

Effect of Fly Ash on Mechanical Properties of Light Weight Vermiculite Concrete

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ABSTRACT: Concrete is second most using material in the world today. Attributing mainly to low cost of materials and maintenance. Much advancements in concrete technology have been occurring from last three decades. Light weight concrete (LWC) is formed by light weight aggregates (Vermiculite) Light weight vermiculite is one type of light weight concrete. Vermiculite is a light weight and cheap product because of its thermal resistance has become a valuable insulating material. The density of these concrete varies from 750 Kg/m³ to 2050 kg/m³. This less density enhances reduction of dead load which results much economical design of structures. Effect of fly ash as partial replacement for cement in light weight vermiculite concrete were investigated by replacing 0%, 10%, 20% and 30% of cement content with fly ash, in which up to 20% shows optimum results and a significant increase in density and compressive strength of light weight vermiculite concrete..

KEYWORDS: Light weight concrete (LWC), Vermiculite and Light weight aggregate.

I. INTRODUCTION

Concrete is one of the composite construction material that composed primarily of aggregate, water and cement. It has been used widely in the field of construction for making various structures such as architectural structures, foundations, pavements, bridges, and so forth. Therefore, the various concrete types available now a day are attributed to the continuous research and development of concrete over the years to provide more alternative construction material for making construction structure. However the popularly utilization of lightweight concrete, also known as aerated concrete in European countries construction field due to its versatilities and lightness, which has brought offer application of new alternative building material for the improvement of concrete density.

By using the lightweight concrete which possesses low density properties, it is capable of contributing towards the reduction of building dead load and resulting in more economic structural design (Short and Kinniburgh, 1978; Narayanan and Ramamurthy, 2000b) as reduction of dead load may consequently the reduction of size of bearing load structure. The practical range of concrete density for lightweight concrete is between 300 kg/m³ and 2050 kg/m³(Neville,2006) 87 to 23% lighter. It was first introduced by Romans in the Second century where 'The

Pantheon' has been constructed using pumice, the most common type of aggregate used in that particular year. From there on, the use of lightweight concrete has been widely spread across other countries such as USA, United Kingdom and Sweden. Besides that, other than lightweight concrete possess the advantage of low density properties, it is also good in fire resistance, thermal insulation properties, and faster buildings rates in construction and lower haulage.

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Nowadays , lightweight concrete are commonly used in precast and pre stressed components, Specifically speaking, while lightweight concrete compels higher costs compares to normal weight concrete, structures may yet have lower costs as a results of the reductions in dead weight, foundation sizes and costs, and consumed reinforcement bars. Common types of lightweight concrete are composed of lightweight aggregates from natural sources (such as pumice, diatomite, scoria and tuff) and processed by-product or unprocessed porous materials (such as expanded clay, slag, slate and vermiculate); the former having comparatively lower costs.

The present research is to study the engineering properties of different types of lightweight concrete incorporated with vermiculite (light weight aggregate) and fly ash in terms of compressive. On overall, this study has to produce a mix proportion using different types of light weight agents with targeted density of 750 to 2000 kg/m³ and tolerance of 50 kg/m³.

LWVC with 100%, 50% and 33% replacement of fine aggregate with light weight vermiculite and replacement of cement with 0%, 10%, 20%, 30% fly ash samples are prepared. During the laboratory work, workability test were carried out before the plain mortar added to the vermiculite to measure the workability of fresh concrete. However, in order to study the maximum compressive strength of light weight concrete produced, optimum w/c ratio must be determined through a trial mixes with various w/c ratio. In this study, the trial w/c ratio for respective mix ranging was started from 0.17 to 1.7. The water curing method is used for further hydration process of concrete cubes for further hydration process of concrete cubes with water curing method used. Then the water cured for concrete cubes for 7 days, 14 days, 28 days were tested by compressive strength test in order to calculate the performance based vermiculite concrete and to obtain the optimum w/c ratio for each mix proportion respectively. The engineering properties of LWVC then studied and discussed.

II. MATERIALS USED

A. Ordinary Portland cement:

The Ordinary Portland Cement (OPC) which is produced by JP cement under the brand name of “JP 53 GRADE” was used throughout the study. The OPC was sieved through 600 μ m sieve and was stored in air tight container in order to maintain the quality of cement such as to prevent air moisture contact as hydrated cement particle would affect the formation of calcium silicate hydrate gel. According to ASTM C150 (2005), the OPC used throughout this research is compiled with Type -1 Portland cement and the details chemical composition of OPC is given in the Table.1

Physical Properties	Test Result
Consistency limit	32% by weight of cement
Setting time (Vicat apparatus	
Initial setting time	115 min
Final setting time	200 min
Compressive strength of cement	49.27 KN/m ³
Fineness of cement	5%

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B. Vermiculite

Vermiculite is a light weight and cheap product that, because of its thermal resistance has become a valuable insulating material. Used as an aggregate with Portland cement it forms an ultra-light weight concrete with an open structure ideal for void filling, suitable for use in most light industrial and domestic applications where thermal insulating and fire proof properties are required.

C. Sand

In this study, only fine sand (zone – III) was used in the production of cement based aerated concrete. The sand was dried in an oven at a temperature of $1050C \pm 50C$ for at least 24 hours to remove the moisture in it. Then, the dried sand was sieved through 425 μ m sieve before it stored in airtight container to prevent atmospheric humidity contact.

D. Fly ash

Fly ash and bottom ash result mostly from coal combustion and significantly from incineration of other materials—to a large extent, municipal waste. Their use is primarily local, except for the amount used to serve the cement industry, which finds the ash's pozzolanic properties attractive as an admixture to Portland cement. Most coal-consuming and waste processes produce fly ash rather than cinders, so fly ash production continues to increase with both the increased use of pulverized coal in electric power generation and with waste incineration.

Approximately 600 kt of fly ash are produced annually, but utilization is only about 13% (Kiser and Zannes 2002). The production of lightweight aggregate from fly ash has potential as a significant market, but improvement in the technology is needed to spur use as a lightweight-aggregate raw material. Fly ash helps to develop long-term compressive strength in concrete.

III. MIX PROPORTIONS AND TRAIL MIX

A trial and error process is commonly adopted to achieve light weight vermiculate concrete with the desired properties. In this study, w/c ratio is determined by trail mixes by considering density of concrete. The optimum mix proportion was obtained based on density and strength of lightweight vermiculate concrete. In this study, during trail mixing, three types of mix proportion were casted such as LWVC with 100% sand as filler (LWVC) which was used as control specimen and sand is replaced by 33% and 50% of vermiculite. The fly ash percentage replacement for cement by 0%, 10%, 20%, 30%. The water to cement ratio for each type of mix proportion was tried from range of 0.60 to 1.65 with the increment of 0.5 to 0.1 for each mix. Density for mix was controlled to $1800 \text{ kg/m}^3 \pm 50 \text{ kg/m}^3$. The effect of fly ash is tested for optimum w/c ratio.

A. Mixing Procedure

Firstly, OPC, sand, vermiculite, and fly ash was weighted and mixed in dry condition in a tray by manual mixing until the dry mix was uniformly mixed. Next, water was weighted and added into the dry mix and mixed until the wet mix was uniformly mixed. 700 to 2050 kg/m^3 was achieved. Water added to the mix calculated depending on workability requirements as a percentage of binding materials. Moulds (150 \times 150 \times 150) mm were used to prepare three samples for each proportion and the surface of each tamped by the rod in order to prepare the mix uniformly, the surface of the mould then was covered by plate (150 \times 150) mm with light load.

B. Curing Condition

Curing condition is very important in gaining the strength of lightweight vermiculite concrete as it provides good condition for hydration process of concrete specimens. In this study, water curing method was adopted and all specimens were cure in water curing after de mould for 7, 14, 28 days until testing age, respectively. The temperature

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of water tank for curing of concrete is controlled in range of 250C to 280C. After one day of the samples were removed from moulds and were soaked in water of 230C Temperature and covered with polythene sheets, and kept to the time of test.

IV. EXPERIMENTAL PROGRAM

Light weight concrete using vermiculite was prepared by replacing conventional aggregate with vermiculite, the light weight aggregate. The replacement of fine aggregate was done completely (100%), 50%, 33%. In other mixes cement was replaced with fly ash and the replacement was done as 0%, 10%, 20% and 30% of cement. The cubes were prepared for test according to above proportions by volume. The proportions of mix design are 1C:1S:1V, 1C:1S:2V, 1C:6V. The results about the compressive strength and densities of light weight concrete using vermiculite. The densities and compressive strength for each mix were discussed. The specimens for each mix proportions were cured in water for 7, 14 and 28 days before carrying out compression test.

V. RESULTS

The test results were represented in tabular forms below and the variation strength with respect to age of curing were represented through graphs. The strength variation with respect to densities of mixes using vermiculite was also mentioned in tabular forms as well as in graphs. The compressive strengths of different mixes with different mixes with different water content were also shown in tabular forms.

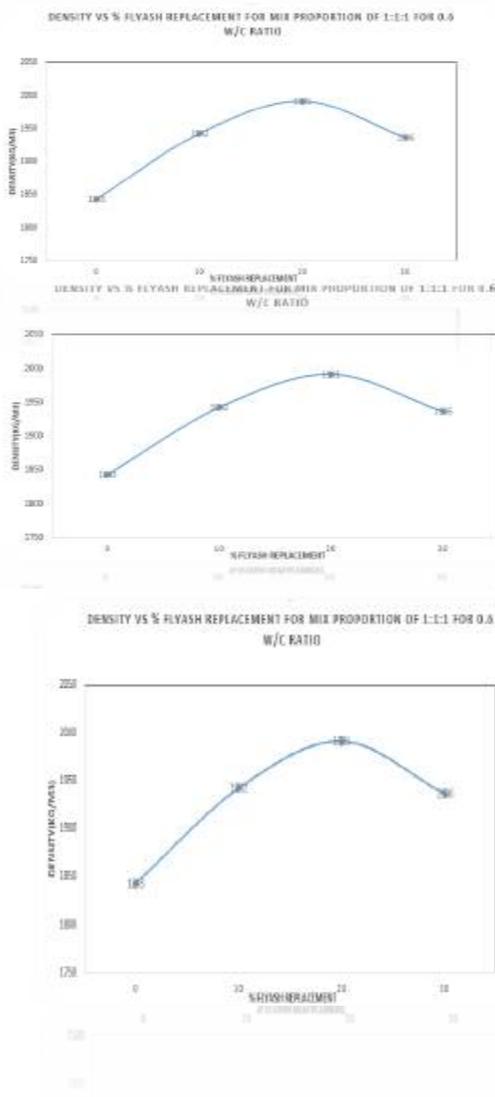
a) Density

Proportions	Fly ash (%)	Densities(KN/m ³)
1:1:1 0.6(w/c)	0	1843
	10	1942
	20	1991
	30	1936
1:1:2 0.65(w/c)	0	1903
	10	1938
	20	1904
	30	1871
1:5 1.6125(w/c)	0	1265
	10	1300
	20	1228
	30	1194

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b) Slump

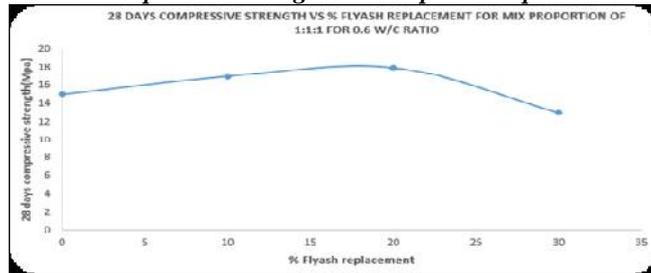
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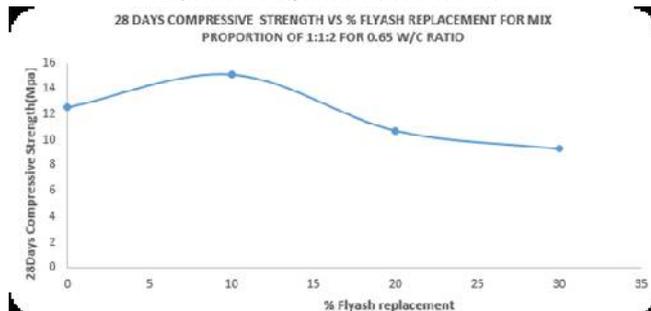
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Proportions	Fly ash (%)	Slump(mm)
1:1:1 0.6(w/c)	0	22
	10	24
	20	21
	30	23
1:1:2 0.65(w/c)	0	21
	10	25
	20	22
	30	23
1:5 1.6125(w/c)	0	24
	10	23
	20	21
	30	22

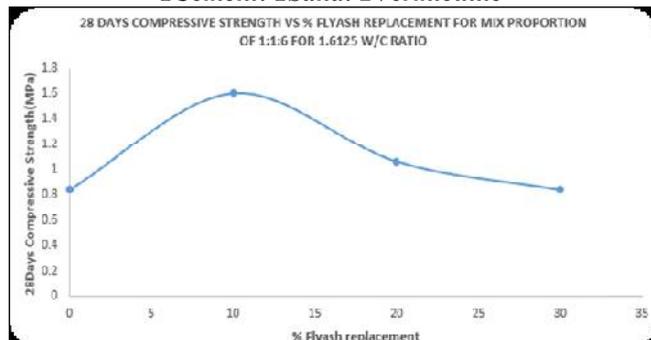
c) *Variation in compressive strengths due to partial replacement of Fly ash*



1Cement: 1Sand: 1Vermiculite



1Cement: 1Sand: 2Vermiculite



1Cement: 6Vermiculite

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From the above graph, it is clear that, effects of partial replacement of cement with fly-ash shows considerable effect on 28 days compressive strength of lightweight vermiculite concrete. So, it is clear that, fly ash only shows significant effect on long-term compressive strength. The effect of vermiculite in lightweight concrete has been studied and discussed in terms of compressive strength and densities. As the water absorption capacity of vermiculite is more compared to conventional aggregates, the normal mix design cannot be used for LWVC. As vermiculite content in concrete increases, the strength of concrete decreases as shown in the graphs above. The partial and complete replacement of sand with vermiculite has been done and results changes as shown in graphs above. The range of densities for LWVC varies from 1194 KN/m³ to 1991 KN/m³ and strength varies from 0.84 MPa to 18 MPa.

VI. CONCLUSION

Based on the laboratory results and observations, the following conclusions can be shown. Based on the study of results, as vermiculite content in concrete increases, strength and densities decreases.

The water absorption percentage increases with increase in vermiculite content in LWC. For LWC, as density increases, compressive strength also increases. As the water absorption of vermiculite is more, this type of concrete is not recommended in places where water scarcity is there. This type of LWC is mostly suitable for insulating materials for increasing fire and sound resistance.

It can also be used as filler material in the field of construction. The proportion 1C: 1S: 1V can be used for structural elements in the construction. Optimum values of density and compressive strength are obtained at fly ash replacement of 10% to 20%. Partial replacement of cement with 0%, 10%, 20% and 30% of fly ash changes long term compressive strength of concrete and density. As the vermiculite percentage increases the strength of lightweight concrete decreases. The effect of fly ash is very less on light weight concrete with higher vermiculite content (i.e 100%replacement) compared to structural lightweight concrete with lower vermiculite content(i.e 33%replacement).

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