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ACCEPTANCE CRITERIA FOR WALL AND ROOF SYSTEMS WITH FOAMED-CEMENT (Proprietary)

AC117

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PREFACE

Evaluation reports issued by the ICBO Evaluation Service, Inc. (ICBO ES), are based upon performance features of the *Uniform Building Code*[™], *ICBO Uniform Mechanical Code*[™] and related codes. Section 104.2.8 of the Uniform Building Code is the primary charging section upon which evaluation reports are issued. Section 104.2.8 reads as follows:

The provisions of this code are not intended to prevent the use of any material, alternate design or method of construction not specifically prescribed by this code, provided any alternate has been approved and its use authorized by the building official.

The building official may approve any such alternate, provided the building official finds that the proposed design is satisfactory and complies with 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 suitability, strength, effectiveness, fire resistance, durability, safety and sanitation.

The building official shall require that sufficient evidence or proof be submitted to substantiate any claims that may be made regarding its use. The details of any action granting approval of an alternate shall be recorded and entered in the files of the code enforcement agency.

The attached acceptance criteria for the general code sections noted have been issued to provide all interested parties with guidelines on implementing performance features of the codes. The attached acceptance criteria were developed and adopted following public hearings conducted by the Evaluation Committee. These criteria may be revised from time to time as the need dictates.

ICBO ES may consider alternate criteria, provided the proponent submits valid data demonstrating that the alternate criteria are at least equivalent to the attached criteria and otherwise meet the applicable performance requirements of the codes. Notwithstanding that a material, type or method of construction, or equipment, meets the attached acceptance criteria, or it can be demonstrated that valid alternate criteria are equivalent and otherwise meet the applicable performance requirements of the codes, if the material, product, system or equipment 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 thereof, ICBO ES retains the right to refuse to issue or renew an evaluation report.

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1. INTRODUCTION

1.1 Scope: The purpose of this criteria is to establish requirements for recognition of roof systems and bearing and nonbearing wall systems with foamed-cement in ICBO Evaluation Service, Inc. (ICBO ES), evaluation reports under the Uniform Building Code. This criteria is applicable to the following:

1.1.1 Wall and roof systems consisting of light gage steel framing with field-cast foamed-cement.

1.1.2 Prefabricated wall and roof panels of light gage steel framing and foamed-cement.

1.1.3 Blocks of foamed-cement precast in an approved fabricator's facility, and assembled at the jobsite with light gage steel wall framing.

1.2 General: Foamed-cement is a substrate for exterior and interior finishes, and distributes out-of-plane loads to the steel framing. The steel framing must be designed in accordance with the code for all design loads. The maximum wall stud and roof joist spacings are 48 and 24 inches on center, respectively. Lateral loads in the plane of the roof and wall must be addressed in the design of each structure, considering the foamed-cement as a nonstructural element. Steel straps are typically designed and installed to resist the lateral loads in the plane of the roof and wall.

The steel framing is embedded in the foamed-cement, with foamed-cement coverage of the steel framing on both faces of the wall and roof systems. The maximum and minimum wall thicknesses are 12 and 4 inches, respectively. The maximum and minimum roof thicknesses are 16 and 8 inches, respectively.

Exterior surfaces of walls are covered with the base coat, nonmetallic reinforcing fabric and finish coat of a direct-applied exterior finish system (DEFS). Interior wall surfaces are covered with full surface of $1/16$ -inch-thick joint compound, complying with ASTM C 475, over the base coat and nonmetallic reinforcing fabric of a DEFS. See Sections 5.6 and 5.7 of this criteria for related requirements.

A layer of welded wire lath, complying with ASTM A 185 and secured to both faces of the steel roof joists, is embedded in the foamed-cement. The interior face of roofs is finished in the same manner as described for the interior wall finish. The exterior face of roofs is finished with an adhered membrane roof covering. See Sections 5.7 and 5.8 for related requirements.

2. DEFINITIONS

2.1 AIR ENTRAINING AGENT: A proprietary liquid used as a component to cause the foamed-cement to be cellular in composition.

2.2 HARDENING AGENT: A proprietary liquid used as a component to harden the foamed-cement.

2.3 THICKENER: A proprietary thickener powder used as a component to thicken the mixture of foamed-cement.

2.4 FOAMED-CEMENT: Air entraining agent, hardening agent and thickener mixed in a special paddle mixer with water and Type I/II or Type II portland cement complying with U.B.C. Standard 19-1. The resulting mix is poured into forms and allowed to cure as required for concrete. Cured foamed-cement has an oven dry density of 35 ± 5 pcf and a minimum 28-day compressive strength of 150 psi.

3. BASIC INFORMATION

The following basic information needs to be furnished:

3.1 Air Entraining, Hardening and Thickening Agents Product Descriptions: Description of materials, including weight, packaging, labeling and shelf life.

3.2 Mixing, Pouring and Curing Instructions: Instructions pertinent to the mixing, pouring and curing of the foamed-cement, including dosage rates, methods of mixing, reinforcement placement and form work dimension limitations.

3.3 Installation Instructions: Instructions pertinent to installation and connections involving the foamed-cement walls and roofs. Joint treatment, flashing and methods of installing the interior and exterior finish must also be included.

3.4 Precast blocks and prefabricated roof and wall panel labeling.

4. TESTING AND REPORTING

4.1 Samples: Test specimens must be prepared using products that are of standard manufacture and representative of products for which recognition is sought. The test laboratory shall obtain random samples from the manufacturer's facility of the air entraining, hardening and thickening agents to be used in tests, or shall purchase the product from the open market. The test laboratory shall witness production of the precast foam-cement blocks and prefabricated roof and floor panels used in the tests.

4.2 Testing Laboratory: All tests must be conducted by an ICBO ES recognized independent testing laboratory at the testing laboratory facility. A qualified representative of the testing laboratory must witness preparation of, or prepare, specimens and conduct the tests.

4.3 Test Reports: Test reports must be prepared by an independent testing laboratory and must comply with the ICBO ES Acceptance Criteria for Test Reports (AC85).

5. REQUIRED DATA

5.1 Physical Property Tests: Physical property tests in Section 6.1 must be performed on each batch of foamed-cement used to prepare test specimens for the structural tests in Sections 5.2 and 5.3. The oven dry density tests of Section 6.1 must be performed on the foamed-cement used to prepare the specimens for the tests in Sections 5.4 through 5.8. The oven dry density of the foamed-cement used to prepare the specimens for all tests shall not exceed 32 pcf, except the bond test specimens subjected to the freeze-thaw testing associated with Section 5.6.2 shall have a density of 35 pcf plus or minus 1 pcf.

5.2 Transverse Load Tests: Transverse load tests must be conducted in accordance with Section 6.2 of this criteria, to evaluate the foamed-cement distributing out-of-plane loads to the steel framing. The allowable service load of each test series shall be the lesser of the following:

5.2.1 Average ultimate load divided by a safety factor of 3, provided each test result does not vary by more than 15 percent from the average of the series, or the lowest test result divided by 3.

5.2.2 Average load at tested out-of-plane deflection of $L/240$ of the span, where L is the framing spacing.

5.2.3 Average load recorded at first cracking or spalling of specimens.

5.3 Concentrated Load Tests: The foamed-cement of roofs must be capable of supporting and distributing a 300-pound concentrated load to the supporting roof framing. The concentrated load must be applied to at least three specimens of each roof thickness with a 3-inch diameter disc in accordance with ASTM E 661-88.

5.4 Durability of Foamed-Cement:

5.4.1 Physical Properties: All physical property tests of Section III A 1 of AC59 must be addressed.

5.4.2 Drying Shrinkage:

5.4.2.1 General: Shrinkage tests shall be conducted according to Section 6.4.

5.4.2.2 Conditions of Acceptance: Average drying shrinkage of three specimens must not exceed 0.20 percent.

5.5 Weather-resistive Considerations: A weather-resistive barrier complying with Section 1402.1 of the code is required, or the water penetration tests of Section 6.5 shall be conducted with the condition of acceptance being no dampness on the unexposed side of any test assembly.

5.6 Exterior Wall Finish: The direct-applied exterior finish (DEFS) components on the exterior face of walls must be recognized in an ICBO ES or NES evaluation report as complying with the ICBO ES Acceptance Criteria for Direct-applied Exterior Finish Systems (AC59). Also, the following must be addressed:

5.6.1 The proponent of the DEFS must acknowledge and concur with the use of DEFS components with the wall and roof systems using foamed-cement.

5.6.2 Sections IV B 3, IV C 2, V E, V F 2 and V F 3 of AC59 must be addressed with foamed-cement used as the substrate.

5.7 Interior Finish: Interior finish of wall and roof must have flame-spread and smoke-development ratings as specified in Section 804.1 of the code when tested under U.B.C. Standard 8-1. To determine the effect of thickness on flame-spread and smoke-development, an analysis of tests conducted on 1- and 5-inch-thick foamed-cement test specimens shall be prepared by the testing laboratory, extending the results of tests to the maximum foamed-cement thickness under consideration. The oven dry density of the foamed-cement must be recorded.

5.8 Roof Covering System: The roof covering system shall consist of a membrane adhered directly to the foamed-cement of the roof. The membrane must be recognized in an ICBO ES or NES evaluation report as complying with the ICBO ES Acceptance Criteria for Membrane Roof-covering Systems (AC75). The following must be addressed:

5.8.1 The proponent of the membrane roof covering must acknowledge and concur with the use of the roof covering applied to foamed-cement.

5.8.1.1 The roof classification requirements of Section 4.4 of AC75 must be addressed with foamed-cement as the substrate.

5.8.1.2 Bond tests shall be conducted to test the tensile bond strength between the roof covering and the foamed-cement. A minimum of five specimens shall be tested in accordance with ASTM C 209. All five specimens shall demonstrate a cohesive failure in the foamed-cement.

5.9 Noncombustible Construction: The system can be recognized for application to walls required to be of noncombustible construction, provided compliance is established with Section 215 of the code.

5.10 Quality Control: Quality control manuals must be developed for the manufacture of the air entraining, hardening and thickening agents, precast foamed cement blocks and prefabricated roof and wall panels. The manuals must be developed in consultation with an ICBO ES or NES recognized quality control agency responsible for follow-up inspections. The manuals must comply with the ICBO ES Acceptance Criteria for Quality Control Manuals (AC10), and must include mix ratios and method of mixing and pouring the foamed-cement.

5.11 Field Inspection Manual: A manual shall be submitted that contains the jobsite construction procedures and testing requirements for installation of field-cast foamed-cement. A copy of this manual shall be available at the jobsite at all times during construction. As a minimum, the manual must include the following:

5.11.1 Title and date.

5.11.1.1 Shelf-life information on air entraining, hardening and thickening agents.

5.11.1.2 Description of field tests to verify quality of air entraining and hardening agents prior to use.

5.11.1.3 Method of placing, supporting and tying steel framing into position.

5.11.1.4 Description and conditions of acceptance of field tests of foamed-cement mix, i.e., air content, wet density and pH of water.

5.11.1.5 Mix ratio and method of mixing and pouring foamed-cement mix.

5.11.1.6 Method of preparing specimens for laboratory tests of foamed-cement.

5.11.1.7 Laboratory test procedures and conditions of acceptance for physical property test of Section 5.1 of this criteria.

5.11.1.8 Curing instructions.

5.11.1.9 Special-inspector instructions.

5.12 Fabricators of Precast Foamed-cement Blocks and Prefabricated Roof and Wall Panels: Each fabricator manufacturing precast foamed-cement blocks and prefabricated roof and wall panels must be recognized by ICBO ES in an evaluation report. Technical data required for each fabricator must include a quality control manual as noted in Section 5.10 and a report of physical property tests as indicated in Table 1 of this criteria. The conditions of acceptance of the test results are that the compressive stress, tensile strength, modulus of elasticity and flexural strength shall be equal to or greater than the corresponding results of tests submitted under Section 5.1 as qualifying test data. The oven dry density must be 35 ± 5 pcf, and the water absorption must be equal to or less than the results of qualifying tests submitted under Section 5.1.

6. TEST PROCEDURES

6.1 Physical Property Tests: The physical property tests are to be conducted in accordance with the corresponding test method noted in Table 1.

6.2 Transverse Load Tests:

6.2.1 Recognition of foamed-cement walls and roofs is limited to materials and sizes used in tests. Sizes recognized shall not exceed the limitations noted in Section 1.1.

6.2.2 Voids for electrical outlet boxes and raceways are permitted, provided they are included in test specimens.

6.2.3 At least six specimens for each wall thickness using precast foamed-cement blocks, and six specimens of each roof thickness, must be prepared in accordance with the proponent's written mixing, pouring, curing and installation instructions. Specimens must be prepared with verification by the testing agency or its representative. Specimens shall be a minimum of 4 feet square and constructed to test the foamed-cement spanning between the framing members.

6.2.4 Test assembly may be mounted horizontally or vertically to facilitate application of loads. Studs or joists supporting the foamed-cement must be located at the maximum spacing for which recognition is desired. In most instances, this will result in double 24-inch spans for roofs and a single 48-inch span for walls. The ICBO ES staff shall be contacted in the event the spans vary from this. Connections to framing members shall be based on minimum conditions, since the test assembly establishes the basis of acceptance. Care must be taken to avoid connections to members that are parallel to the span where the height-to-width ratio of the wall specimen is less than 2:1.

6.2.5 Three tests each are required for positive and negative loadings. Tests are conducted in accordance with ASTM E 330 Method B, with load application after 30 psf (positive or negative) in increments not exceeding 15 psf, maintained for a minimum of 30 seconds before proceeding to the next increment. Tests must be completed within 45 days of specimen construction.

6.2.6 In addition to data required by the ICBO ES Acceptance Criteria for Test Reports, the following must be reported:

6.2.6.1 Load-deflection readings.

6.2.6.2 Compressive strength at time of transverse load tests.

6.2.7 Where tests are not conducted to failure, the highest load achieved for each test will be assumed as ultimate.

6.2.8 Three physical property compression test specimens shall be tested for each test series in accordance with Section 6.1. These tests shall occur within 48 hours of transverse load tests, for correlation of material properties to transverse load test results. In addition, specific gravity tests shall be conducted on the cured material used to prepare structural test specimens.

6.3 Freeze-thaw: A total of six specimens are cut from the transverse load test assemblies. Sample size shall be the panel thickness by 6 inches by 6 inches.

The test is to be conducted according to ASTM C 67. The exterior surface is to be placed in the 1/2-inch water depth. The cycle of freeze-thaw shall be repeated for 50 cycles. After completing the 50th cycle, the specimens are oven-dried and the dry weight is recorded.

6.4 Drying Shrinkage: Drying shrinkage tests are conducted according to ASTM C 341. Three specimens are cut from the transverse load test assemblies. As an alternate, three specimens are cast without reinforcement from the same batch of foamed-cement used to produce the structural panel test assembly. The specimens shall be 2 inches by 2 inches in cross section and of sufficient length to provide a minimum 10-inch gage length. After curing, all specimens are conditioned by immersion in water at $75 \pm 3^\circ\text{F}$. for 48 hours. Length measurement shall be conducted within five minutes of removal from water.

6.5 Water-penetration Test: The water-penetration test shall be conducted on at least six specimens in accordance with ASTM E 514, with exceptions noted herein. Three samples shall be prefabricated wall panels with an untreated vertical joint, and three specimens shall consist of precast blocks of foamed-cement and steel without wall coverings and without joint treatment unless the durability of the joint treatment is addressed. The thickness of specimens shall represent the minimum wall thickness. Specimen age shall be a minimum of 28 days, with curing according to manufacturer's instructions. The duration of the test is four hours, with water applied at a rate of 5 gallons per square foot per hour. The chamber pressure shall be 2.86 psf. The condition of the specimen shall be recorded every 30 minutes for the first two hours, and every hour thereafter. Oven dry density tests shall be conducted on cured material used to prepare the water-penetration test specimens.

7. MISCELLANEOUS

7.1 Special inspection according to Section 1701 of the code and the Field Inspection Manual of Section 5.11 of this criteria, is required for field-cast applications of foamed-cement.

7.2 Plans, details and specifications concerning proper installation of the system that are applicable to specific buildings under consideration, must be a part of plans submitted to the building department for approval.

7.3 Foamed-cement walls shall not be exposed to sulfate-containing solutions or soils.

7.4 Foamed-cement shall be protected from free water until covered with exterior finish.

TABLE 1—PHYSICAL PROPERTY TESTS

ITEM NO.	PROPERTY	NO. OF SPECIMENS	TEST METHOD
1	Compressive stress ¹	4 ²	ASTM C 495 or C 513
2	Oven dry density	5	ASTM C 642
3	Water absorption	5	ASTM C 642
4	Tensile strength perpendicular to surface	5	ASTM C 209
5	Modulus of elasticity	5	ASTM C 469-87a
6	Flexural strength	5 ³	ASTM C 78

¹Wet density and air content tests shall be conducted of the batch of foamed-cement used to produce the compression test specimens. The method used to determine the wet density shall be reported. Air content tests shall conform to ASTM C 796.

²Determine compressive stress with 3-inch-diameter-by-6-inch cylinder specimens, according to ASTM C 39.

³Determine flexural strength with a test span of minimum 12 times the depth and for a test span of 5 times the specimen depth maximum. Five specimens are required for each condition.