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Study of properties of Portland cement concrete of fly ash and silica fumes

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Abstract
The aim of present study was to study of properties of Portland cement concrete of Fly Ash and Silica Fumes. Concrete pavement has long been considered an environmentally and economically sustainable pavement choice for its longevity. This hallmark of concrete pavements ensures that the desirable performance characteristic of the pavement remains essentially intact for several decades. Concrete pavement mixtures incorporate industrial by products i.e., (fly ash and silica fumes) which lower the disposal needs, reduces the demand on virgin materials, and conserves natural resources. The technical characteristics of the concrete which includes local Fly Ash and Silica Fumes are well described including durability performance observation. The usage of these industrial by products to replace the cement is because the production of cement emits carbon dioxide gas in to atmosphere by increasing the effect of global warming.

Keywords: Ordinary Portland cement (OPC), fly ash and silica fumes

Introduction

Fire causes thousands of deaths and loss of property loss every year. The need to understand the manner in which cement based material such as brick behave at higher temperature is cardinal need for public safety. There are two fundamentally different approaches exist to make brick and other building products. The first is to make bricks in the same way fired clay bricks are made except for the use of fly ash to substitute for a portion of the clay or the entire amount of clay used in making bricks. This approach requires the newly shaped bricks to be heated in kilns fired to over 2000°F, which consumes much energy, pollutes air and contributes to global warming. The second method is to make bricks with the help of fly ash (Class F) that contain large amount of silicate, do not need to fire or heat the products in kiln. Instead, the products can be cured in the same way concrete is cured by keeping the products in a wet environment for more than 24 hours until the material sets and harden due to chemical reaction with water or moisture contained in the products. Fly ash is a by-product from coal based thermal power plants. Its large-scale availability in countries like India creates disposal problems and hence need for development of its eco-friendly applications. FA utilisation level at present is only about 60%. Fly ash is generated in thermal power stations. It is fine particulate material precipitated from the stack gases of industrial furnaces.

In conventional method of concrete pavement construction natural resources like sand, stone metal are used which causes ecological imbalances. The use of Fly Ash and silica fumes in concrete pavement construction will save such resources. The costly ingredient in concrete is cement; some portion of the cement is replaced by silica fumes and fly ash which results in reducing the cost of the concrete without any change in strength. The usage of industrial wastages such as Fly Ash and Silica Fumes will solve the problem of disposal and automatically reduces the cost of the pavement construction. Properly designed and constructed concrete structures are favorable compared to the other material like steel and timber. So we can obtain low cost concrete mix with partial replacement of mineral admixtures such as Fly Ash and Silica Fumes.

Sasikumar (2016) [1] Performed an Experimental Investigation on Properties of Silica Fumes as a Partial Replacement of Cement. Main parameter investigated in this study is M30 grade concrete with partial replacement of cement by silica fume 0%, 25%, 30%, 40% and 50%. The normal consistency increases about 40% when silica fume percentage increases from 0% to 25%. The optimum 7 and 28-day compressive strength has been obtained in the 25 % silica fume replacement level. Also the split tensile strength is high when using 25% silica fume replacement for cement.

Amarkhail (2015) [2] observed Effects of Silica Fume on Properties of High-Strength Concrete. He found that up to 10% cement may be replaced by silica fume without harming the concrete workability. Concrete containing 10% silica fume replacement achieved the highest compressive strength followed by 15% silica fume replacement with a small difference. Concrete with 15% silica fume content achieved the highest flexural strength. 10% and 15% silica fume content as replacement of cement were found to be the optimum amount for significantly enhancement of compressive strength and flexural strength respectively.

Chindaprasirt, *et al.* (2005) [3] investigated on class F Fly Ash of two different fineness, taken from Mae Moh Power plant in north of Thailand and replaced the Portland cement at 0%, 20%, and 40% by weight. It was observed that the compressive strength of classified fly ash (CFA) is higher than original fly ash (OFA) cement paste. It was also found replacement of OPC (ordinary Portland cement) with OFA increases the porosity and decreases the average pore size of the paste. In order to achieve higher strength it is therefore necessary to reduce porosity of cement paste. The blain fineness of OFA and CFA was taken as 300 and 510 m2/kg, and the specific gravities of these two were 2.33, 2.54 respectively. It was found that compressive strength decreases as the total porosity of blended cement paste increases.

Berndt (2009)[4] studied properties of concrete which were made by using partial replacement of fly ash, slag and recycled concrete aggregate. He made different mix by the use of fly ash and blast furnace slag. The results indicates that the concrete having 50% replacement as blast furnace slag provided improvement in mechanical properties and durability.

Jain & Pawade (2015) [5] studied the Characteristics of Silica Fume Concrete. The physical properties of high strength silica fume concretes and their sensitivity to curing procedures were evaluated and compared with reference Portland cement concretes, having either the same concrete content as the silica fume concrete or the same water to cementitious materials ratio. The experimental program comprised six levels of silica-fume contents (as partial replacement of cement by weight) at 0% (control mix), 5%, 10%, 15%, 20%, and 25%, with and without superplasticizer. It also included two mixes with 15% silica fume added to cement in normal concrete. Durability of silica fume mortar was tested in chemical environments of sulphate compounds, ammonium nitrate, calcium chloride, and various kinds of acids.

Hanumesh, Varun & Harish (2015) [6] observes the Mechanical Properties of Concrete Incorporating Silica Fume as Partial Replacement of Cement. The main aim of this work is to study the mechanical properties of M20 grade control concrete and silica fume concrete with different percentages (5, 10, 15 and 20%) of silica fume as a partial replacement of cement. The result showed that The compressive strength of concrete is increased by the use of silica fume up to 10% replacement of cement. From 10% there is a decrease in compressive strength and The split tensile strength of concrete is increased by the use of silica fume up to 10% replacement of cement. From 10% there is a decrease in split tensile strength. The optimum percentage of replacement of cement by silica fume is 10% for M20 grade of concrete.

Methodology

The materials used in this project are:

Cement: 53 grade (OPC – Ultratech Cement) was used in the experimental investigation. It was tested for its physical properties in accordance with Indian Standard specifications. The fine aggregate used in this investigation was clean river sand, passing through 4.75 mm sieve with specific gravity of 2.6. The grading zone of fine aggregate was zone II as per Indian Standard specifications. Machine crushed granite broken stone angular in shape was used as coarse aggregate. The maximum size of coarse aggregate was 20 mm with specific gravity of 2.60. Ordinary clean portable water free from suspended particles and chemical substances was used for both mixing and curing of concrete

Fine aggregate: The fine aggregate obtained from river bed, clear from all sorts of organic impurities was used in this experimental program. The fine aggregate was passing through 4.75 mm sieve and had a specific gravity of 2.44. The grading zone of fine aggregate was zone II as per Indian Standard specifications.

Coarse Aggregate: In this project we are considering angular shaped aggregate of maximum size, 20 mm are tested as per IS: 383-1970. It is crushed granite stone obtained from the local quarry having specific gravity of 2.76.

Fly ASH: Fly ash is a byproduct of the combustion of pulverized coal in thermal power plants. A dust-collection system removes the fly ash, as a fine particulate residue, from combustion gases before they are discharged into the atmosphere. The types and relative amounts of incombustible matter in the coal used determine the chemical composition of fly ash. More than 85% of most fly ashes is comprised of chemical compounds and glasses formed from the elements silicon, aluminum, iron, calcium, and magnesium.

Silica Fumes: Silica Fumes, also known as micro silica or condensed silica fume is another material that is used as artificial mineral admixture. It is an amorphous (non-crystalline) polymorph of silicon dioxide, silica. In the manufacture of silicon or ferrosilicon alloy, high purity quartz is reduce in electrical arc furnace which results in the production of Silica Fumes.

Size of the specimen = 150mm in diameter and 300mm long

Area of the specimen = 17671.45 nm^2

$$\text{Compressive stress} = \frac{load\ in\ N}{area\ in\ nm^2} \ldots\ldots.. N/nm^2$$

$$\text{Strain} = \frac{deformation\ in\ nm}{original\ length\ in\ nm} \ldots\ldots\ldots No\ units$$

Results and discussion

To enhance the strength properties of the ordinary Portland cement (OPC), industrial by products such as Fly Ash and Silica Fumes can be utilized. The effect of Silica Fumes and Fly Ash as a partial replacement of Ordinary Portland Cement on compressive strength, split tensile strength and stress strain behavior of concrete has been studied. To study these properties of concrete, it was categorized in to two groups with two water cement ratios of 0.3 and 0.35. Five types of mix proportions were used to cast the test specimens for both groups. The replacement levels of OPC by silica fumes were 0%, 10%, 20%, 25%, and 30% where replacement levels by Fly Ash were 0%, 10%, 20%, 25% and 30%. All these specimens are tested for 28 days strength. 20% of silica fumes and 20% of fly ash where found to be optimum for maximum compressive strength, maximum split tensile strength at low cost than that of conventional concrete which reduces the consumption rate of cement by 173 kg per cubic meter. Hence by reducing usage of amount of cement the cost of construction can be decreased which leads to low cost concrete pavements with high efficiency.

Table 1: Compressive strength of M 25 concrete at 28 days

S. No.	Properties	W/C Ratio	Average Compressive Strength (N/mm^2)
1.	Conventional Concrete	0.3	39.613
		0.35	36.211
2.	80% Cement +10% Fly Ash +10% Silica Fumes	0.3	25.743
		0.35	34.212
3.	60% Cement +20% Fly Ash +20% Silica Fumes	0.3	18.101
		0.35	31.676
4.	50% Cement +25% Fly Ash +25% Silica Fumes	0.3	12.448
		0.35	23.203
5.	40% Cement +30% Fly Ash +30% Silica Fumes	0.3	11.884
		0.35	23.767

4. Conclusion

Based on the experimental investigations, mechanical properties of concrete like compressive strength, tensile strength durability aspects and stress strain behavior of low cost concrete (with fly ash and silica fumes). The following conclusions are drawn At 28 days the compressive strength of conventional concrete and low cost concrete of mix (60% cement + 20% Fly Ash + 20% Silica Fumes) is similar to that of the target compressive strength of M25 mix. The stress-strain behavior for conventional concrete and low cost concrete with various proportions of fly ash and silica fumes is observed to be similar. This shows addition of mineral admixture to optimum values does not affect the stress strain behavior. The peak stress values for low cost concrete are similar to that of conventional concrete only varies by 0.2%.

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6. References

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