Study of Engineering Properties of Silica Fume and Marble Dust Blended Concrete

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***Abstract*- The prime objective of this study is to design, Analyse and optimize the silica fume and marble dust blended concrete Experiment and to explore the practicability of marble dust with silica fume.**

In this study, the silica fume is added as pozzolanic material and marble dust is added as fine aggregate in concrete. The isolated behaviour of silica fume and marble dust is compared with mixture of silica fume and marble dust blended concrete, the properties which are used for comparison are 7 days compressive strength, 28 days compressive strength and slump value. The components of concrete mixture are Cement, silica fume, water and aggregate. Total of 10 runs or Mix Designations are selected for experimentation which are combinations of proportions and laboratory experiment is carried out on these Mix Designations and 7 days, 28 days compressive strength and slump value is measured.

***Index Terms*- Silica Fume, Cement, Marble dust, Aggregates.**

1. INTRODUCTION

Concrete is an indispensable and important construction material. Now a day, Concrete is not a simple mixture of four components, that is, cement, water, coarse aggregate and fine aggregate. Modern concrete is a complex mixture of cement, water, supplementary cementitious materials such as pozzolanic materials, fine aggregate, coarse aggregate and various chemical and mineral admixtures.

Portland cement is a binder available which maintains and enhances the performance of concrete. However, modern cement industry also poses many environmental threats such as air pollution, waste dumping, emission of dangerous gases, and reduction of natural resources. Fossil fuels are used in the production of cement which on combustion emit Carbon dioxide. Carbon dioxide is a greenhouse gas, which absorbs and emits infrared radiations due to which surface of the earth and the lower atmosphere get warm and the upper atmosphere gets cool and this process is called as the greenhouse effect. Greenhouse effect is the main reason for the rise of average global temperature. There is 5% of total carbon dioxide is emitted in the production of cement globally. Approximately 1Tonne of carbon dioxide is exhausted in the production of same amount of cement. After China, India is second largest producer of cement in the world. Approx. 7% of India's CO_2 emission is due to cement production. Therefore, in order to keep the position of concrete as dominant and indispensable material in the future, the concrete industry needs to be switched towards "sustainability"

Portland cement releases the calcium hydroxide as a by-product when reacts with water. Pozzolanic materials utilize this calcium hydroxide. Pozzolanic materials are siliceous or combination of siliceous and aluminous materials, which alone do not have any cementing property ,but in the finely divided form, react with calcium hydroxide and form compounds having cementing properties. Silica present in pozzolanic material is important constituent which reacts with calcium hydroxide. The name "Pozzolan" is derived from a name of town "Pozzuoli" in Italy where volcanic tuff or ash is found having properties similar to pozzolan. Basically pozzolanic material contains Silica or Silicon dioxide as main constituent. Ancient Romans and Greeks used this volcanic tuff or ash with lime to obtain compounds having strong cementing properties.

The reaction between pozzolanic material and calcium hydroxide is termed as pozzolanic reaction. The by-products of various industries such as thermal power plants and metallurgical industries have pozzolanic properties.

These by-products are silica fume, ground granulated blast furnace slag, and fly-ash etc. These by-products are also called artificial Pozzolan. Volcanic tuff and volcanic ash are called as natural pozzolan.

Silica fume is also a pozzolanic material. Silica fume is a by-product which is generated during production of silicon alloy in the process of reduction of high purity quartz with coal in electric arc furnace.

Silica fume has finely divided spherical particles of size less than 1 micron. Its particles are 100 times smaller than cement particles and having specific surface area of 20,000 m^2/kg measured using nitrogen adsorption techniques. It is also called as micro silica or condensed silica. Silica fume is highly reactive pozzolan and its pozzolanic activity is highest as compared to fly-ash, GGBS or any other pozzolan. Portland cement reacts with water and releases the calcium hydroxide as by-product. Silica fume reacts with calcium hydroxide and forms a cementing compound calcium silicate hydrate (C-S-H gel). The optimum replacement level of silica fume is 10% to 15% of cement by weight.

Marble is used as building material and typically used for decorative purposes and for making small models of temples and other religious things. Marble is obtained from quarry and then processed and cut to final usable form. In this process about 30 percent marble is wasted in the form of fine powder. This fine powder of marble is called marble dust. This marble powder is waste material.

The marble powder creates air and water pollution and leads to serious problem to environment. The disposal of this marble powder is also a serious problem because it will contaminate ground water.

The typical chemical component of marble powder is calcium carbonate. This marble powder can be used as filler material for concrete i.e. as a fine aggregate in cement concrete. However the chemical components present in marble powder can impart extra strength by chemically reacting with cement: and silica. In this study marble dust is used as fine aggregate in cement concrete.

2. LITERATURE REVIEW

Many researchers have studied the effect of partial replacement of cement by silica fume in concrete, Also the engineering properties of silica fume in concrete is being a favorite topic of research for researchers in various mix design.

Sidhu D.S [1] investigated the behaviour of silica fume in concrete at early ages. He investigated the influence of silica fume addition on compressive strength, modulus of elasticity and density of concrete. He used two grades M30 and M50 for experiment. The level of replacement of cement with silica fume was from 0 % to 25 % by weight of cement. He carried out tests at the age of 1, 3, 7, 14, 21 and 28 days. He also measured the density and modulus of elasticity of concrete specimens. He observed that the density of silica fume blended concrete was 2.3 percent less as compared to concrete without silica fume. He also observed that at age of 7 days, the control specimen had higher strength as compared to silica fume blended specimen and after 14 days the strength of silica fume blended concrete increased. He found that at the age of 28 days, the compressive strength of silica fume blended concrete was significantly high than control concrete. He concluded that optimum level of replacement of cement with silica fume is 15 % after which compressive strength decreases. He also concluded that the effects of silica fume addition in concrete appears after 7 days.

Asrar Nausha et al [2] carried out experiments in order to evaluate the resistance of silica fume blended Reinforced concrete to diffusion of oxygen, chloride ions, carbon dioxide and moisture. The replacement level of cement with silica fume was 10 % by weight of cementitious content. They performed Salt Fog test, Salt ingress test, immersion test, potential test, Rapid Chloride Permeability Test, Sulphate Resistance test and Compressive strength test. They observed that incorporation of silica fume in Reinforced cement concrete decreases the corrosion of rebar due to decreased permeability. They also observed that chloride ion diffusion decreased drastically due to incorporation of silica fume in concrete.

3. METHODOLOGY

3.1. Research Methodology:

The procedure of Silica fume and marble dust blended concrete experiment is as follows:

1. Selection of components of concrete.

2. Selection of properties.
3. Proportioning.
4. Laboratory Experiment
5. Results and Conclusions.

3.1.1. Selection of components of concrete.
In this stage, the components of concrete are selected.
3.1.2. Selection of properties.
In this stage, properties of concrete are selected. In this study, the properties of concrete 7 days and 28 days compressive strength and slump value which is measure of workability.

3.1.3 Proportioning
Proportion is taken according to IS: code 10262-2009 and IS: 456-2000.
The components of concrete are cement, silica fume, water and aggregates and marble dust. The proportions of component of concrete are expressed by volume. The unit of volume is m^3. The total volume of concrete mixture is unity i.e. 1 m^3.

3.1.4 Laboratory Experiment
Laboratory experiment is carried out and properties are calculated using laboratory test on concrete.

3.1.5. Result and Conclusions:
Results are obtained from laboratory experiments and the evaluation is done and conclusions are drawn from the result.

4. EXPERIMENT

M20 grade of concrete is used for control.
Proportions of different components of M20 grade of concrete are shown in table no1.
In this table mix designations are used C, SF3, SF5, and SF7 MD10, MD15, MD20. C is the control, SF3 is 3% of silica fume, SF5 is 5% of silica fume, and SF7 is 7% of silica fume. Cement is replaced by silica fume. MD10 is 10% of marble dust, MD15 is 15% of marble dust, and MD20 is 20% of marble dust. Fine aggregate is replaced by marble dust and combinations of 3% of silica fume with marble dust 10%, 15%.20% respectively 6 cubes are prepared for each mix. 3 cubes for 7 days compressive strength measurement and 3 cubes for 28 days compressive strength measurement.
Table No: 1 Proportion of different components

S.No	Designation	Cement (kg/m3)	Silica Fume (kg/m3)	Water (kg/m3)	Coarse Aggregate (Kg/m3)	Fine Aggregate (Kg/m3)	Marble Dust (kg/m3)
1.	C	372	0	186	1144.22	762.6	0
2.	SF3	360.84	11.16	186	1144.22	762.6	0
3.	SF5	353.04	18.6	186	1144.22	762.6	0
4.	SF7	345.96	26.04	186	1144.22	762.6	0
5.	MD10	372	0	186	1144.22	686.34	76.26
6.	MD15	372	0	186	1144.22	648.21	114.6
7.	MD20	372	0	186	1144.22	610.08	152.52
8.	SF3MD10	360.84	11.16	186	1144.22	686.34	76.26
9.	SF3MD15	360.84	11.16	186	1144.22	648.21	114.6
10.	SF3MD20	360.84	11.16	186	1144.22	610.08	152.52

5. RESULTS

This section deals with the results obtained from experiment
The compressive strength at the age of 7 days, 28 days and slump value is measured for each concrete mix and test results are shown in Table.2
Table no 2: Responses of mixture which are measured in laboratory.

S.no	Designation	Average 7 days compressive strength (MPa)	Average 28 days compressive strength (MPa)	Slump value (mm)
1.	C	15.45	27.11	70
2.	SF3	17.23	28.45	65
3.	SF5	17.67	30.26	60
4.	SF7	17.9	31.21	55
5.	MD10	15.23	27.10	72
6.	MD15	15.45	27.80	68
7.	MD20	15.31	27.91	61
8.	SF3MD10	17.5	28.88	63
9.	SF3MD15	17.48	31.67	57
10.	SF3MD20	17.29	32.24	51

5.1. Graphical interpretation
Comparison of different mix designation on the basis of 7 days compressive strength is shown in Figure.1 the comparison shows that there is significant increase in compressive strength of concrete having silica fume. Similarly it is also that there is no decrease in strength when adding marble dust in concrete. Marble dust and silica fume enhances the properties of concrete.
Comparison of different mix designation on the basis of 28 days compressive strength is shown in

Figure.2.same results are obtained for 28 days concrete which shows that silica fume and marble dust can enhance properties of concrete.

Similarly Comparison of different mix designation on the basis of Slump value is shown in Figure.3 Comparison shows that there is decrease in workability of concrete on the incorporation of silica fume and marble dust.

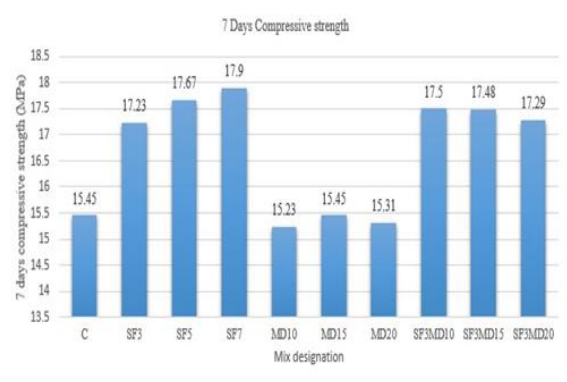

Figure no: 1. 7 days compressive strength

In this figure no.1 shows compressive strength of concrete after 7 days of curing.in this figure where c is the control of concrete. Its means simple concrete and compressive strength is 15.45Mpa.SF3 is 3% of silica fume is replaced into cement and compressive strength is 17.23 Mpa. Similarly as SF5 and SF7 compressive strength shows in figure.1, MD10 is 10% of marble dust is replace into fine aggregate.in this combination of concrete gives strength is 15.23 Mpa. Similarly as MD15 and MD20 compressive strength is shows in figure.1

SF3MD10 is 3% of silica fume and 10% of marble dust Is added in this mix and compressive strength is 17.5 Mpa. Similarly SF3MD15 and SFMD20 as shown in figure.1

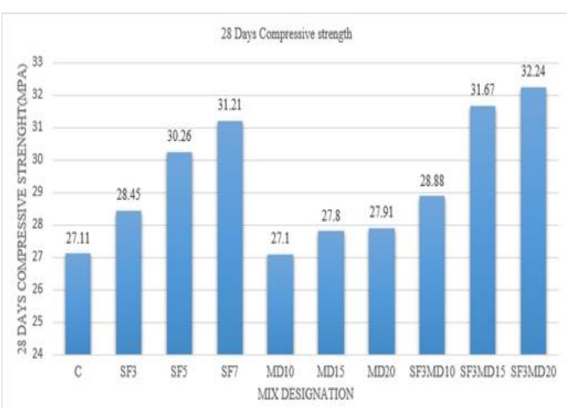

Figure no: 2. 28 days compressive strength

In this figure no.2 as shown the compressive strength of concrete after 28 days of curing. The mix design is same as figure.1

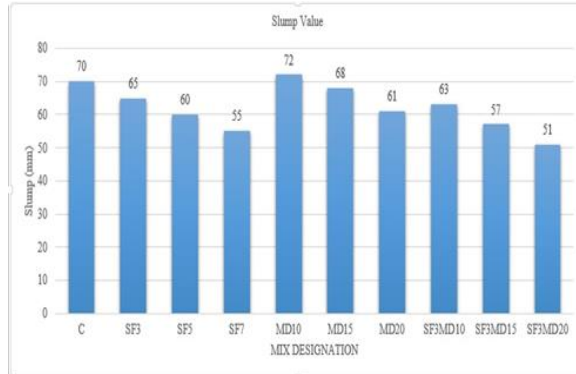

Figure no: 3 Response trace plot of Slump value.

In this figure.3 is shows the slump value of concrete. The is same mix design. The slump value is measuring with the slump cone apparatus. In this figure different slump values are indicated in mm.

6. CONCLUSION

Following conclusions can be drawn from study:

1. Silica fume and marble dust can be effectively incorporated in concrete to improve the mechanical properties of concrete for M20 grade of concrete.
2. The 3%, 5%, & 7% replacement of cement with silica fume is effective to improve the properties of concrete.
3. It is found that compressive strength of concrete increases with increase of silica fume percentage however study is done on 3%, 5% & 7% respectively.
4. It is found that silica fume decreases the workability of concrete which can be enhanced by adding admixtures.
5. Marble dust can be used as fine aggregate and addition of marble dust does not decreases the compressive strength of concrete.
6. 15% replacement of fine aggregate with marble dust is effective and increase to 20% decreases the compressive strength of concrete.
7. Combination of silica fume and marble dust can also be used because this mixture improves the properties of concrete.

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