“AN EXPERIMENTAL INVESTIGATION ON THE MECHANICAL PROPERTIES OF CONCRETE WITH GRADE M55 AND M60 BY PARTIAL REPLACEMENT WITH SILICA FUME”

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Abstract: Green Concrete is a homogenous artificial mixture of cement, natural sand, coarse aggregate and water. Its achievement lies in its versatility as it can be designed to withstand harvest environment while taking on the most inspiring forms. This study investigates the performance of concrete under influence of silica fume in terms of slump, compressive strength at 7 days and 28 days, flexural strength of beam at 28 days and splitting tensile strength of Cylinder at 28 days respectively. Total number of specimens of cubes, cylinders and beams were 50, 30 and 30 respectively, which were casted for testing to study influence of Silica fume on concrete. These Concrete specimens were deep cured in water under normal atmospheric temperature. On the basis of result that Silica fume mix concrete was found to increase in all strength (Compressive, Flexural & Splitting Tensile strength) of various mix of concrete at all age when compared to normal concrete. Its use should be promoted for better performance as well as for environmental sustainability. A total ten mix (trial mix, control mix and variation mix) were prepared for M55 & M60 grade of concrete.

Keywords: Concrete, Silica Fume, Workability, Compressive Strength, Flexural Strength, Splitting Tensile Strength.

I. INTRODUCTION

Green Concrete is an artificial mixture of cement, natural sand, coarse aggregate and water. Its achievement lies in its versatility as it can be designed to withstand harvest environment while taking on the most inspiring forms. Engineers and scientists are further try to increase its limits with the help of innovative chemical admixtures such as water reducer, mineral admixture and various supplementary cementations materials (SCMs). The uses of SCMs basically industrial waste in concrete manufacture not only prevent these materials to check the pollution but also to enhance the properties of concrete in fresh and hydrated states. Silica fume is one of the versatile mineral admixture which can also be utilized to improve compressive strength, flexural strength and splitting tensile strength or as a super workability aid to improve flow. OPC is perfect to take into use for work and also minimize the quantity of cement when it is designed for mix proportion with super plasticizer and no doubt, PPC is eco-friendly, economical but does not achieve high strength quickly, but make durable at later stage.

II. LITERATURE SURVEY

Parthasarathi & Prakash (April 2017) had studied on experimental study on partial replacement of cement with egg shell powder and silica fume Egg shell powder is replaced by 5%, 10% and 15% in addition with the silica fume by 2.5%, 5%, and 7.5% of weight of cement. An
Experimental research demonstrates the strength features such as split tensile strength, compressive strength, and flexural strength test of egg shell based concrete were investigated.[1]

Upadhyay et.al (Feb 2014) had studied on the Compressive strength of high performance concrete with the replacement of cement with Micro silica fume.
- In this study the effect of Micro silica fume as a supplementary cementing material and filling material on the strength of concrete was investigated.
- The maximum compressive strength of concrete is achieved by using Micro silica fume 10% [5]

Kumar et.al (Oct. 2014) had studied on the experimental study for evaluation of durability characteristics of high performance concrete made from mixes by means of various percentages of fly ash and silica fume. Durability characteristics such as water absorption, permeability, sulphate attack resistance and abrasion resistance are low for the fly ash and silica fume replacing cement based concrete materials as compared with conventional high performance concrete.[6]

III. MATERIAL & EXPERIMENTAL STUDIES
Concrete is a composite material which is prepared with mix of cement, fine aggregate, coarse aggregate and water. It can be broadly used for any type of structure as per choice and demand and percentage ingredients of concrete can be changed as per load and strength requirement of construction work. Concrete is cheap as compared to steel structure and it has also low cost of maintenance, easy mechanism for work.

3.1 Coarse Aggregate
It is the aggregate most of which is retained on 4.75 mm IS sieve and contains only so much finer material as is permitted for the a variety of types described in IS-383:1970. According to size, coarse aggregate is explain as graded aggregate of its nominal size i.e. 40 mm, 20 mm, 16 mm, 12.5 and 10 mm etc. for example a graded aggregate of nominal size 20 mm means an aggregate most of which passes through 20 mm IS sieve.

3.2 Fine Aggregate
It is an aggregate most of which passes through 4.75 mm IS sieve and contains only so much coarser as is allowed by specification. According to size, the fine aggregate may be classified as coarse sand, medium sand and fine sand.

3.3 Cement
Cement is a binder, a substance that sets and hardens and can join other materials together. Cement used in construction can be characterized as being either hydraulic or non-hydraulic, depending upon the capability of the cement to be used in the presence of water.

3.4 Silica Fume
Silica fume is a product resulting from decrease of high purity quartz with coal in an electric arc furnace in the manufacture of silicon or ferrosilicon alloy. It cools, condenses together in cloth bags. It is further processed to eliminate impurities and to manage particle size. The use of silica fume in combination with super plasticizer has been the backbone of modern high performance concrete.

3.5 Super-plasticizers
The super-plasticizer which were used for the investigational performance is Kavassu Plast SP-431/ Shaliplast SP-431.
IV. METHODOLOGY

Following Test is Adopted for testing of concrete.

- Density
- Compressive Strength
- Flexural Strength

4.1 Density Test Result

The density of specimen was determined before testing the specimen of cube, beam & cylinder and before determination of density of specimen, surface of specimen was cleaned and swept with clean cotton cloths.

4.2 Compressive Strength

IS Code 516:1959 use for method of tests for compressive strength of concrete. The size of specimens 150mm x 150mm x 150mm. The specimens were tested after deep curing for 7 days and 28 days.

4.3 Flexural Strength

IS Code 516:1959 use for method of tests for flexural strength of concrete. The size of beam 700mm x 150mm x 150mm. The specimens were tested after deep curing for 28 days. The central point loading method was used for this testing. Flexural Strength = \(\frac{3PL}{2bd^3}\) (Unit = N/mm\(^2\) or MPa), Where, \(P\) = Load, \(L\) = Distance between centre of two supports, \(d\) = Depth of specimen, \(b\) = Width of specimen.

V. RESULTS AND DISCUSSIONS

The variations had been ready with cement by replacing percentage of cement with silica fume which varies from (silica fume 0% to 10% at interval of 2.5%) for both concrete mixes of M55 & M60.

5.1 Density Test Result

The density of specimen was determined before testing the specimen of cube, beam & cylinder and before determination of density of specimen, surface of specimen was cleaned and swept with clean cotton cloths. Average weight of Cube,Beam and Cylinder are 8.52 Kg (for 28 days), 39.35 Kg (for 28 days) and 12.86 Kg (for 28 days) respectively.

| Sl. No | Percentage of Silica Fume | Density of Hardened Concrete (Kg/m\(^3\)) |
|--------|--------------------------|------------------------------------------|
| 1      | 0                        | 2827.55                                  |
| 2      | 2.5                      | 2878.66                                  |
| 3      | 5.0                      | 2923.11                                  |
| 4      | 7.5                      | 2954.66                                  |
| 5      | 10                       | 2990.66                                  |
Table 2: Density of hardened Concrete on Replacement of OPC by Silica Fume for M60

| Sl.No | Percentage of Silica Fume | Density of Hardened Concrete (Kg/m³) |
|-------|---------------------------|--------------------------------------|
| 1     | 0                         | 3127.11                              |
| 2     | 2.5                       | 3162.22                              |
| 3     | 5.0                       | 3204                                 |
| 4     | 7.5                       | 3229.77                              |
| 5     | 10                        | 3289.77                              |

5.2 Compressive Strength

Table 3: 7 & 28 Days Compressive Strength of Cube on Replacement of OPC by Silica Fume for M55

| Sl. No | % Mix (Cement + Silica Fume) | Average For Compressive Strength M55 (N/mm²) |
|--------|-----------------------------|---------------------------------------------|
|        |                             | 7 Days                                      | 28 Days                                      |
| 1      | OPC+ SF (100+0)             | 44.56                                       | 63.63                                        |
| 2      | OPC+ SF (97.5+2.5)          | 45.48                                       | 64.77                                        |
| 3      | OPC+ SF (95+5)              | 46.11                                       | 65.79                                        |
| 4      | OPC+ SF (92.5+7.5)          | 46.56                                       | 66.52                                        |
| 5      | OPC+ SF (90+10)             | 47.25                                       | 67.30                                        |

Table 4: 7 & 28 Days Compressive Strength of Cube on Replacement of OPC by Silica Fume for M60

| Sl. No | % Mix (Cement + Silica Fume) | Average For Compressive Strength M60 (N/mm²) |
|--------|-----------------------------|---------------------------------------------|
|        |                             | 7 Days                                      | 28 Days                                      |
| 1      | OPC+ SF (100+0)             | 49.25                                       | 70.36                                        |
| 2      | OPC+ SF (97.5+2.5)          | 49.81                                       | 71.15                                        |
| 3      | OPC+ SF (95+5)              | 50.46                                       | 72.09                                        |
| 4      | OPC+ SF (92.5+7.5)          | 51.08                                       | 72.97                                        |
| 5      | OPC+ SF (90+10)             | 51.82                                       | 74.02                                        |
The Flexural strength of concrete mixes with replacement of silica fume by weight of OPC was measured with beam specimen of size 700mm(length) x 150mm(width) x 150mm (depth). The samples were tested after curing for 28 days fully absorbed in water tank as per IS 516:1959 for method of tests for strength of concrete. The method used for this testing was centre point loading.

### Table 5: 28 Days Flexural Strength of Beam on Replacement of OPC by Silica Fume for M55

| Sl. No | %Mix (Cement + Silica Fume) | Average For Flexural Strength M55 (N/mm²) |
|-------|-----------------------------|------------------------------------------|
| 1     | OPC+ SF (100+0)             | 7.63                                     |
| 2     | OPC+ SF (97.5+2.5)          | 7.77                                     |
| 3     | OPC+ SF (95+5)              | 7.89                                     |
| 4     | OPC+ SF (92.5+7.5)          | 7.97                                     |
| 5     | OPC+ SF (90+10)             | 8.07                                     |
Table 6 : 28 Days Flexural Strength of Beam on Replacement of OPC by Silica Fume for M60

| Sl. No | % Mix (Cement + Silica Fume) | Average For Flexural Strength M60 (N/mm²) |
|--------|-----------------------------|------------------------------------------|
| 1      | OPC+ SF (100+0)             | 8.44                                     |
| 2      | OPC+ SF (97.5+2.5)          | 8.54                                     |
| 3      | OPC+ SF (95+5)              | 8.65                                     |
| 4      | OPC+ SF (92.5+7.5)          | 8.76                                     |
| 5      | OPC+ SF (90+10)             | 8.88                                     |

Fig.4: Comparison of Flexural strength M55 & M60 In Replacement at 28 Days

VI. CONCLUSIONS

• The evaluating the mechanical properties by experimental investigation, we observed the maximum density is 2990.66kg/m³ for Grade M55 and 3289.77kg/m³ for grade M60 at 10% replacements of cement by silica fume because the surface area of silica fume is 100000 cm²/gm and cement have 3000 to 3500cm²/gm.
• The compressive strength continuously increases up 10% replacement of cement by silica fume after 10% the compressive strength get reduced and the maximum compressive strength will achieved 67.29N/mm² for M55 grade and 7402 N/mm² after 28 days.
• The flexural strength continuously increases up 10% replacement of cement by silica fume after 10% the flexural strength get reduced and the maximum flexural strength will achieved 8.07N/mm² for M55 grade and 8.88 N/mm² after 28 days.
• The compressive strength and flexural strength increases up to 10% replacement of cement by silica fume because the surface area of silica fume is 100000 cm²/gm and cement have 3000 to 3500cm²/gm and pores filed by the fine particle by silica fume so that concrete will reached in high dense state.
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