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STUDY OF VERMICULITE AS FINE AGGREGATE IN CONCRETE

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ABSTRACT- *The developments in the field of construction raise the need for concrete with less weight, efficient, durable, ecofriendly and Fire safety. All the above mention properties can be achieved by expanded vermiculite. In this project, expanded vermiculite replaced by the fine aggregate. Furthermore, different concrete mixes design by varying the proportion of vermiculite and fine aggregate. By varying proportion vermiculite concrete results of compressive strength are noted at 7, 14, 28 days.*

Keywords: - *Light weight concrete, vermiculite concrete, Fine aggregate*

1. INTRODUCTION

1.1 General

Buildings are a major energy consuming sector in the economy. About 35 to 40% of total energy is used by buildings during construction. The major consumption of Energy in buildings is during construction and later in lighting or air-conditioning systems. Green building is reducing building impacts of human health and the environment, through better site selection, design, construction, operation, maintenance and demolition. A green Building uses less energy, water and other natural resources creates less waste & Green House Gases and is healthy for people during living or working inside as compared to a standard Building. Another meaning of Green Structure is clean environment and healthy living.

A very hard building material made by mixing together cement, coarse and fine aggregate, admixture (if required) and water.

The aim is to mix these materials in measured amounts to make concrete that is easy to: Transport, place, compact, finish and which will set, and harden, to give a strong and durable product. The amount of each material (i.e. cement, water and aggregates) affects the properties of hardened concrete.

Vermiculite is the geological name given to a group of hydrated laminar minerals which are aluminium-iron-magnesium silicates, resembling mica in appearance. A yellow or brown mineral found as an alteration product of mica and other minerals, used for insulation or as a moisture-retentive medium for growing plants. Vermiculite is a unique, naturally occurring, inert laminar mineral that finds use in many construction, industrial, home, agricultural and garden products and systems. Vermiculite is exfoliates (expands) when subjected to heat, this product is lightweight, incombustible, compressible, highly absorbent, and non-reactive and it may also have high cation exchange capacity.

Deposits of vermiculite are found in the states of Andhra Pradesh, Karnataka, Gujarat, Tamil Nadu, West Bengal, Madhya Pradesh and Rajasthan.

1.2 Vermiculite based concrete

Modern civil and industrial construction makes ever greater demands for building materials for a variety of parameters such as less weight, efficiency, durability, environmental, fire safety, etc. To a large extent all the above qualities has a modern building material – expanded vermiculite. Due to its porous structure, expanded vermiculite is an excellent heat and sound insulator.

1.3 Properties

Various chemical formulae are given for vermiculite. One of them is as given below.
$(Mg,Fe^{++},Al)_3(Al,Si)_4O_{10}(OH)_2 \bullet 4(H_2O)$

Table 1.1:- TYPICAL PHYSICAL PROPERTIES

Properties	Vermiculite	Sand
Color	Gold—brown	Light—Brown
Free moisture	1.44	0.8
Water absorption	6.33	0.05
Specific gravity	2.5	2.605
Specific heat	1.08 kJ/kg.K	0.83 kJ/kg.k
Fusion Point	2200-2400F (1315 °C)	2930F (1610 °C)

Vermiculite

Sand

Fig 1.1:- Image of vermiculite and sand sample

1.4 Objectives

To replace the vermiculite as fine aggregate in concrete.
To make light weight concrete.
To check the temperature effect on vermicrete.

1.5 Scope of work

To achieve above objectives the scope of work has been identified as follows:

The Basic information about constituents required to produce vermiculite concrete such as vermiculite, coarse aggregate, and fine aggregate is to be studied.

Total five concrete mixes are to be prepared for studying the salient parameters of vermiculite concrete as a part of preliminary investigation.

It is planned to cast 45 cubes of size 150mm x 150 mm x 150 mm for this study. Average result of three cubes specimens for all above parameters are to be considered as the main results. A mix design process based on the result of preliminary investigation is to be developed for vermiculite concrete. Mix design of Concrete with 0%, 20%, 40%, 60%, 100% and 100% replacement of fine aggregate with vermiculite.

2. LITERATURE REVIEW

2.1 General

This chapter presents a brief review of the needs of the development of light weight concrete for the present construction industry and background of vermiculite and vermiculite concrete. Application of vermiculite, and past studies on vermiculite concrete has been included in this chapter.

2.2 Background

The term vermiculite applies to a group of minerals characterized by their ability to expand into long, worm-like strands when heated. This expansion process is called exfoliation. The name vermiculite is derived from a combination of the

Latin word vermiculare meaning mineral or rock. In its expanded form, vermiculite has a very low density and thermal conductivity, which makes it attractive for use as a lightweight construction aggregate. Expanded vermiculite also has a very large chemically active surface area, which makes it useful as an absorbent in some chemical processes. When vermiculite is ground into a fine powder, it is used as a filler in inks, paints, plastics, and other materials.

2.3 Raw Materials

Technically, vermiculite encompasses a large group of hydrated laminar magnesium-aluminum-iron silicates, which resemble mica. One of the most common forms of vermiculite is generally known as commercial vermiculite. This is the form that is mined and processed for various end uses. It is derived from rocks containing large crystals of the minerals biotite and iron-bearing phlogopite. As these rocks are exposed to the weather, they start to decompose, allowing water to enter and react with the various chemicals present. As the decomposition and chemical reactions proceed, vermiculite is formed.

2.4 The Manufacturing Process

The manufacturing process used to produce commercial expanded vermiculite consists of two separate operations. The mining and concentrating operations that produce raw vermiculite flakes are conducted at one location. The exfoliation and classifying operations that produce various sizes of lightweight, expanded vermiculite granules for use in other products are conducted in another location. Sometimes these two locations can be half a world apart. There are many different methods used in both of these operations. The exact methods vary from mine to mine and plant to plant. Here is a typical manufacturing process used to produce commercial expanded vermiculite.

2.5 Mining

1) Rocks containing vermiculite are dug from a huge open pit in the ground. The soil on top of the rocks, called the overburden, is removed with power shovels or earth scrapers. The exposed rock layers are then drilled with large pneumatic or hydraulic drills, and the holes are filled with explosive charges. When all personnel and equipment have been moved out of the area, the explosive charges are detonated.

2) The resulting heap of loose rocks are scooped up with power shovels and dumped into trucks or train cars, which carry the rocks to a nearby processing plant.

2.5 Concentrating

3) The rocks are fed through a series of crushers and screens to reduce their size. The vermiculite is separated from the surrounding rocks and dirt using various wet or dry techniques depending on the particular mining operation and local environmental regulations. These techniques may include froth flotation, gravity separations, winnowing, or electrostatic separation. In each of these techniques, either the vermiculite itself or the other materials are trapped and separated from each other until the resulting vermiculite flakes are about 90% pure by weight.

4) The vermiculite flakes extracted from various sections of the mine may be blended together before further processing to ensure uniformity of the product.

2.6 Grading

5) The separated vermiculite flakes are sorted by size. This may be done with a series of screens or it may be done in a long-enclosed wind tunnel. In the wind tunnel, the flakes are fed into the upstream end of the tunnel and are carried along the length of the tunnel by the flow of air. The larger flakes, being heavier, fall out of the air stream first and are caught in a hopper at the bottom of the tunnel. This separation by weight continues down the length of the tunnel until all the flakes are caught in hoppers. By controlling the length of each hopper opening and the velocity of the air, the flakes can be sorted into various sizes, or grades, ranging from about 0.63 in (16 mm) down to about 0.02 in (0.8 mm) in diameter. If the particular vermiculite being mined tends to form a high percentage of large flakes, the flakes may be slightly crushed to delaminate them and reduce their size. This process is called debooking and allows the flakes to be quickly heated during the exfoliation process.

6) The graded vermiculite flakes are dumped into large plastic bags or other containers for shipping to various exfoliation plants. If the flakes are to be shipped to plants overseas, they are loaded in bulk into the holds of ships for transport.

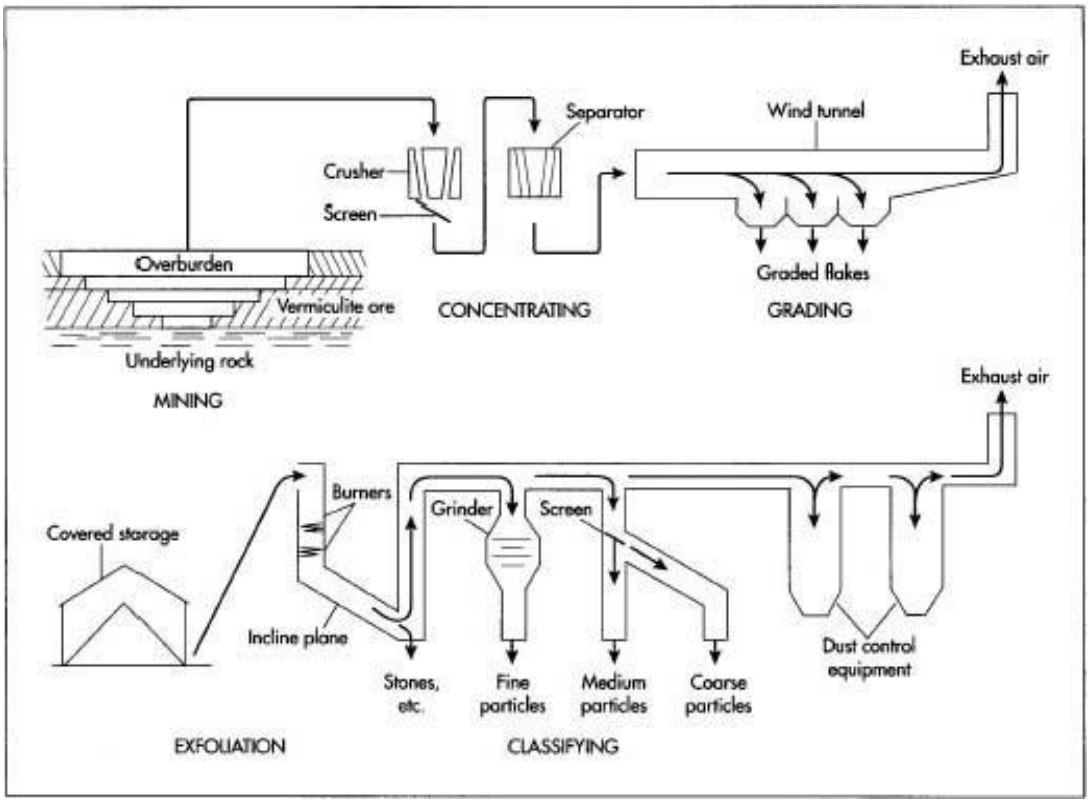

Fig 2.1:- The processing of vermiculite

2.7 Exfoliating

7) The vermiculite flakes are transported by truck or train from the port or mine to the exfoliation plant, where they are offloaded and stored in a covered area to protect them from contaminants and the weather. It is important to prevent the flakes from absorbing moisture. Otherwise, it will take too much energy to heat the flakes to the required temperature to make them expand.

8) The flakes are loaded onto a conveyor belt and lifted to the top of a 20-25 ft (6.1-7.6 m) high vertical furnace lined with ceramic bricks. As the flakes fall down the length of the furnace, they pass through one or more burners fired by natural gas. The temperature inside the furnace reaches approximately 1,000-1,500°F (540-810°C), which is sufficient to make the trapped water in the flakes flash to steam and cause the flakes to expand into worm-like particles. At the bottom of the furnace, the particles slide down an inclined plane. This delays the exit of the particles from the furnace and allows the vermiculite to be heated further in order to reach full expansion. Other exfoliation plants may use different furnace configurations, but the general sequence of operations is similar.

2.8 Classifying

9) The hot, expanded vermiculite particles are then drawn up a vertical tube by a vacuum. Any small stones or other solid contaminants are too heavy to be carried upward by the gentle flow of air and fall out the bottom of the tube. The air flow also acts to cool the hot vermiculite.

10) If a customer or application requires fine particles, the vermiculite may be ground and screened to produce a specific size or range of sizes before it is packaged for shipping. In some exfoliation plants, the larger particles may also be screened or sorted into various sizes, depending on the final use.

11) The sorted, or classified, vermiculite particles are then deposited into storage hoppers, where they are dispensed into individual 4-6 cu ft (0.10-0.15 cu m) paper or plastic bags for retail sales or placed into larger 50 cu ft (1.3 cu m) bags for use in various commercial applications. The bags are sealed, labeled, and moved to a warehouse for shipping.

3. EXPERIMENTAL PROGRAM

3.1 Strength of vermiculite concrete cube

The strength graph of vermiculite concrete shown as below is % of replacement vs strength of Mpa graph. That shows Normal concrete cube strength and 20%, 40%, 60%, 100% replacement of sand with respect to the 7 days, 14 days, 28 days strength.

The avg. weight of 20% replacement concrete cube is 6.75 kg.
The avg. strength for 7, 14 and 28 days is 22.43, 26.3 and 30.43 Mpa respectively.
So, from above data for 20% mix the avg. strength is 21.72, 24.97 and 27.49 Mpa and for 40% mix 19.87, 22.23 and 25.2 Mpa can be achieved at 28 days age and for 60% and 100% mix strength is very low. The avg. weight difference at 20% is 0.17 kg at 40% is 0.39 kg at 60% is 0.98 kg and at 100% is 1.72 kg.

Graph of compressive strength

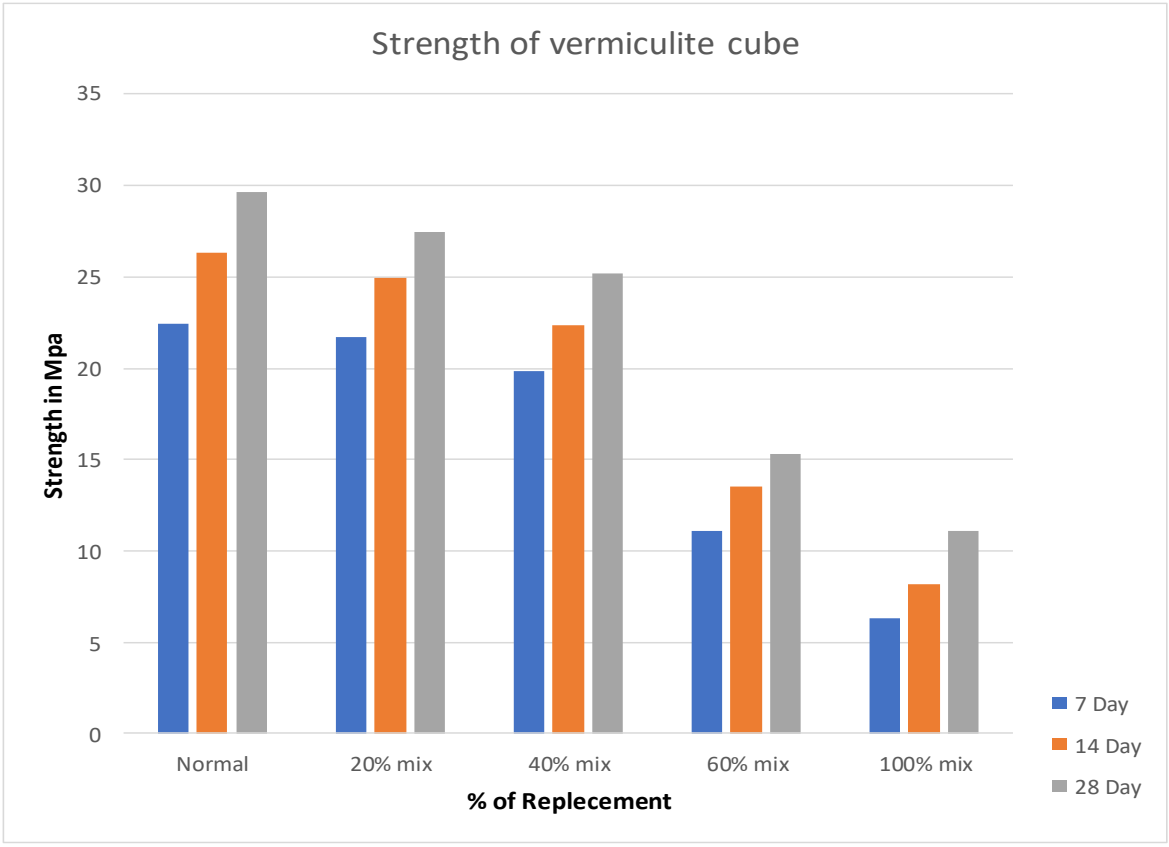

Fig 3.1:- Compressive Strength

3.2 Procedure

3.2.1 Sample preparation

Before the mixing procedure, a part of mixing water at the percentage of water absorption capacity of expanded vermiculite aggregate by weight was added to vermiculite to make it fully saturated with water.
Fig. shows the expanded vermiculite particles saturated with water.

Fig 3.2:- Sample preparation

3.2.2 Mixing

Then, the rest of the mixing water cement and silica fume or steel fiber were mixed together for 1 minute in a mixer, and finally, expanded vermiculite aggregate saturated with water was added to cement slurry and mixed for 3 minutes again, to get a homogenous structure.

Fig 3.3:- mixing and cube casting

3.2.3 Compaction

After proper mixing of concrete the compaction of concrete in cube is done by surface vibrator.

Fig 3.4:- Compaction

3.2.4 Compression Testing

Compression testing is carried out for 7, 14, 28 days.

Fig 3.5: - Testing of concrete cube

4. CONCLUSION

The initial test results shown that adding vermiculite in to lightweight concrete 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 replacement up to 40% is recommended. Here from experiment the Conventional concrete cube and the vermiculite concrete cube strength is comparatively same up to 40%.

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