Review Paper on Utilization of Fly ash Cenospheres in Cement Concrete

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Abstract— Cenospheres are light weight, idle, inert and hollow particles. These are the constituent particles of fly ash, which is librated from coal based thermal power plant. These are the microscopic spherical balls made up of minor ceramic elements with smooth silica and alumina as the major componenets. It is used in few industries like ceramic, plastic, nylon and construction etc. Many researchers and scientists have been performed the physical, chemical and micro-structural properties analysis of cenospheres to determine its basic properties and beneficial uses. Present research work is focused on the feasibility of cenospheres with cement concrete. In this review paper the effect of cenospheres in cement concrete is discussed, which include the thermal properties, self-weight and strength parameters of cenospheres mixed cement concrete. The aim is the analysis of potential for practical use of fly-ash cenospheres as a binding material in the cement concrete.

Keywords: Cenospheres, microscopic hollow balls, fly ash, thermal power plant, cement concrete

I. INTRODUCTION

Cenospheres are hollow, empty, strong, microscopic spherical particles, comprising of silica and alumina as major elements loaded with air or gases. Cenospheres are the result of ignition of pulverized coal at high temperature in thermal power plant. Cenospheres are light weight inert and idle particles, which are made up of silicon dioxide, aluminium oxide and iron oxide. The size of these particles are found in the range of 1to 500µ. They possess lower density due to hollowness and higher strength with, about 300psi as average compressive strength. These are the by-product in the form of fly-ash of coal burning power plants. In the process of burning of coal in thermal power plants, the fly-ash is librated as waste product containing ceramic particles of alumina and silica. When burning of coal is occurred at 1500^0 to 1750^0 C temperature, these cenosphere particles are produced, through complicated physical and chemical transformation.

The physical properties of the cenosphere particles are as follow:-

- Particle density – 0.6 – 0.7 g/cc
- Moisture – <0.5%
- Particle size – 10-300micron

The chemical compounds presents in the cenosphere particles are as follow:-

Silica	(SiO_2)	55 – 58 %
Alumina	(Al_2O_3)	>35 %
Iron oxide	(Fe_2O_3)	<2 %
Calcium oxide	(CaO)	>2 %
Magnesium oxide	(MgO)	< 1 %
Potassium oxide	(K_2O)	>1 %

Table 1: Chemical Composition of Cenospheres

These particles are utilizing by various industries in present days like, paints, plastics, ceramics, etc. But their production rate is much higher than its utilization rate. On other side, fly-ash as well as cenospheres both are air pollutants, which cause so many harmful impacts on human life. On the bases of researches conducted on cenospheres, it is observed that cenosphere particles can also be used in construction industries.

II. LITERATURE REVIEW

Asad Hanif, Pavithra Parthasararhy (2017) Thermal insulating composites help to reduce total power consumption in a building by creating a barrier between external and internal environment. This study proposes to produce light weight cement based composite for thermal insulating application. Cement is partially replaced with Silica fume and fly ash cenosphere and used as the light weight filler. Aerogel is used to improve thermal insulating behaviour. The samples are tested for density test, thermal property and morphological and micro structural characteristics. Various tests like, Scanning Electron Microscopy, Energy Dispersive X-ray Spectroscopy (EDS) compression test flexural test are performed. The concrete mix samples are also tested for maximum temperature difference between outer face and inner surface. The difference in temperature up to 16.78^0C is achieved which indicated thermal barrier of building. The micro structural analysis indicated excellent bonding of fly ash cenospheres and aerogel in cementious system.

Zeyu Lu, Yu Cheng, Su Diao, (2017), in their experimental study the effects of various lightweight functional filler materials on the properties of cement concrete are investigated. They include fly ash cenospheres and glass micro-spheres in different proportions. The developed composites are tested for compressive, flexure and tensile strength. The result indicated that both cenospheres and glass micro-sphere are excellent filler materials for strong lightweight composites. They can be employed for structural purposes where higher mechanical strength is required. Fly ash cenospheres and glass micro-sphere are well suited for fibre-reinforced composites to efficiently utilize the tensile properties of fibres. Higher weight fraction of the fillers in composition leads to increased porosity which might be determinal to their strength development.

Subharjit Sen (2014). In this research work the physical properties of fly ash cenosphere is analysed by experimental analysis. Various tests like particle size distribution, specific surface area, compaction characteristics, composition analysis morphological analysis and thermal analysis. On the basis of result it has found that cenosphere consists of particles with wider range between 0.005mm to 0.035mm, and mean diameter is 0.117mm. Quartz and alumina are most abundant minerals in cenosphere. Its particles are stable up to higher temperature (1000^0 C) with negligible mass loss.

Jun-Yan Wang, Wei Li, KOk-Seng Chie (2012), in their research work, the characteristic properties and stability

of cenospheres particles used in lightweight cement composites are analysed. ASTM C227 test and C1260 test are used to calculate that cenosphere is potentially deleterious due to alkali-silica reaction. Energy-Dispersive X-ray Spectroscopy, X-ray diffractometer and thermogravitymetry test were on sample. Results show that the cenospheres particles used, are not found potentially deleterious due to alkali silica reaction. Expansion of mortar specimen is found to be affected by pozzolanic reactivity of cenosphere. Fine cenosphere showed less pozzolanic reactivity at temperature of 28-30^{0}C and 38^{0}C, but exhibited higher pozzolanic reactivity at 80^{0}C in which aluminium tobermorite is found as the main reaction product.

Dung D. Luong, Nikhil Gupta Atef Daoud (2011) in this study the rate of strain dependence of compressive strength is determined for aluminium alloy and hollow fly ash cenospheres composites. Quasi static and higher strain rate compressive test are conducted. From tests it is concluded that alloy do not show any significant strain rate sensitivity, but the composite showed higher compressive strength at higher strain rate. For fly ash cenosphere composites, the energy absorption capability is also found to be higher when strain rate is higher.

S. P. Mc Bride, A. Shukla, A. Bose (2002) conducted the analysis to prepare light weight concrete using ceramic microsphere, known as cenosphere, as a primary aggregate. This concrete sample was tested for various tests like compressive strength test, tensile strength test, flexural strength test and fracture toughness. Silica fume and Saline™ were added to improve interfacial strength between cement and cenosphere. It was found, from test results, adding high volume of cenosphere significantly loweres the density of concrete. But it is responsible some strength losses that can be recovered by silica fume.

P. K. Koyal, D. N. Singh (2000) in this investigation the basic properties of cenosphere like physical chemical and thermal properties is analysed. The particle size is found range from 0.03 to 0.055 mm. The specific gravity of cenospheres sample is observed to be 0.78. The most predominant minerals of cenosphere observed are Alumina and quartz. These particles are observed approximately uniform in size and specific surface area is quite low. The thermally stability of cenospheres sample is observed up to a maximum of 280^0 C.

F. Blanco et al., (2000) the study was done to find the possibility to manufacturing the light weight concrete using cenosphere. The concrete mix was tested for thermal conductivity, mechanical resistance and acoustic absorption. Cenospheres are advantageous to prepare light weight concrete than other filling materials because it is hollow particle. When the pores of concrete were filled by cenospheres particles, better improvement was noticed in thermal conductivity y. On the other hand the strength was reduced in concrete.

Nikhil Barbare (2003), this study is based on low specific gravity (0.67) materials that makes them as the ideal replacement for sand to prepare low density concrete. Moisture content of cenosphere and sand are compared. The equilibrium moisture content of cenospheres is nearly 18 times greater than sand, which reflects the porous nature of cenospheres. The wash-burn is used to analyse the temporal evolution of water penetration into the cenosphere-concrete. The result shows the less of connectivity among the pores, which leads to allow low permeability. The water vapour flux, away from both the cenosphere concrete and normal concrete, indicates a nonlinear change with water content throughout the drying cycle, which ultimately shows that the pore structure within the concrete strongly influences the drying behaviour.

III. Conclusion

Cenospheres are micro-structural, light weight, hollow particles. They are extracted from industrial waste fly ash. On the bases of literature discussed here it is concluded that cenospheres can be used in concrete which modify the properties of concrete. It provides better thermal insulation and reduces its self-weight. When some additives with conospheres are used like aerogel, silica fume, etc. the adhesive property of concrete increase, which improves the strength of concrete. But the quantity of cenospheres used in concrete have some limitations. If it is used in higher than optimum amount it reduces strength of concrete. Keeping all these points in consideration, finally it may be concluded that cenospheres can be used in concrete beneficially to improve the quality of conventional concrete.

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