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Guide Specification for

Structural Lightweight Concrete

Section 03313

This guide specification supplements the architect/engineer□s standard concrete specifications for structural lightweight concrete. Boxed comments precede or follow each specification section and should be deleted from the final specification.

PART I. □ GENERAL

1.1 Reference Standards

> This guide specification follows the 16 Division Format of the Construction Specification Institute□s, Section 03313 Concrete.
>
> The enclosed text and commentary are intended to assist the architect/engineer write specifications that include appropriate limits so that quality structural lightweight concrete can be provided economically.
>
> Reference Standards are incorporated in this guide specification and an appendix lists additional publications that will help the architect/engineer/designer prepare concrete specifications. ASTM publication *STP 169 C* provides a comprehensive overview of structural lightweight concrete.

American Society for Testing & Materials (ASTM)

- C 31 *Practice for Making and Curing Concrete Test Specimens in the Field*
- C 33 *Specification for Concrete Aggregates*
- C 39 *Test Method for Compressive Strength of Cylindrical Concrete Specimens*
- C 94 *Specification for Ready-Mix Concrete*
- C 127 *Test Method for Specific Gravity and Absorption of Coarse Aggregates*
- C 138 *Test Method for Unit Weight, Yield, and Air Content (Gravimetric) of Concrete*
- C 143 *Test Method for Slump of Hydraulic Cement Concrete*
- C 150 *Specification for Portland Cement*
- C 172 *Practice for Sampling Freshly Mixed Concrete*
- C 173 *Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method*
- C 260 *Specification for Air-Entraining Admixtures for Concrete*
- C 330 *Specification for Lightweight Aggregates for Structural Concrete*
- C 494 *Specification for Chemical Admixtures for Concrete*
- C 567 *Test Method for Density of Structural Lightweight Concrete*
- C 595 *Specification for Blended Hydraulic Cements*
- C 618 *Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete*
- C 845 *Specification for Expansive Hydraulic Cement*
- C 989 *Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars*
- C 1017 *Specification for Chemical Admixtures for Use in Producing Flowing Concrete*
- C 1240 *Specification for Use of Silica Fume as A Mineral Admixture in Hydraulic-Cement Concrete, Mortar, and Grout*

American Concrete Institute (ACI)

- ACI 211.2 *Standard Practice for Selecting Proportions for Structural Lightweight Concrete*
- ACI 301 *Specifications for Structural Concrete for Buildings*
- ACI 304.2 *Placing Concrete by Pumping Methods*
- ACI 318 *Building Code Requirements for Reinforced Concrete*

1.2 Performance

Except as modified or exceeded by these specifications, all cast-in-place structural lightweight concrete work shall conform to ACI 301.

1.3 Storage of Materials

Cement: Store in accordance with ACI 318.

Aggregates: Each grading and type shall be stockpiled separately. Storage shall minimize segregation and prevent contamination.

PART II □ PRODUCTS

2.1 Materials

Cement: Shall meet ASTM C 150, C 595, or C 845

The effect and compatibility of various combinations of cement, pozzolans, and admixtures are generally the same in ESCS lightweight concrete as in normalweight concrete.

Aggregate: Expanded Shale, Clay, or Slate (ESCS) lightweight aggregate produced by the rotary kiln method shall meet ASTM C 330. Normalweight aggregate shall meet ASTM C 33.

Expanded Shale, Clay, and Slate (ESCS) is a unique ceramic lightweight aggregate prepared by expanding select minerals in a rotary kiln at temperatures of 1000ºC.

Water: Shall meet ACI 318.

Air-Entraining Admixtures: Shall meet ASTM C 260.

Admixtures have demonstrated satisfactory performance with ESCS concretes. Consult the ESCS producer for information on admixture performance and recommendations, especially if the concrete is to be pumped.

Chemical Admixtures: Set-controlling and water-reducing admixtures shall meet ASTM C 494 and the manufacturer□s recommendations.

Fly Ash: Shall meet ASTM C 618.

Ground Granulated Blast-Furnace Slag: Shall meet ASTM C 989.

Silica Fume: Shall meet ASTM C 1240.

2.2 Concrete Properties

Repeat this section if the design requires more than one type of concrete. ACI 211.2 provides guidance for proportioning mixtures.

Strength: Materials shall be proportioned to produce concrete with a minimum compressive strength _____psi (_____MPa) at 28 days.

ESCS aggregate has been used in lightweight concrete for practically every type of structural application. It has been furnished at all compressive strength levels common to construction practices today.

Density: Materials shall be proportioned to produce concrete with a calculated equilibrium density of _____lb/ft³ ± 3 lb/ft³ (_____kg/m³) as determined by ASTM C 567-00, Section 9.2.

ASTM C 567-00 fundamentally revised 567-91 and replaced deprecated term □Unit Weight□ with metric □Density□, and replaced □Air-dry□ with □Equilibrium□.

ASTM C 567-00, Section 3.2.1 defines equilibrium density as the density reached by structural lightweight concrete after exposure to relative humidity of 50 ± 5% and a temperature of 73.4 ± 3ºF (23 ± 1.7ºC) for a period of time sufficient to reach a density that has an insignificant further decrease over time.

The equilibrium density of ESCS concrete may be customized over a wide density range from 80 to 135 lb/ft³ (1280 to 2160 kg/m³) to meet the designer□s application. A wide range of strength-density combinations may be specified based upon the recommendations of technical service available from the ESCS manufacturer.

Equilibrium density will be approximately 5 to 10 lb/ft³ less than the fresh density, (approximately 3 lb/ft³ greater than oven dry density) depending on the mixture proportions, and as batched moisture content of the aggregate.

The Calculated Equilibrium Density (ASTM C 567-00, Section 9.2) provides a rapid method

for calculating the equilibrium density using batch weights, aggregate moisture content, and concrete yield.

Slump: Concrete shall be delivered at the minimum slump necessary for efficient mixing, placing, and finishing. The maximum slump shall be _____in. (_____mm) with a tolerance of ± _____in. (_____mm). Consult ASTM C 94 for guidance on tolerances.

The architect/engineer should require that the mixture be designed for the specified compressive strength and equilibrium density with a slump that will enable the concrete to be placed and finished efficiently and economically. This slump should be specified. If the concrete will be placed by pumping (See Section 3.1), certain considerations such as prewetting of lightweight aggregates, use of admixtures, and minimum cement content may be necessary. The lightweight aggregate producer can supply the architect/engineer with a recommended mixture for special placing conditions. The workability of structural lightweight concrete is comparable to that of normalweight concrete having 1 to 2 in. (25 to 50 mm) greater slump.

Air: The air content shall be _____ percent by volume with a tolerance of ± 1.5 percent.

Air entrainment in structural lightweight concrete, as in normalweight concrete, improves durability and workability, and reduces bleeding. For durability, air content shall meet the recommendations of ACI 211.2. For workability, 4 to 7 percent is generally satisfactory depending on nominal aggregate size. The architect/engineer should specify the air content appropriate for the most economical mixture for the specific application.

Mixture Proportions: The contractor shall furnish the mixture proportions that will meet the strength and fresh and equilibrium density requirements of the concrete specified. The mixture proportion shall be prepared in accordance with ACI 318, and subject to the approval of the architect/engineer.

In establishing batch proportions, the trial mixture should produce concrete with an average compressive strength higher than that specified. Trial mixture procedures are outlined in ACI 211.2 *Standard Practice for Selecting Proportions for Structural Lightweight Concrete.* The degree of over-design required depends on variability of test results. (See ACI 318, *Building Code Requirements for Reinforced Concrete)* the architect/engineer can obtain from the lightweight aggregate producer recommendations for cement content, mixture proportions, slump, air content that will provide the desired strength, fresh and equilibrium densities, and finishing qualities of the concrete.

Batching and Mixing: The concrete shall be batched and mixed in accordance with the applicable section of ACI 301 and ASTM C 94.

The concrete producer□s quality control personnel or a qualified laboratory should establish and maintain the mixture proportions based on the aggregate producer□s recommendation. With this approach, the variations that exist in batching concrete will be minimized. ASTM STC 169 C also offers guidance in this regard.

PART III □ FIELD CONTROL

3.1 Control: The control of the concrete shall be under the supervision of the architect/engineer. Field-testing shall be performed by an ACI Certified Field Technician.

Fresh Density: The concrete shall have a maximum fresh density of _____lb/ft³ (_____kg/m³).

Unless long-term density measurements are made on the mixture proposed for the project (ASTM 567), the maximum allowable fresh density will be equal to the sum of the specified equilibrium density and the density loss due to drying. The density loss due to drying is dependent on mixture proportions and the moisture absorbtion of the aggregates. Contact the lightweight aggregate supplier for details.

Pumping: If the concrete is to be pumped, follow the recommendations of ESCSI information sheet

4770.1, *Pumping Structural Lightweight Concrete – The Team Approach* and ACI 304.2R.

Sampling: Samples of concrete shall be obtained in accordance with ASTM C 172 and shall be transported to a place on the site where tests can be made and cylinders stored without being disturbed for the first 24 hours. If the concrete is placed by pumping, samples shall be obtained from the end of the pump discharge line.

Pumping may result in the reduction of slump and/or air content. Therefore, the concrete mixture should be proportioned to provide the desired fresh concrete properties at the point of placement.

Concrete Specimens: Compressive strength specimens shall be made in accordance with ASTM C 31 and tested in accordance with ASTM C 39. Density, slump, and air content of fresh concrete shall be determined form each batch of concrete sampled for compressive strength tests. Fresh density, slump, and air content shall be determined by ASTM C 138, C 143, and C 173 respectively.

The density, slump, and air content determinations at specified intervals enable the architect/engineer to maintain uniformity in the concrete mixture. As long as there is no appreciable change in the density (i.e., not more than 3 lb/ft³ [48 kg/m³] variation from the established fresh density), there is reasonable certainty that the correct proportions are being batched. Variations greater than 3 lb/ft³ (48 kg/m³) indicate that some change has taken place in air content, moisture or density of aggregate, or batch weights, thereby resulting in a variation of yield. When this occurs, adjustments in the mix should be made.

APPENDIX: The following publications will assist the architect/engineer when preparing structural lightweight aggregate concrete specifications.

ACI 212.3R *Chemical Admixtures for Concrete*
ACI 213R *Guide for Structural Lightweight Aggregate Concrete*
ACI 216R *Guide for Determining the Fire Endurance of Concrete Elements*
ACI 304R *Guide for Measuring, Mixing, Transporting and Placing Concrete*
ACI 304.5R *Batching, Mixing, and Job Control of Lightweight Concrete*
ACI 305R *Hot Weather Concreting*
ACI 306R *Cold Weather Concreting*
ACI 311.1R *ACI Manual of Concrete Inspection*
ACI 311.4R *Guide for Concrete Inspection*
ACI 347R *Guide to Formwork for Concrete*
ASTM STP 169 C Significance *of Tests and Properties of Concrete and Concrete-Making Materials,* Chapter 48, *Lightweight Concrete and Aggregates*.

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