

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Vol. 5, Issue 2, February 2016

An Experimental Investigation on Light Weight Cement Concrete using Vermiculite Minerals

S Syed Abdul Rahman¹, Gijo K Babu²

Assistant Professor, Department of Civil Engineering, SRM University, Chennai, India¹

Student, Department of Civil Engineering, SRM University, Chennai, India²

ABSTRACT: In recent development scenario, the lightweight concrete is a versatile material, which offers a range of technical, economic and environmental –enhancing and preserving advantage and is designed to become a dominant material in the millennium. For structural application of light weight concrete, the density is often more important than the strength. A decreased density for the same strength level reduces the self weight, foundation size and construction cost. Structural lightweight aggregate concrete is generally used to reduce dead weight of the structure as well as to reduce the risk of seismic damage to a structure because the seismic forces that will influence the civil engineering structures are proportional to the mass of those structures.

In this study, structural light weight aggregate concrete was designed with the use of natural vermiculite aggregate that will provide an advantage of reducing dead weight of structure and to obtain a more economical structural light weight concrete by the use of vermiculite powder as a partial replacement of sand. Three mixes were produced with the cement content of 479kg/m^3 in M_{30} grade and water cement ratio is 0.40. More over the group had proportion of 0%, 5%, 10%, as vermiculite replacement. The main scope of our project is to learn and gather knowledge of strength, and density. It may help us to get clear idea about the light weight concrete, using vermiculite.

KEYWORDS: Compressive strength, Density, Vermiculite

I. INTRODUCTION

Vermiculite is a phyllosilicate mineral group and is micaceous in nature. It is found in so many parts of the world but only a limited number of sources are worked as commercial deposits. The vermiculite is mined and refined using a variety of techniques and supplied commercially in a range of particle size grades of vermiculite concentrate (unexpanded).

Vermiculite is the name used in commerce for a group of micaceous minerals that expand or exfoliate many times (commercial varieties exfoliate 8 to 20 times or more) the original thickness when heated. They show the characteristic micaceous structure of basal cleavage and occur as soft, pliable inelastic lamina. Their basal cleavages are not so perfect as those of mica. Vermiculite exists in so many colors from black through various shades of brown to yellow. Its chemical composition varies widely consisting of a complex hydrated aluminum, magnesium silicate and hence the analysis of the mineral is of little use in determining the vermiculite for commercial utility a technical trial of the material provides the only satisfactory test.

Vermiculite owes its commercial utility to its property of exfoliation when heated. It exfoliates into a yellow to bronze colored mass giving an appearance of a cluster of worms - vermicular, an Italian word for worm from which it has derived its name as vermiculite. Some authorities quote the Latin word vermicular from which the name vermiculite might have been derived.

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II. SCOPE AND OBJECTIVE

The objective of present investigation is to development of normal strength in lightweight concrete using natural sand as fine aggregate and also trial mixes by replacing 0.5, 10 percent of the weight of natural sand by vermiculite minerals. The investigation is also aimed at finding out the optimum percentages of natural sand replacement using vermiculite minerals for superior strength, density and fire resistant characteristics. To study and compare the performance conventional and vermiculite minerals in lightweight concrete. To understand the effectiveness of vermiculite minerals in strength enhancement. To study the physical and chemical properties of vermiculite minerals and the ingredients in lightweight concrete.

The scope of this project is to know the effect on workability, strength properties of lightweight concrete mix with varying percentage replacement of natural sand by vermiculite minerals. To find out the optimum percentage of natural sand replacement by vermiculite minerals for which the lightweight concrete yields the superior mechanical properties. To compare the variation of compressive strength at 7 days, 14 days and 28 days curing strength with conventional cube. The effect of vermiculite minerals on compressive strength of lightweight concrete as partially replacement of fine aggregates can be analyzed. The tensile strength of lightweight concrete also can be studied by using vermiculite minerals in a lightweight concrete.

III. DISCUSSION ON MATERIALS

Vermiculite is a naturally occurring mineral composed of shiny flakes and mica. When vermiculite is heated to high temperature it expands 8-30 times than its original size. Expanded vermiculite is used in numerous products because it as property of light weight, fire resistant and odorless. This expanded vermiculite is used in construction and consumer materials. Shape of expanded vermiculite granules are small accordions, and vary in color from silver/gold to gray/brown. The vermiculite particles are typically platelets, and its diameter is ranging from 0.04 μ m to 4mm. The particle shape and size mainly depend on the mineralogical phases and collection system. The particle shape affects the water demand of standard paste. If number of platelets particle increase the water demand decreases. Requirement of water for mortars decreases, if vermiculite increases.

Characteristics of vermiculite is mainly based on its color may be brown to golden brown, can also be white, colorless or yellow, its luster is Pearly to greasy, its transparency is translucent crystals, its hardness is about 1.5, its specific gravity is in between 2.3-2.5. Physical characteristics of vermiculite are its Crystal Habit is Pseudo hexagonal tabular crystals, its Sintering temperature is about 1260 Degrees C, its Melting Point is 1330 Degrees C, its Specific Heat is 1.8 kJ/kg.K, pH value of vermiculite is about 8.0-9.5 and thermal Conductivity of vermiculite is in between 0.062-0.0656 W/m.K. Chemical characteristics of Vermiculite is a fine particle with the main chemical constituents being SiO₂, AlO₃, Fe₂O₃ and CaO which are responsible for its pozzolanic activity. It also consists of MgO, Mn₂O₃, P₂O₅, SO₃, Na₂O and. There is a possibility for variation in composition from plant to plant and even in one plant from time to time. SiO₂ 38-46, MgO 16-24, Al₂O₃ 11-16, Fe₂O₃ 8-13, K₂O 4-6, CaO 1-3, TiO₂ 1-3, MnO .1-0.2, Cr₂O₃ 0.05-0.2, Na₂O 0.1-0.3. Vermiculite crystallizes in the monoclinic system, and the crystal faces are often marked with triangular lines at 60 degrees and 120 degrees. The main composition are in vermiculite are Silica, 31-41% Alumina, 10-17% Iron oxides, 5-22% Magnesium oxide, 11-13%.

IV. MIX DESIGN OF VERMICULITE CONCRETE

In this investigation M₃₀ grade design mix is used.

Table 1: mix proportion of vermiculite concrete

Cement Kg/m ³	F.A Kg/m ³	C.A Kg/m ³	Water Litres	Vermi Culite %	SP %
479	527	1168	192	0-10	3

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V. BULK DENSITY

For determination of dry density of the cured mortar or concrete mixture samples, specimens of size 83mm diameter and 50mm thick samples were cast and cured for 28 days in water. As per ASTM C642-97, the cured samples must be free from observable cracks, fissures and shattered edges.

Table 2: Bulk density of different % of replacement

% of replacement	Vol m ³	Bulk density kg/m ³		
		7days	14days	28days
0	0.003375	2477	2471	2486
5	0.003375	2382	2261	2282
10	0.003375	2358	2098	2167

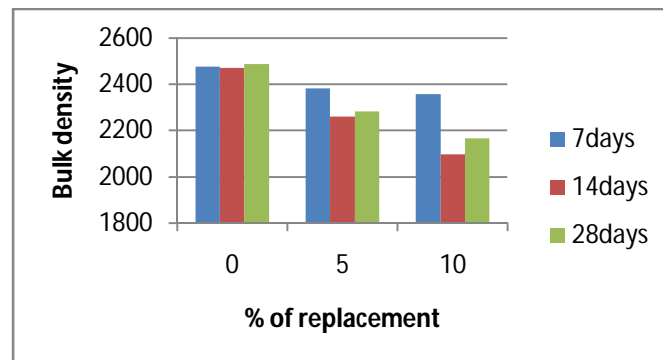


Figure 1: Bulk density of different % of replacement

VI. COMPRESSIVE STRENGTH

The average compressive strength for OPC and vermiculite blended concrete (0-10%) for different curing periods are shown in tables 3. From these tables it can be noted that, vermiculite blended concrete shows adequate compressive strength up to 10 %. After 28 days curing, the vermiculite system up to 10 % performs well comparing to control concrete.

Table 3: Compressive strength of different % of replacement.

% of replacement	Avg compressive strength (N/mm ²)		
	7days	14days	28days
0	22.02	28.47	32.4
5	17.66	24.58	30.6
10	14.66	21.44	28.03

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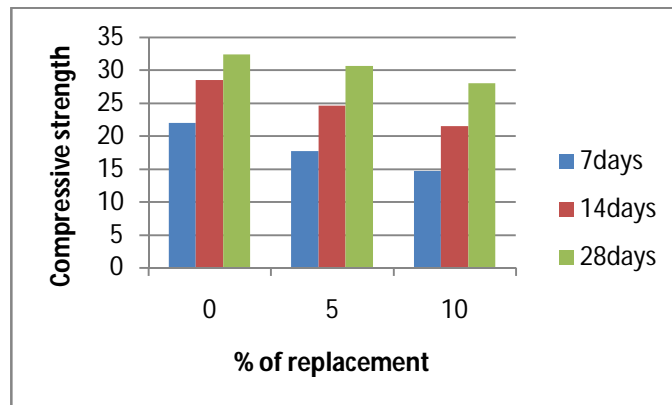


Figure 2: compressive strength of different % of replacement

VII. ADVANTAGES OF LIGHTWEIGHT CONCRETE

A. Fireproof

The fireproofing characteristics of vermiculite concrete are recognized nationwide by insurance companies, state rating bureaus and local building officials. Underwriters' Laboratories have assigned up to 4-Hour ratings to systems that employed vermiculite as one of the components.

B. Insulation

Vermiculite concrete has excellent insulating properties. Three inches of vermiculite concrete is equivalent to 1 1/2" of rigid board insulation layed over steel decks. One inch of vermiculite concrete is equal in insulating value to 20 inches of regular concrete.

C. Ease of Application

Vermiculite insulating concrete is easily placed by modern specially designed pumping equipment. Up to 25,000 square feet can readily be placed in one day.

VIII. CONCLUSION

The initial test results shown that adding vermiculite in to lightweight concrete decreases the compression strength and by adding super plasticizers the decreased compression strength of the cube can be regained. Compare with conventional cube the cube with vermiculite had less density. Thus we can come to an conclusion that vermiculite added light weight concrete cannot be useful for load bearing purpose, rather it can be used as non load bearing purpose like heat insulation, weathering course etc.

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