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A REVIEW OF LIGHT WEIGHT CONCRETE USING VERMICULITE

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Abstract - It is evident from literature review that in the recent decades the thrust for finding an alternative to the costly steel reinforcement is increasing, several alternatives have been tested across the globe. Some viable alternatives are found, also many techniques of replacing the sand and addition of compressive strength to concrete is studied. The methods which are found to be cost effective and feasible are also tried in construction in various areas. Once, such alternative technique is providing subsidiary reinforcement in the way of addition of vermiculite to the concrete. This project is to be carried out on concrete cubes with various percentage of vermiculite 5%, 10% and 20% by volume of sand. Experiments were conducted on testing cubes after casting which increases the strength considerably by adding vermiculite. In addition to that, Vermiculite plays a major filler role in concrete instead to sand. By using this material, the wastes are recycled. Because Vermiculite is an abundantly available waste from the vehicle production industry. This is recycled without emitting as solid waste into the environment.

Keywords- Compressive strength, Flexural strength, Vermiculite, Density

I. Introduction

Lightweight concrete can be defined as a type of concrete which includes an expanding agent in that it increases the volume of the mixture while giving additional qualities such as nail ability and lessened the dead weight. It is lighter than the conventional concrete. The use of lightweight concrete has been widely spread across countries such as USA, United Kingdom and Sweden. The main specialties of lightweight concrete are its low density and thermal conductivity. Its advantages are that there is a reduction of dead load, faster building rates in construction and lower haulage and handling costs. Focused were on the performance of aerated lightweight concrete such as compressive strength tests, water absorption and density and supplementary tests and comparisons made with other types of lightweight concrete.

Pozzolanic admixtures react with CaOH generating additional CSH phases, resulting in a more compact concrete with increase durability. Some supplementary cementitious material, like fly ash has very slow hydration characteristics thus providing very little contribution to early age strength, while others like vermiculite possess a high reactivity with calcium hydroxide having the ability to accelerate cement hydration. Since current concrete structures present higher permeability levels that allow aggressive elements to enter, leading corrosion problems, using pozzolanic admixtures not only reduce carbon dioxide emissions but also allow structures with longer service life, thus lowering their environmental impact. Nevertheless, studies on the durability performance of concrete containing pozzolanic by-products are recent and still scarce. This paper presents experimental data about the strength and durability performance of vermiculite, fly ash based concrete. An effective way to reduce the impact on the environment is to use supplementary cementitious materials (SCM) as a partial substitute for cement. This strategy has the potential to reduce costs, save energy and reduce waste volumes. There are so many studies in the literature focusing on the improvement of concrete performance by replacement of Portland cement to some extents of various mineral admixtures; such as, fly ash, silica fume, blast-furnace slag, etc. Generally, the effects of mineral admixtures may be assessed as improvement in workability, durability to thermal cracking, durability to chemical attacks, and production of high performance concrete. In addition to their positive environmental impact, SCMs may improve concrete workability, mechanical properties, and durability. SCMs may possess pozzolanic or latent hydraulic reactivity or a combination of these. The term pozzolan refers to a siliceous material, which, in finely divided form and in the presence of water, will react chemically with calcium hydroxide to form cementitious compounds. Pozzolans can be of natural or industrial origin. Natural pozzolans include volcanic ash and diatomaceous earth, although pozzolans from industrial by-products are more commonly used today. Recently, there has been a growing interest in the utilization of high-reactivity vermiculite as a supplementary cementitious material in concrete industry.

Types of Lightweight Concrete - Lightweight concrete can be prepared either by injecting air in its composition or it can be achieved by omitting the finer sizes of the

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aggregate or even replacing them by a hollow, cellular or porous aggregate. Particularly, lightweight concrete can be categorized into three groups: i) No-fines concrete ii) Lightweight aggregate concrete iii) Aerated/Foamed concrete .

No-fines concrete can be defined as a lightweight concrete composed of cement and fine aggregate. Uniformly distributed voids are formed throughout its mass. The main characteristics of this type of lightweight concrete is it maintains its large voids and not forming laitance layers or cement film when placed on the wall. It usually used for both load bearing and non-load bearing for external walls and partitions. The strength of no-fines concrete increases as the cement content is increased. Insufficient water can cause lack of cohesion between the particles and therefore, subsequent loss in strength of the concrete. Likewise too much water can cause cement film to run off the aggregate to form laitance layers, leaving the bulk of the concrete deficient in cement and thus weakens the strength.

Porous lightweight aggregate of low specific gravity is used in this lightweight Concrete instead of ordinary concrete. The lightweight aggregate can be natural aggregate such as pumice, scoria and all of those of volcanic origin and the artificial aggregate such as expanded blast-furnace slag, vermiculite and clinker aggregate. The main characteristic of this lightweight aggregate is its high porosity which results in a low specific gravity. The lightweight aggregate concrete can be divided into two types according to its Application. One is partially compacted lightweight aggregate concrete and the other is the structural lightweight aggregate concrete. The partially compacted lightweight aggregate concrete is mainly used for two purposes that is for precast concrete blocks or panels and cast in-situ roofs and walls. The main requirement for this type of concrete is that it should have adequate strength and a low density to obtain the best thermal insulation and a low drying shrinkage to avoid cracking. Structurally lightweight aggregate concrete is fully compacted similar to that of the normal reinforced concrete of dense aggregate. It can be used with steel Reinforcement as to have a good bond between the steel and the concrete. The concrete should provide adequate protection against the corrosion of the steel. The shape and the texture of the aggregate particles and the coarse nature of the fine aggregate tend to produce harsh concrete mixes.

Aerated concrete does not contain coarse aggregate, and can be regarded as an Aerated mortar. Typically, aerated concrete is made by introducing air or other gas into a cement slurry and fine sand. In commercial practice, the sand is replaced by pulverized fuel ash or other siliceous material, and lime maybe used instead of cement. There are two methods to prepare the aerated concrete. The first method is to inject the gas into the mixing during its plastic condition by means of a chemical reaction. This method is usually used in precast concrete factories where the precast units are subsequently autoclaved in order to produce concrete with a reasonable high strength and low drying shrinkage. The second method, air is introduced either by mixing-in stable foam or by whipping-in air, using an air- entraining agent. It is mainly used for in-situ concrete, suitable for insulation roof screeds or pipe lagging.

II. Vermiculite in Light Weight Concrete

A. V. V. Sairam (2017)In this case fine aggregate is partially replacement of vermiculite. Use of vermiculite in concrete it will enhance the shrinkage and crack resistance, fire resistance and reduces environmental impact and also reduce the cost. In this present study, an attempt has been made to study the mechanical properties of M35 grade concrete with different percentages at a range of 5%, 10%, 15%, 20%, 25% and 30% as partially replacement with vermiculite to the total weight of fine aggregate along with mineral admixtures like Fly ash (FA) is replace with cement by various percentages i.e., 10%, 15% and 20% and silica fume (SF) as adding of 5%, 7.5%, 10% and 12.5% by weight of cement. Water cement ratio is 0.42. Optimum percentage of compressive strength is obtained.

NM Wajid (2016)In this paper, an adsorption Heat Storage System (AdHS-R134a)/heating system utilizing Vermiculite and Calcium Chloride composite adsorbent material was experimentally investigated. The main aim of the experimental investigations is to carry out preliminary tests on a small scale Adsorption Heat Storage Systems (AdHS-R134a) using a heat pump circuit as the regeneration heat source. The test rig was constructed using Vertical Glass Pipes with a heat pump circuit using a mini compressor for transporting the refrigeration gas a a heat source for desorption cycle. The system also incorporates condenser coils, evaporator coils, and an expansion valve. The integration with a heat pump circuit is to analyze the performance of an AdHS-R134a using off-peak power in desorption/charging cycle or utilizing renewable energy sources to minimize conventional energy generated from fossil fuels. Firstly, desorption phase occurs during night hours, when cheap off-peak electricity is available under the 'Economy 7' tariff that is more suitable for households with night storage heaters or if we use lots of electricity at night. Secondly, in the heat pumping phase/adsorption loop which will occur during the day. The useful heat of adsorption in the adsorbent pipe could be used for under floor heating (35°C-40°C), or for domestic hot water production (55°C-60°C) during the day. The maximum temperature lift observed from the adsorption process is 68.67°C (inside adsorption pipe) with the corresponding COP of 0.55-1.39.

S Syed Abdul Rahman (2016)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 power as a partial replacement of sand. Three mixes were produced with the cement content of 479kg/m^3 in M30 grade and water cement ratio is 0.40. More over the group had proportion of 0%, 5%, 10%, as vermiculite replacement.

L.Vijayan (2016)In this paper the exfoliated vermiculite is used as a replacement of fine aggregate. This project is mostly related in places where the ecological temperature is very high. The Replacements were done in 5, 10 and 15% of fine aggregate. And finally conclude that the Vermiculite replaced concrete shows insignificant decrease in density up to 15% when compared to normal concrete. In split tensile test no much variation in split tensile strength when compare to normal concrete.

S Syed Abdul Rahman (2016)In their 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 reasonable structural light weight concrete by the use of vermiculite power as a partial replacement of fine aggregate. Three mixes were created with the cement content of 479kg/m^3 in M30 grade and water cement ratio is 0.40.The proportion of 0%, 5% and 10%, as vermiculite replacement to fine aggregate. And lastly they concluded that the 10% replacement of vermiculite to fine aggregate well compared to control mix.

M.R.Divya (2016) have study on M30 grade concrete using vermiculite as partial replacement with 40%, 50% and 60% to the total weight of fine aggregate. The aim of their project is to study the strength parameters such as compressive strength, split tensile & flexural strength of concrete. Result shows the optimum strength in compare the strengths for different vermiculite percentage was observed to be 50%.

Praveen Kumar E(2015)In the present study, exfoliated vermiculite is studied, it is used as a filler material because of its low bulk density, high refractoriness, low thermal conductivity and adequate chemical inertness. All along vermiculite has high amount of silica content. Thus effective utilization of silica based materials as a building material. Presently, vermiculite is used for its light weight in the construction industry as a filler material above the deck slab. Experimentally some of cases are studied by using vermiculite in some of the applications in the construction industry. Case 1: One of the famous for tradition was originated in India at conventional tile which is especially designed for Chettinad. Following some same methodology of the traditional tiles designed some of the mix proportions by increasing the usefulness of the tile. The tile which accepts the heat resisting parameters we designed the tile fulfilling the heat insulation property, flooring tile, roofing tile and as well as in weathering course tile replacing conventional weathering coarse tiles. Various mixes were prepared using different percentage of vermiculite and water cement ratio. The developed vermiculite cement tiles exhibited low water absorption, better strength properties compared with the tradition famous conventional tiles used for flooring tile purpose. Thus it involves a continuous study and it combined by introducing the material which is suited for construction industry with vermiculite. Vermiculite insulated tile which is light in weight which is easy to handle. Designed some vermiculite mortar with various mix design ratios. Second case if it is implemented in concrete the strength parameters and some of the physical properties of the vermiculite insulated products. The special characteristics and usage of this material would decrease the structural weight can be decreased. Considering some other characteristics it is quite good material if it is replaced partial form gives better result.

F.P. Alvaraz Rabanal (2013)Present work is to study the effect of mixing of vermiculite in weathering coarse and flooring works. Vermiculite, in ore concentrate and exfoliated state, may contain small quantities of crystalline silica, as quartz. This is usually only present as non-respirable particles but mechanical action such as milling may reduce any quartz that may be present to a respirable particle size. Silica is a very abundant material in a variety of forms and accounts for approximately 20% of the earths crust with 95% being quartz. It is present in nearly all mining operations, and as an extremely common mineral has been the subject of many detailed studies, summarized in the Crystalline Silica Primer published by the US Bureau of Mines. Trace amounts of free silica are often found in silicate minerals while materials such as sand and gravel consist mainly of free silica. It has been known for centuries that prolonged and excessive exposure to high concentrations of respirable free silica in dust can cause a related lung disease of occupational origin, silicosis. This

is a non-cancerous, but extremely serious lung disease. Recent attention has focused on a relationship between silica and lung cancer. Confounding factors in human studies and flaws in animal studies have not given rise to conclusive evidence, however the International Agency for Research on Cancer (IARC) have now classified crystalline silica as a carcinogen. Some countries will even require any material containing more than 0.1% crystalline silica to be labeled as a carcinogen. Reported that in recent years, an attempt to increase the utilization of vermiculite in worldwide up to 80%.vermiculite is partially replace the use of ordinary Portland cement, in concrete has been gathering momentum. Results of an experimental study have been presented to determine the effect of randomly The developed vermiculite concrete exhibited low water absorption, better strength properties and low thermal conductivity compared with the ordinary cement concrete used for light weight concrete purpose.

Fuat Koksal (2012)This paper presents the results of study undertaken to investigate the feasibility of using vermiculite cement in concrete. The effects of replacing cement by vermiculite to increase the compressive strength of concrete. Two test groups were constituted with the replacement percentages of 0%, 5%, and 10%.The results showed the effect of vermiculite on concrete has a considerable amount of increase of the compressive strength. Light weight concrete is to reduce the self-weight of structure at the same time gives high Strength to compare the conventional concrete. Add chemical bonding materials gives enormous strength occur in concrete. Cement replacement levels and also compare with vermiculite concrete and ordinary concrete.

III. Conclusion

This review was conducted to evaluate the effect of using Vermiculite as the partial replacement of fine aggregate in concrete composites and also give an idea using these materials within specific range. Several tests were conducted on the materials of the concrete composites and the reports are noted. From this study we can understand exact percentage of increase in Compressive and Flexural strength of the Concrete and moreover, Durability results. Due to this vermiculite can be considered as a very high efficient replacement material. Experimental study in this shall prove the results.

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