LABORATORY EVALUATION OF
NORLITE AND SOLITE LIGHTWEIGHT AGGREGATE
CONCRETE MIXTURES

REPORT 81-8
DECEMBER 1981

Reporting on Work Plans 78-C&R-21
and 78-C&R-34

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION

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R. F. NICHOLSON, P.E., MATERIALS & RESEARCH ENGINEER
P. A. COVER, P.E., STRUCTURAL CONCRETE ENGINEER

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Structural Concrete Subdivision

Reviewed By:
R. F. Nicholson, P.E.
Materials & Research Engineer

Date: Sept. 9, 1982
"The information contained in this report was compiled for the use of the Vermont Agency of Transportation. Conclusions and recommendations contained herein are based upon the research data obtained and the expertise of the researchers, and are not necessarily to be construed as Agency policy. This report does not constitute a standard, specification, or regulation. The Vermont Agency of Transportation assumes no liability for its contents or the use thereof."
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<td>Proposed Specifications for Structural Lightweight Concrete &amp; Lightweight Coarse Aggregate for Structural Concrete (Transmitted to Structures Division by Memo Dated January 12, 1979)</td>
<td></td>
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</table>
ABSTRACT

Two lightweight coarse aggregates were examined and compared with a normal weight dolomite coarse aggregate. Concrete mixes were prepared and tests performed in the laboratory to provide information for design, specification and construction purposes.
INTRODUCTION

Concrete bridge barrier curbs were planned for use on the Milton - Colchester F028-1(3) project. Structural lightweight concrete was proposed for these curbs to reduce the dead load carried by the exterior beams of the bridge. This investigation of lightweight aggregate was initiated at the request of the Structures Division to provide information for design, specification and construction purposes.

Samples of structural lightweight aggregate were obtained from two manufacturers. The aggregates were tested for compliance with the Standard Specifications for Highway and Bridge Construction and concrete mixes were designed and prepared in the laboratory.

Results of tests performed on concretes containing the lightweight aggregates were compared with results obtained using a dolomite normal weight aggregate. Freeze-thaw durability, compressive and bond strengths, resistance to chloride intrusion and unit weight were examined for all concretes. Sample sections of curb were cast, using the lightweight concretes to determine how variations in slump would affect the surface texture of the finished product.
MATERIALS

Following are listed the materials used in this investigation and their sources: (See Table 1 and Table 2 for aggregate test data.)

COARSE AGGREGATES:

Reference Aggregate:

3/4" Crushed Dolomite
F. W. Whitcomb
Winooski, Vermont

Lightweight Aggregates:

3/4" Expanded Shale (Norlite)
Norlite Corporation
Cohoes, New York

3/4" Expanded Slate (Solite)
Hudson Valley Lightweight Aggregate Corp.
West New York, New Jersey

FINE AGGREGATE:

S. T. Griswold
Williston, Vermont

CEMENT:

Type II
Glens Falls Portland Cement Co.
Glens Falls, New York
AIR ENTRAINING ADMIXTURE:
Darex AEA
W. R. Grace & Co.
Cambridge, Mass.

RETARDING ADMIXTURE:
Daratard H C
W. R. Grace & Co.
Cambridge, Mass.
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% passing</td>
<td>% passing</td>
<td>% passing</td>
<td>% passing</td>
</tr>
<tr>
<td>1&quot;</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>3/4&quot;</td>
<td>100</td>
<td>94</td>
<td>100</td>
<td>90-100</td>
</tr>
<tr>
<td>3/8&quot;</td>
<td>25</td>
<td>15*</td>
<td>36</td>
<td>20-55</td>
</tr>
<tr>
<td>#4</td>
<td>2</td>
<td>3</td>
<td>3</td>
<td>0-10</td>
</tr>
<tr>
<td>#8</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>0-5</td>
</tr>
</tbody>
</table>

Thin and/or elongated particles (%) 1

L.A. Abrasion (T96)(% loss)
Reference Aggregate 14 30 Max.
Lightweight Aggregate 30 50 Max.

Specific Gravity
Bulk (Dry) 1.25** 1.49 2.69 NA
Bulk (SSD) - 1.69 2.70 NA
Apparent - 1.86 2.72 NA

Absorption (%)
24 hours 13.3 13.0 0.5 NA
30 minutes 5.3 5.7 - NA

Soundness (% loss) 0.27 2.38 0.15 8 Max.

Weight per cubic foot (lbs.)
Dry Loose 40.51 49.38 - 55 Max.
Dry Rodded 45.00 54.07 95.63 NA

* This material did not have the required minimum 20 percent passing the 3/8" sieve. The material was used, as received, and was not processed to meet requirements.

** From Manufacturer's Data Sheet.
<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>% passing</th>
<th>Specification Requirements</th>
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</thead>
<tbody>
<tr>
<td>3/8&quot;</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>#4</td>
<td>99</td>
<td>95 -100</td>
</tr>
<tr>
<td>#8</td>
<td>85</td>
<td>NA</td>
</tr>
<tr>
<td>#16</td>
<td>68</td>
<td>50 - 80</td>
</tr>
<tr>
<td>#30</td>
<td>48</td>
<td>25 - 60</td>
</tr>
<tr>
<td>#50</td>
<td>23</td>
<td>10 - 30</td>
</tr>
<tr>
<td>#100</td>
<td>3</td>
<td>2 - 10</td>
</tr>
<tr>
<td>Fineness Modulus</td>
<td>2.69</td>
<td>2.60 - 3.10</td>
</tr>
<tr>
<td>Organic Impurities (Color)</td>
<td>-1</td>
<td>2 Max.</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bulk (Dry)</td>
<td>2.60</td>
<td>NA</td>
</tr>
<tr>
<td>Bulk (SSD)</td>
<td>2.63</td>
<td>NA</td>
</tr>
<tr>
<td>Apparent</td>
<td>2.68</td>
<td>NA</td>
</tr>
<tr>
<td>Absorption (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24 hours</td>
<td>1.1</td>
<td>NA</td>
</tr>
<tr>
<td>Soundness (% loss)</td>
<td>2.03</td>
<td>8 Max.</td>
</tr>
</tbody>
</table>
CONCRETE MIXES

CONCRETE MIXING AND PROPORTIONS

ACI Standard 211.1 Recommended Practice for Selecting Proportions for Normal Weight Concrete was used for establishing mix proportions for the reference concrete and lightweight concrete.

All concrete mixes were prepared in the laboratory using a Lancaster pan type mixer. Prior to mixing the lightweight concrete, the lightweight coarse aggregate was placed in the mixer with part of the mixing water. The aggregate was allowed to soak for 30 minutes before adding the remainder of the ingredients.

Table 2 presents the mix proportions used.

Table 2
MIX PROPORTIONS, POUNDS PER C.Y.

<table>
<thead>
<tr>
<th>Concrete</th>
<th>Coarse Aggregate (dry)</th>
<th>Fine Aggregate (dry)</th>
<th>Cement</th>
<th>Net Water</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference</td>
<td>1651</td>
<td>1260</td>
<td>660</td>
<td>273</td>
</tr>
<tr>
<td>Norlite</td>
<td>776</td>
<td>1242</td>
<td>660</td>
<td>292</td>
</tr>
<tr>
<td>Solite</td>
<td>920</td>
<td>1208</td>
<td>660</td>
<td>295</td>
</tr>
</tbody>
</table>

FRESH CONCRETE TESTS

Slump, air content, and unit weight tests were performed in accordance with AASHTO T119, T152 (Reference Concrete), T196 (Lightweight concrete) and T121 respectively. Table 3 presents the results of these tests.
Table 3
FRESH CONCRETE TESTS

<table>
<thead>
<tr>
<th>Concrete</th>
<th>Slump</th>
<th>Air Content</th>
<th>Unit Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inches</td>
<td>Percent</td>
<td>Lbs/ft³</td>
</tr>
<tr>
<td>Reference</td>
<td>3</td>
<td>6.9</td>
<td>143.0</td>
</tr>
<tr>
<td>Norlite</td>
<td>3 1/4</td>
<td>7.3</td>
<td>109.4</td>
</tr>
<tr>
<td>Solite</td>
<td>3 1/4</td>
<td>6.6</td>
<td>117.9</td>
</tr>
</tbody>
</table>

UNIT WEIGHT - HARDENED CONCRETE

The unit weight of hardened concrete was obtained by weighing test cylinders in a saturated surface-dry (SSD) condition and by determining the air-dry unit weight of lightweight concrete in accordance with ASTM C567. Table 4 presents the results of these tests.

Table 4
UNIT WEIGHT-HARDENED CONCRETE

<table>
<thead>
<tr>
<th>Concrete</th>
<th>SSD Weight</th>
<th>Air Dry Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Lbs/ft³</td>
<td>Lbs/ft³</td>
</tr>
<tr>
<td>Reference</td>
<td>144.7</td>
<td>--</td>
</tr>
<tr>
<td>Norlite</td>
<td>112.9</td>
<td>109.5</td>
</tr>
<tr>
<td>Solite</td>
<td>122.0</td>
<td>118.1</td>
</tr>
</tbody>
</table>

COMPRESSIVE STRENGTH

The compressive strengths of the various concretes were determined using 6 by 12 inch cylinders in accordance with AASHTO T22. Specimens were cured in the moist room until time of testing. All concretes had 28 day compressive strengths in excess of 4000 psi. Table 5 presents the results of compressive strength tests.
Table 5

AVERAGE COMPRESSION STRENGTH, psi.

<table>
<thead>
<tr>
<th>Concrete</th>
<th>7 days</th>
<th>14 days</th>
<th>28 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference</td>
<td>3457</td>
<td>4229</td>
<td>4485</td>
</tr>
<tr>
<td>Norlite</td>
<td>3534</td>
<td>4170</td>
<td>4542</td>
</tr>
<tr>
<td>Solite</td>
<td>3457</td>
<td>4076</td>
<td>4861</td>
</tr>
</tbody>
</table>

BOND STRENGTH

The bond strengths of all concretes were tested at 10 days, in accordance with Vt. Agency of Transportation - MRD-3-77. Table 6 presents the bond strength test results.

Table 6

BOND STRENGTH

<table>
<thead>
<tr>
<th>Concrete</th>
<th>Average Bond Strength, psi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference</td>
<td>278</td>
</tr>
<tr>
<td>Norlite</td>
<td>473</td>
</tr>
<tr>
<td>Solite</td>
<td>653</td>
</tr>
</tbody>
</table>

FREEZE-THAW DURABILITY

The resistance of the concretes to freeze-thaw damage was examined, following procedures described in Vt. Agency of Transportation-MRD-4-77. The results indicated the performance of Norlite concrete was approximately equal to the Reference concrete at the 28 day and 60 day curing periods. After 90 days of curing, the Norlite concrete performed slightly better than the Reference concrete.

Solite concrete exhibited less weight loss for all curing ages than either the Norlite or Reference concretes. The results of freeze-thaw testing are shown in Table 7.
**Table 7**

FREEZE-THAW DURABILITY

<table>
<thead>
<tr>
<th>Cure Time Prior to Testing and Concrete Type</th>
<th>Percent Weight Loss After 25 cycles</th>
<th>50 cycles</th>
<th>75 cycles</th>
<th>100 cycles</th>
</tr>
</thead>
<tbody>
<tr>
<td>#1 Cured 20 days</td>
<td>Reference</td>
<td>16</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Norlitech</td>
<td>14</td>
<td>20</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>Solite</td>
<td>6</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>#2 Cured 60 days</td>
<td>Reference</td>
<td>10</td>
<td>16</td>
<td>18</td>
</tr>
<tr>
<td></td>
<td>Norlitech</td>
<td>11</td>
<td>17</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>Solite</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6</td>
</tr>
<tr>
<td>#3 Cured 90 days</td>
<td>Reference</td>
<td>8</td>
<td>8</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>Norlitech</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Solite</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

* Testing discontinued due to excessive deterioration of samples.

** Identification marks on these samples were destroyed and testing was discontinued.

**CHLORIDE PERMEABILITY**

Chloride permeability of the various concretes was determined using the Vermont Agency of Transportation-MRD 20-77 procedure. Chloride contents were determined at three depths in the concrete; 1/2 - 1 inch, 1 - 1 1/2 inch, and 1 1/2 - 2 inches.

The corrosion threshold range is currently thought to be between 300 and 400 ppm of chloride at the rebar level. After 200 days of continuous ponding with a 3% NaCl solution, none of the concretes contained an amount of chloride at the 1 1/2 - 2 inch depth which would be considered harmful. The Solite concrete did allow slightly more chloride ingress at the 1/2 - 1 1/2 inch levels after 200 days of ponding than either the Reference or Norlitech concretes. Table 8 presents the results of the chloride permeability tests.
### Table 8

**CHLORIDE PERMEABILITY**

<table>
<thead>
<tr>
<th>Concrete</th>
<th>Sampling Depth, inches</th>
<th>Total Chloride, PPM/lbs per CY Ponding For</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>100 days</td>
</tr>
<tr>
<td>Reference</td>
<td>1/2 - 1</td>
<td>602/2.4</td>
</tr>
<tr>
<td></td>
<td>1 - 1 1/2</td>
<td>65/0.3</td>
</tr>
<tr>
<td></td>
<td>1 1/2 - 2</td>
<td>43/0.2</td>
</tr>
<tr>
<td>Norlite</td>
<td>1/2 - 1</td>
<td>72/0.3</td>
</tr>
<tr>
<td></td>
<td>1 - 1 1/2</td>
<td>50/0.2</td>
</tr>
<tr>
<td></td>
<td>1 1/2 - 2</td>
<td>42/0.2</td>
</tr>
<tr>
<td>Solite</td>
<td>1/2 - 1</td>
<td>95/0.4</td>
</tr>
<tr>
<td></td>
<td>1 - 1 1/2</td>
<td>68/0.3</td>
</tr>
<tr>
<td></td>
<td>1 1/2 - 2</td>
<td>60/0.2</td>
</tr>
</tbody>
</table>

**SAMPLE BRIDGE BARRIER CURBS**

Sample sections of bridge barrier curbs were cast using the Norlite and Solite concretes to examine the type of surface texture which might be encountered on the sloped surfaces of the curbs.

Two samples were cast for each of the concretes; one using a low slump (1 1/2 - 2 inches), the other using a higher slump (4-4 1/2 inches). The samples were cast in an upright position using plywood forms. Horizontal joints in the forms were sealed with reinforced tape. Consolidation of the concrete was achieved with an internal vibrator.

An examination of the samples indicated that a better surface texture, i.e., less "bug holes" and other defects, will be obtained using low slump concrete.

Figure I shows the typical section of the sample curbs. Photographs showing some of the surface textures are displayed on pages 13 through 16.
CONCRETE BRIDGE BARRIER CURB - TYPICAL SECTION

FIGURE I
SOLITE CONCRETE

4 1/2" Slump

1 1/2" Slump

Upper Sloped Surface

Lower Sloped Surface
SOLITE CONCRETE

$1\frac{1}{2}''$ Slump

Upper Sloped Surface

Lower Sloped Surface
SOLITE CONCRETE

\( \frac{4}{5} \text{ in. Slump} \)

Upper Sloped Surface

Lower Sloped Surface
NORLITE CONCRETE

$4\frac{1}{2}''$ Slump

Upper Sloped Surface

Lower Sloped Surface
A. All concretes exhibited average 28 day compressive strengths greater than 4000 psi.

B. Air contents of the lightweight and reference concretes were within the ranges recommended by the American Concrete Institute.

C. When subjected to freeze-thaw testing, the concrete containing Solite coarse aggregate exhibited less weight loss than the concrete containing the Norlite coarse aggregate and the concrete containing the Reference coarse aggregate.

D. After 200 days of continuous ponding with a 3% NaCL solution, none of the concretes examined contained an amount of chloride at the 1\(\frac{1}{2}\) - 2 inch depth which would be considered harmful.

E. The lightweight concrete containing Norlite coarse aggregate weighed approximately 8\(\frac{1}{2}\) lbs/ft\(^3\) less than the concrete containing the Solite coarse aggregate.

F. Lightweight concrete of stiff consistency (low slump) produced a better finish on the sloped surfaces of the sample curbs than the higher slump concrete.
IMPLEMENTATION

Information obtained, as a result of this investigation, was used in the preparation of specifications for lightweight coarse aggregates and lightweight concrete. The experience gained was beneficial to Structural Concrete Subdivision personnel who provided assistance with the testing of lightweight concrete on several Agency projects and on the Barre Courthouse project.
STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS DIVISION - RESEARCH & DEVELOPMENT SUBDIVISION

RESEARCH INVESTIGATION
Work Plan No. 78-C&R-21

Subject
Investigation of the durability of lightweight concrete (Norlite)

Investigation Requested By
Wendell Smith, Structures Engineer

Date
May 17, 1978

Date Information Required
April, 1979

Purpose of Investigation
To compare freeze thaw durability; compressive and bond strength; resistance to chloride intrusion; base level chloride content; w/c ratio; unit weight; and percentage of air of a Class A concrete using Norlite coarse aggregate to a Class A Reference Mix using a Dolomite normal weight aggregate.

Proposed Tests or Evaluation Procedure

1. Aggregates will be tested for compliance with Item 704.01 and Item 704.02.

2. Compressive strengths 7 days, 14 days, 28 days.

3. Bond test 10 days.

4. Sample curbs will be poured to determine the best procedure to obtain the desired finish in the field.

5. Freeze thaw durability (wgt. loss @ 25 cycle intervals). The specimens will be cured for the various ages of 3, 14, 28, and 50 days before the cycling begins.

6. Chloride Intrusion 50 day intervals after 28 day cure.

7. Chloride content analysis.

Proposal Discussed With
R. Haupt, R. Frascoia

Projected Manpower Requirements
Preparation & Testing 7 man days, report - 3 man days

Investigation To Be Conducted By
Structural Concrete and Research & Development

Proposed Starting Date
July, 1978

Estimated Completion Date
March, 1979

Approval/Disapproval by Materials Engineer

Comments by Materials Engineer

Materials Division
Agency of Transportation
STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS DIVISION - RESEARCH & DEVELOPMENT SUBDIVISION

RESEARCH INVESTIGATION
Work Plan No. 78-CR-34

Subject: Investigation of the durability of lightweight concrete (Solite)

Investigation Requested By: Wendell Smith, Structures Engineer  Date: May 17, 1978

Date Information Required: April, 1979

Purpose of Investigation: To compare freeze-thaw durability; compressive and bond strengths; resistance to chloride intrusion; base level chloride content; w/c ratio; unit weight; and percentage of air of a Class A concrete using Solite coarse aggregate to a Class A Reference Mix using a Dolomite normal weight aggregate.

Proposed Tests or Evaluation Procedure:

1. Aggregates will be tested for compliance with Item 704.01 and Item 704.02.
2. Compressive strengths: 7 days, 14 days, 28 days.
3. Bond test: 10 days.
4. Sample curbs will be poured to determine the best procedure to obtain the desired finish in the field.
5. Freeze-thaw durability (wgt. loss @ 25 cycle intervals). The specimens will be cured for the various ages of 3, 14, 28, and 50 days before the cycling begins.
6. Chloride Intrusion: 50 day intervals after 28 day cure.
7. Chloride content analysis.

Proposal Discussed With: R. Haupt, R. Frascoia

Projected Manpower Requirements: Preparation & Testing: 7 man days, report - 3 man days

Investigation To Be Conducted By: Structural Concrete and Research & Development

Proposed Starting Date: July, 1978  Estimated Completion Date: March, 1979

Approval/Disapproval by Materials Engineer: [Signature] 7/21/78

Commences by Materials Engineer: 

Materials Division
Agency of Transportation: 20
OFFICE MEMORANDUM

TO:        R. Haupt, P.E., via W. Smith, P.E., Structures Engineer
FROM:      E. R. Waibel, P.E., Structural Concrete Eng. via R. F. Nicholson, P.E., Materials and Research Engineer
DATE:      January 12, 1979
SUBJECT:   Proposed Specifications for Structural Lightweight Concrete and Lightweight Coarse Aggregate for Structural Concrete

Per your request we have drawn up the enclosed specification to permit the use of lightweight concrete for bridge construction.

The enclosed specifications are for your review and comments.

RFN/ERH/msd
cc: RFN/Lab File
    HHH/Structural Concrete Chrono file
    E. Englehardt
    E. Waibel
    Central Files
501.02 MATERIALS, is hereby modified by adding the following subsection of Division 700 - Materials:

Lightweight Coarse Aggregate For Structural Concrete 704.22

501.03, CLASSIFICATION AND PROPORTIONING. Table 501.03A is hereby modified by adding the classification of structural lightweight concrete (LW) as follows:

**TABLE 501.03A**

<table>
<thead>
<tr>
<th>Class</th>
<th>Lbs/Cy</th>
<th>Minimum Cement</th>
<th>Maximum Water Content</th>
<th>Maximum Water</th>
<th>Range Air</th>
<th>Coarse Aggregate Gradation</th>
<th>28 Day**</th>
</tr>
</thead>
<tbody>
<tr>
<td>LW</td>
<td>660</td>
<td>5.0</td>
<td>.44</td>
<td>1-3</td>
<td>6.41</td>
<td>704.02B</td>
<td>4000</td>
</tr>
</tbody>
</table>

**Unit Weight of Concrete**

<table>
<thead>
<tr>
<th>Plastic max. lb. per cu. ft.</th>
<th>Dry max. lb. per cu. ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>120</td>
<td>115</td>
</tr>
</tbody>
</table>

**The listed 28 day compressive strengths will serve as the basis of designing or approving the concrete mix.**
704.22 LIGHTWEIGHT COARSE AGGREGATE FOR STRUCTURAL CONCRETE

Lightweight coarse aggregate for structural concrete shall be clean, hard and uniformly graded. It shall be reasonably free from dirt, deleterious material, pieces which are structurally weak and shall meet the following requirements.

(a) General Characteristics. Two general types of lightweight aggregates may be used.

1. Aggregates prepared by expanding, calcining, or sintering products such as blast furnace slag, clay, shale or slate. Other raw materials may be used if the aggregates prepared meet the requirements of this specification.

2. Aggregates prepared by crushing, screening, and cleaning natural lightweight materials such as pumice, scoria, or tuff.

(b) Grading. The grading shall conform to the requirements given in Table 704.02B.

(c) Percent of Wear. The percent of wear shall not be more than 50 when tested in accordance with AASHTO T96.

(d) Thin and Elongated Pieces. The thin and elongated pieces shall conform to the requirements of subsection 704.02(d).

(e) Soundness. The soundness shall conform to the requirements of subsection 704.02(e).

(f) Unit Weight. The maximum dry loose weight of the lightweight coarse aggregate shall not exceed 55 lbs/cu. ft. when tested in accordance with AASHTO T19.