

PREFACE

Evaluation reports issued by ICC Evaluation Service, Inc. (ICC-ES), are based upon performance features of the International family of codes and other widely adopted code families, including the Uniform Codes, the BOCA National Codes, and the SBCCI Standard Codes. Section 104.11 of the International Building Code® reads as follows:

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

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

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

ICC-ES may consider alternate criteria, provided the report applicant submits valid data demonstrating that the alternate criteria are at least equivalent to the criteria set forth in this document, and otherwise demonstrate compliance with the performance features of the codes. Notwithstanding that a product, material, or type or method of construction meets the requirements of the criteria set forth in this document, or that it can be demonstrated that valid alternate criteria are equivalent to the criteria in this document and otherwise demonstrate compliance with the performance features of the codes, ICC-ES retains the right to refuse to issue or renew an evaluation report, if the product, material, or type or method of construction is such that either unusual care with its installation or use must be exercised for satisfactory performance, or if malfunctioning is apt to cause unreasonable property damage or personal injury or sickness relative to the benefits to be achieved by the use of the product, material, or type or method of construction.

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

ACCEPTANCE CRITERIA FOR STRUCTURAL CONCRETE WITH LIGHTWEIGHT SYNTHETIC PARTICLES (AC408)

1.0 INTRODUCTION

1.1 Purpose: The purpose of this acceptance criteria is to establish requirements for structural concrete with lightweight synthetic particles to be recognized in an ICC Evaluation Service, Inc. (ICC-ES), evaluation report under the 2006 *International Building Code*[®] (IBC) and the 2006 *International Residential Code*[®] (IRC). Bases of recognition are IBC Section 104.11 and IRC Section R104.11. Applicable code sections are IBC Sections 1901.2 (Plain and Reinforced Concrete), 1909 (Structural Plain Concrete) and 1910 (Minimum Slab Provisions); and IRC Section R402.2 (Minimum Specified Compressive Strength of Concrete), and R506 [Concrete Floors (On Ground)].

The reason for the development of this criteria is to set requirements for evaluation of lightweight synthetic particles used in structural concrete, since the codes do not provide requirements for evaluation of such particles in structural concrete.

1.2 Scope: Lightweight synthetic particles are added to concrete as a partial replacement for conventional fine or coarse aggregate, to create a structural concrete while maintaining mechanical and durability characteristics as defined by the applicable codes. The concrete produced using these synthetic particles can be used as structural lightweight plain concrete and reinforced concrete provided the resulting concrete meets the design compressive strength and other specified engineering properties and durability requirements that are applicable. The lightweight synthetic particles can be used along with normal-weight concrete aggregates that comply with ASTM C 33 or lightweight aggregates that meet requirements of ASTM C 330.

1.2.1 Consideration shall be given to the minimum and maximum replacement volume, maximum size, gradation and density of synthetic particles used. Extrapolation to other volumes, sizes, densities, and types of synthetic particles is not allowed.

This criteria requires assessment of synthetic particle properties and effects on concrete mechanical and durability properties.

1.3 Codes and Referenced Standards:

1.3.1 2006 *International Building Code*[®], International Code Council.

1.3.2 2006 *International Residential Code*[®], International Code Council.

1.3.3 ASTM International:

1.3.3.1 ASTM C 33-03, Standard Specification for Concrete Aggregates.

1.3.3.2 ASTM C 39-05, Test Method for Compressive Strength of Cylindrical Concrete Specimens.

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

1.3.3.4 ASTM C 94/94M-04, Standard Specification for Ready-Mixed Concrete.

1.3.3.5 ASTM C 138/138M-01a, Standard Test Method for Unit Weight, Yield, and Air Content (Gravimetric) of Concrete.

1.3.3.6 ASTM C 172-04, Standard Practice for Sampling Freshly Mixed Concrete.

1.3.3.7 ASTM C 192-05, Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory, ASTM International.

1.3.3.8 ASTM C 234-91a, Standard Test Method for Comparing Concretes on the Basis of the Bond Developed with Reinforcing Steel.

1.3.3.9 ASTM C 330-04, Standard Specification for Lightweight Aggregates for Structural Concrete.

1.3.3.10 ASTM C 469^{e1}-02, Standard Test Method for Static Modulus of Elasticity and Poisson's Ratio of Concrete in Compression.

1.3.3.11 ASTM C 494/494M-05a, Standard Specification for Chemical Admixtures for Concrete.

1.3.3.12 ASTM C 496/496M-04, Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens.

1.3.3.13 ASTM C 567-05a, Standard Test Method for Determining Density of Structural Lightweight Concrete.

1.3.3.14 ASTM C 666/666M-03, Test Method for Resistance of Concrete to Rapid Freezing and Thawing.

1.3.3.15 ASTM C 1581-04, Standard Test Method for Determining Age at Cracking and Induced Tensile Stress Characteristics of Mortar and Concrete under Restrained Shrinkage.

1.3.3.16 ASTM E 119-00, Test Methods for Fire Tests of Building Construction Materials, ASTM International.

1.3.3.17 ASTM E 136-99^{e01}, Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750° C, ASTM International.

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

1.4 Definitions:

1.4.1 Lightweight Synthetic Particles: Expanded proprietary polystyrene spheres with closed-cell inner structure containing air. Maximum bead diameter shall be less than 0.25 inch (6.4 mm) and the bulk density shall be less than 20 lb/ft³ (320 kg/m³).

1.4.2 Structural Concrete: Structural concrete is defined in Section 2.2 of ACI 318-05.

2.0 BASIC INFORMATION

2.1 General: The following information shall be submitted:

2.1.1 Product Description: Complete information concerning material specifications, bulk density, maximum size, gradation and absorption characteristics.

ACCEPTANCE CRITERIA FOR STRUCTURAL CONCRETE WITH LIGHTWEIGHT SYNTHETIC PARTICLES (AC408)

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 the product and identifying it in the field. Identification provisions shall include the evaluation report number.

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

2.3 Test Reports: Test reports shall comply with AC85. Test reports shall include the following:

2.3.1 Description of type and source of lightweight synthetic particles.

2.3.2 Description of test procedure.

2.3.3 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 shall be given to the volume, maximum size, gradation and type of synthetic particles used. Extrapolation to other volumes, sizes and types of synthetic particles is not allowed. Recognition in evaluation reports of lightweight synthetic particles in concrete shall be divided into the following categories:

3.1.1 Recognition in structural plain concrete.

3.1.2 Recognition in reinforced concrete.

3.2 Test Requirements:

3.2.1 For recognition under Section 3.1.1.1, results of tests conducted in accordance with Sections 4.1 through 4.8, inclusive, are required. Reports of tests described in Sections 4.10 to 4.11 also may be submitted as optional information.

3.2.2 For recognition under Section 3.1.1.2, results of tests conducted in accordance with Sections 4.1 through 4.9, inclusive, are required. Reports of tests described in Sections 4.10 to 4.11 also may be submitted as optional information.

3.2.3 If results of tests conducted in accordance with Section 4.10 of this criteria are not submitted, recognition shall be limited to combustible construction.

3.2.4 If results of tests conducted in accordance with Section 4.11 of this criteria are not submitted, recognition shall be limited to non-fire-resistance rated construction.

4.0 TEST METHODS

4.1 Synthetic Particle Properties: The purpose of the test is to evaluate the maximum diameter, gradation, bulk density and water absorption of the synthetic particles. The test shall be conducted and results shall be provided in accordance with the standards shown in Table 1. Any necessary modifications to the ASTM standards shall be described in the test report.

4.2 Concrete Compressive Strength: The purpose of the test is to evaluate the compressive strength of

concrete with the addition of maximum replacement volumes of the synthetic particles to be recognized in the ICC-ES evaluation report.

4.2.1 Tests shall be conducted in accordance with ASTM C 39.

4.2.2 Tests shall be conducted on five specimens in concrete with synthetic particles.

4.2.3 Average compressive strength shall be reported in accordance with the applicable ASTM standard.

4.3 Equilibrium Concrete Density: The purpose of the test is to evaluate the equilibrium density of concrete with the addition of maximum replacement volume of the synthetic particles to be recognized in the ICC-ES evaluation report.

4.3.1 Tests shall be conducted in accordance with ASTM C 567.

4.3.2 Tests shall be conducted on three specimens in concrete with synthetic particles.

4.3.3 Average density shall be reported in accordance with applicable ASTM standard.

4.4 Concrete Flexural Strength: The purpose of the test is to evaluate **whether** the addition of lightweight synthetic particles to a concrete mixture adversely affects the flexural strength of the concrete.

4.4.1 Tests shall be conducted in accordance with ASTM C 78.

4.4.2 Sampling and conditioning shall comply with ASTM C 192 as referenced in Section 5 of ASTM C 78.

4.4.3 Tests shall be conducted on three specimens with maximum lightweight synthetic particle replacement volume in the concrete mixture.

4.4.4 Conditions of Acceptance: The average modulus of rupture of the three specimens with lightweight synthetic particles shall be at least equal to $7.5\sqrt{f_c}$, where f_c is the measured compressive strength of the concrete with lightweight synthetic particles at 28 days in accordance with ASTM C 39.

4.5 Concrete Splitting Tensile Strength: The purpose of the test is to evaluate whether the addition of lightweight synthetic particles to a concrete mixture adversely affects the tensile strength of the concrete.

4.5.1 Tests shall be conducted in accordance with ASTM C 496.

4.5.2 Sampling and conditioning shall comply with ASTM C 192 as referenced in Section 6 of ASTM C 496.

4.5.3 Tests shall be conducted on three specimens with maximum lightweight synthetic particle replacement volume in the concrete mixture.

4.5.4 Conditions of Acceptance: The average splitting tensile strength of the three specimens with lightweight synthetic particles shall be at least equal to $6.7\sqrt{f_c}$, where f_c is the measured compressive strength of the concrete with lightweight synthetic particles at 28 days in accordance with ASTM C 39.

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4.6 Concrete Modulus of Elasticity: The purpose of the test is to evaluate whether the addition of lightweight synthetic particles to a concrete mixture adversely affects the modulus of elasticity of the concrete.

4.6.1 Tests shall be conducted in accordance with ASTM C 469.

4.6.2 Sampling and conditioning shall comply with ASTM C 192 as referenced in Section 5 of ASTM C 469.

4.6.3 Tests shall be conducted on three specimens with maximum replacement volume of synthetic particles in the concrete mixture.

4.6.4 Conditions of Acceptance: The average modulus of elasticity of the three specimens shall be at least equal to $w_c^{1.5} 33\sqrt{f_c}$, where f_c is the measured compressive strength of the concrete with lightweight synthetic particles at 28 days in accordance with ASTM C 39, and w_c is the unit weight of the concrete measured according to ASTM C 138.

4.7 Restrained Shrinkage Cracking: The purpose of the test is to show that concrete with lightweight synthetic particles will maintain the same crack resistance as concrete without lightweight synthetic particles.

4.7.1 Comparative tests shall be conducted in accordance with ASTM C 1581.

4.7.2 Sampling and conditioning shall comply with ASTM C 192, where applicable.

4.7.3 Tests shall be conducted on three specimens with maximum lightweight synthetic particle replacement volume in the concrete mixture, and three specimens without lightweight synthetic particles (control). The control mixture shall be a concrete of equal water-to-cementitious ratio and equal cementitious material composition and content (by volume) to the mixture with lightweight synthetic particles.

4.7.4 Conditions of Acceptance: The age of cracking of the three specimens with lightweight synthetic particles shall be at least equal to the average cracking of the control specimens.

4.8 Freezing and Thawing Durability: The purpose of the test is to evaluate whether the addition of lightweight synthetic particles to a concrete mixture adversely affects the freezing and thawing durability of the concrete.

4.8.1 Tests shall be conducted in accordance with Procedure A of ASTM C 666.

4.8.2 Tests shall be conducted on three concrete specimens with maximum lightweight synthetic particle replacement volume in concrete.

4.8.3 Conditions of Acceptance: The Durability Factor (DF) of each of the three specimens containing maximum volume of lightweight synthetic particles must be calculated in accordance with ASTM C 666 and shall be at least 80 percent at 300 cycles.

4.9 Effect on Reinforcement Bond Strength: The purpose of the test is to determine whether the addition of lightweight synthetic particles to a concrete mixture adversely affects the bond strength between the reinforcement and concrete.

4.9.1 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.

4.9.2 Tests shall be conducted on three concrete specimens with maximum value of lightweight synthetic particles and three specimens without lightweight synthetic particles (control). The control concrete shall be a mixture of equivalent compressive strength, as measured by ASTM C 39, when compared to the mixture containing lightweight synthetic particles.

4.9.3 Conditions of Acceptance: The average bond strength for the steel reinforcement embedded in the concrete with the lightweight synthetic particles shall be at least equal to, or better than, the average bond strength for the steel reinforcement embedded in the control specimens.

4.10 Noncombustible Building Material (Optional): The purpose of this test is to demonstrate that concrete with lightweight synthetic particles may be considered a noncombustible building material.

4.10.1 For use in Type I, II, III, or IV construction, the concrete with lightweight synthetic particles shall be tested in accordance with ASTM E 136 using the maximum volume of lightweight synthetic particles.

4.10.2 Conditions of Acceptance: The specimens of concrete with lightweight synthetic particles shall satisfy the requirements set forth in Section 703.4 of the IBC.

4.11 Fire-resistance-rated Construction Test (Optional): The purpose of the test is to determine the fire resistance ratings of the lightweight synthetic particles in a concrete mixture.

4.11.1 Testing shall be conducted in accordance with ASTM E 119.

4.11.2 Conditions of Acceptance: The conditions of acceptance shall comply with ASTM E 119. The fire resistance rating and the construction of the assembly shall be detailed in the evaluation report. Lesser volumes of lightweight synthetic particles than the volume tested shall be considered to have the same fire-resistance rating as the tested assembly.

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 required for synthetic particles under this acceptance criteria. The inspections shall be conducted by an inspection agency accredited by the International Accreditation Service or otherwise acceptable to ICC-ES.

6.0 EVALUATION REPORT RECOGNITION

6.1 If the applicant for an evaluation report purchases the lightweight synthetic particles from a manufacturer, evidence is needed of an agreement between the manufacturer and the applicant indicating that the manufacturer will inform the applicant of any changes to the particles. The applicant shall then notify ICC-ES.

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6.2 The evaluation report shall include a condition that use of the lightweight synthetic particles must be approved by the project engineer or architect.

6.3 In addition to the items noted in Section 16.1 of ASTM C 94, the delivery ticket from a ready-mix plant shall include the type and amount of lightweight synthetic particles added to the concrete mixture.

6.4 The evaluation report shall state that plain or reinforced concrete systems must be designed in accordance with the provisions of Chapter 16 and 19 of the IBC, and ACI 318-05. Concrete shall be designed as structural lightweight concrete.

6.5 The evaluation report shall state that, for applications where computed deflections contain long-term deflections due to sustained loads, creep effects shall be considered based on creep test results.

6.6 When supported by results of investigation, the evaluation report shall state the need for special or modified tests to measure the properties of fresh concrete.

6.7 The evaluation report holder shall disclose to the design professional the amount of water-soluble chloride in the synthetic particles. ■

TABLE 1– REFERENCE TEST METHODS

PRODUCT ATTRIBUTE	REFERENCE TEST METHOD
Maximum diameter	ASTM C 136-06
Gradation	ASTM C 136-06
Bulk density	ASTM C 29-07
Absorption	ASTM C 128-07a