CAC for Refractory Applications

Lumnite (Calcium Aluminate Cement) for refractory concrete mixes based on ESCS and ESCS plus Vermiculite

INTRODUCTION

LUMNITE cement is often used with lightweight aggregates described by the broad term expanded shale, clay or slate (ESCS) to produce refractory concretes or mortars, that provide high strength, good resistance to abrasion and corrosion, and good insulating properties. For some installations, strength and abrasion and corrosion resistance are of secondary importance, and the major function of the refractory lining is that of insulation. In these cases, very lightweight aggregate such as Vermiculite (exfoliated mica) may be used in conjunction with LUMNITE and ESCS aggregates.

PRODUCTION

ESCS aggregates are produced after being crushed in either a rotary kiln or traveling grate-type sintering process. The burning temperature is in the range of 2000° to 2200° F, which results in the removal of combustible and foreign waste. After cooling, it is crushed screened and graded to size. The aggregates are usually available in at least two sizes, fine and coarse, but some producers provide a blended gradation. ESCS aggregates are manufactured by a number of firms across the United States under a variety of trade names. While the chemistry of these materials may vary somewhat, they generally have an oxide analysis comparable to that shown in Table 1.

Vermiculite is a form of mica which consists of paper-thin sheets. Trapped between these sheets and within the mineral are molecules of water. The raw ore is crushed, cleaned, dried and sized before being directly exposed to open heat at about 2000° F (1095° C) which turns the entrapped water to steam, causing the sheets to separate and move apart. At the same time the granules expand from 12 to 15 times their original size, forming in the process thousands of tiny cells of dead air. It is these cells that provide most of the insulating properties of the expanded vermiculite. The remainder comes from the shiny surfaces of the particles, which reflect radiant heat somewhat as a mirror will reflect light.
The particles of the finished aggregate are relatively soft and the color varies from brown to buff with a characteristic pearly luster.

ESCS Oxide Analysis			
SiO_2	60.5%	**MgO**	2.4%
$Al2O_3$	20.8%	**MnO**	0.01%
$Fe2O_3$	8.0%	K_2O	4.4%
CaO	2.6%	Na_2O	0.95%

Table 1

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PROPERTIES – ESCS MIXES

The chemical analysis of ESCS is presented only as information and should not be considered as a criteria for acceptance or the ability of any given ESCS aggregate to perform satisfactorily with LUMNITE. While many of these aggregates display good volume stability when exposed to temperatures of 2000° F (1095° C) and higher, some of them exhibit a high degree of volume change at temperatures below 2000° F. In the absence of recent proven records of satisfactory performance in refractory concrete, tests may be required on a particular aggregate to determine its suitability for use at the anticipated service temperature.

LUMNITE in combination with ESCS aggregates has over the years produced refractory concretes with good strength, satisfactory resistance to abrasion and corrosion and good insulating properties.

The data in the following tables are presented as an example of the properties that can be achieved under laboratory conditions from a LUMNITE-ESCS or LUMNITE-ESCS Vermiculite concrete. This data was developed using a particular ESCS and Vermiculite. Other ESCS aggregates may produce different results depending on their gradation method of manufacture, etc.
The data presented in figure 1 and 2 was developed on specimens made from small size batches according to the guide formulations given in table 3 under laboratory conditions where temperature, humidity, and curing were closely controlled. Actual field conditions may produce variable results.

LINEAR CHANGE AGAINST TEMPERATURE

ESCS

	72°F (22°C)*	220°F (105°C)	500°F (260°C)	1000°F (540°C)	1500°F (815°C)	2000°F (1095°C)
Linear Change %	-	-	-0.10	-0.05	-0.06	-0.02
Unit Weight lb/ft³ (g/cm³)	92.7 (1.48)	88.6 (1.42)	83.2 (1.33)	84.2 (1.35)	84.6 (1.36)	82.1 (1.32)
Compressive Strength psi (Mpa)	4450 (30.7)	3630 (25.0)	2540 (17.5)	2390 (16.5)	2310 (15.9)	2480 (17.1)
Modulus of Rupture psi (Mpa)	590 (4.1)	660 (4.5)	330 (2.3)	360 (2.5)	390 (2.7)	480 (3.3)

Figure 1

ESCS+VERMICULITE MIX

	72°F (22°C)*	220°F (105°C)	500°F (260°C)	1000°F (540°C)	1500°F (815°C)	2000°F (1095°C)
Linear Change %	-	-	-0.33	-0.35	-1.44	-
Unit Weight lb/ft³ (g/cm³)	91.3 (1.46)	58.4 (0.94)	52.4 (0.84)	54.3 (0.87)	53.1 (0.85)	51.5 (0.82)
Compressive Strength psi (Mpa)	110 (0.78)	330 (2.24)	150 (1.03)	170 (1.17)	180 (1.23)	200 (1.38)
Modulus of Rupture psi (Mpa)	70 (0.48)	120 (0.82)	65 (0.45)	70 (0.50)	75 (0.51)	80 (0.54)

Figure 2

ESCS AND VERMICULITE GRADATION AND BULK DENSITY
(Cumulative Percent Retained on Each Sieve)

Tyler (Mesh)	0.371 in	4	8	14	28	48	100	Bulk Density
U.S. (Alternate)	3/8 in	4	8	16	30	50	100	lb/ft³
	(9.5 mm)	(4.75 mm)	(2.36 mm)	(1.18 mm)	(600 µm)	(300 µm)	(150 µm)	(g/cm³)
ESCS Size "A"	0	0	2.6	41.9	63.2	76.2	84.7	54.5 (0.87)
ESCS Size "B"	26.0	87.7	97.5	99.1	99.4	99.5	99.5	38.8 (0.62)
Vermiculite	0.0	2.9	13.4	33.5	64.2	90.0	98.5	9.6 (0.15)

Table 2

PROPERTIES – ESCS AND VERMICULITE

While the insulating properties of LUMNITE-ESCS concretes are not as good as could be achieved by using some of the very lightweight aggregates such as perlite or vermiculite, they combine good strength as well as corrosion and abrasion resistance with their insulating value and are used for lining stacks, ducts and breechings, as well as in and around process vessels in petroleum and petrochemical industries.

Very lightweight aggregates (vermiculite, perlite, calcined diatomaceous earth) should only be used in applications where insulation is the prime consideration and strength and abrasion and corrosion resistance are of little or no significance.

Since vermiculite and the other very lightweight aggregates are highly absorbent, the amount of water required to produce a plastic workable concrete or mortar containing these aggregates is naturally very high. This water content is partially responsible for the very low strengths, and also results in rather large volume changes when the concrete or mortar is dried and fired.

Expanded shale

CONCRETE MIX		
Aggregate:	1 Part Size „B“: 2 Parts Size „A“ by Weight	Size „A“: (2 Parts Size by Volume)
Expanded Shale:	Bulk Density = 52.6 lb/ft3 (0.84 g/cm^3)	Bulk Density=54.5 lb/ft^3 (0.87 g/cm^3)
Vermiculite:	–	4 Parts by Volume Bulk Density=9.6 lb/ft^3 (0.15 g/cm^3)
Mix Proportions:	1:4 Lumnite:ESCS by dry loose, volume Water Solids (W/S) = 26.0% by weight	1:2:4 LUMNITE : Haydite : Vermiculite by dry, loose volume Water Solids (W/S) = 56.1% by weight
Consitency:	Wet „Ball-in-Hand“	Wet „Ball-in-Hand“

Table 3 Note: Aggregate presoaked (15 minutes) with approximately 2/3 of required water.

BENEFITS

CALUCEM Calcium Aluminate Cements are a cost efficient solution for insulating and dense refractory products. CALUCEM Calcium Aluminate cements are used in precast shapes or in premixed refractory formulations. They can be applied as concretes or gunning mixes and offer the following benefits:

- High Temperature Resistance
- Abrasion and Mechanical Resistance
- Strictly monitored chemical composition for consistent high product quality
- Reliable behavior of CALUCEM Calcium Aluminate Cements during installation

START FORMULATIONS

Starting formulations are available upon request.

MORE INFO

For additional information about CALUCEM Calcium Aluminate Cements, please visit our web site at **www.calucem.com** or contact us worldwide.

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