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An experimental study of concrete when cement is partially replaced with marble powder and fly ash

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Abstract-This paper reports an experimental study of the influence of fly ash and marble powder used as partial substitute for Portland cement on the mechanical properties and durability of high performance concrete. Concrete has become an indispensable construction material and it is now used in greater quantities than any other material. In the present context durability, strength economy and stainable development are key issues for 25% of fly ash and marble powder is used as partial replacement of cement in different proportions. This paper aims to study the effect of using fly ash and marble powder as partially replacement on M20 grade of concrete. Leaving the waste materials to the environment directly can cause environmental problem. Hence the reuse of waste material has been emphasized. Waste can be used to produce new products or can be used as an admixture so that natural resources are used more efficiently and the environment is protected from waste deposits. Here cement was partially replaced by 5%, 10%, 15%, 20%, 25% of fly ash and marble powder by weight. Compressive strength test, flexural strength test, spilt tensile strength were performed according to guidelines of BIS. The high results were obtained at a percentage of 15% (11.25% FA & 3.75% MP) from experimental results it was observed that workability of concrete increases with increase in fly ash and marble powder.

Index Terms-durability, strength, waste materials, environment

1. INTRODUCTION

Concrete is an important material in the construction other than steel and timber. Its main constituents are cement, fine aggregate and coarse aggregate. The durability of concrete is a major consideration in its applications in aggressive environments for a long service life. Concrete incorporates large amount of natural resources as aggregates and cement with water. Cement production consumes huge energy and causes about 7% of total greenhouse gas emission in the world. Hence utilization of supplementary cementitious materials such as fly ash, slag, marble powder, and silica fume is being researched extensively over the last few decades to enhance durability and sustainability of concrete. Fly ash is a by-product of the combustion of pulverised coal and is a pozzolona material. When it is mixed with Portland cement and water, it generates a product similar to that formed by cement hydration but having a denser microstructure that is less permeable. The fly ash replacement level as 15 – 25% is recommended for high strength concrete (ACI committee 211 2008) while it can be used as more than 50% of total binder for normal strength concrete. As marble powder is the waste product, obtained during the process of sawing and shaping of marble by parent marble rock, contains heavy metals which makes the water unfit for use, marble powder creates environmental problems. Due to environmental problems, it has great impact on human health as well as on nature. To control its effects we have to use this waste.

2. LITERATURE REVIEW

A.S.E.Belaidi, L. Azzouz, E. Kadri, S. Kenai (2012)investigated the effect of natural pozzolona and marble powder on the properties of self-compacting concrete. Ordinary Portland cement was partially replaced by different percentages of pozzolona and marble powder (10 - 40%). The use of both pozzolona and marble powder as substitution to cement has no negative effects on the workability of self-compacting concrete as it showed improvement in the workability of concrete with the use of pozzolona and marble powder.

Satish H. Sathawane, Vikrant S. Vairagade, Kavita S. Kene (2013) reported that the investigation was carried out on concrete with partial replacement of cement with fly ash and rice husk ash. Fly ash and rice husk ash was replaced with different ratios up to 30%. OPC of 43 grade, natural river sand and coarse aggregate of 20mm was used. It was observed that the compressive, flexural and split tensile strength was maximum at 22.5% fly ash and 7.5% rice husk ash.

Kishan p pala et al (2015) studied the behaviour of self-compacting concrete when cement is partially replaced with marble powder and fly ash. They investigated the hardened properties, durability and also investigated the compactibility of marble powder in self-compacting concrete along with chemical admixture such as super plasticizer.

.**VishaRaval et al (2017)** examined the feasibility of using industrial wastes such as marble powder and fly

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ash partial replacement of cement with different ratios up to 25%. They observed that by replacing 10% marble powder and 25% fly ash concrete shows maximum compressive strength.

SerkanSubas, HakanOzturk , Mehmet Emiroglu (2017) utilized the waste ceramic powder as filler material in self-consolidating concrete, in this study finely grounded waste ceramic powder were substituted for Portland cement at a level of 5%, 10%, 15% and 20% by weight. From experimental results they achieved that flow ability of fresh concrete was improved with increment of waste ceramic powder without affecting the hardened concrete properties.

3. MATERIALS

Ordinary Portland cement (OPC) 43 grade conforming 8112: 1989 was used. The fineness of cement was 2.69.

Fine aggregate locally available natural sand was u throughout the investigation. The various properties of aggregate are shown in table 1.

Properties of Fine Aggregate
Table 1

Properties	Value Obtained
Fineness Modulus	2.70
Specific Gravity	2.75
Water Absorption	1.42%

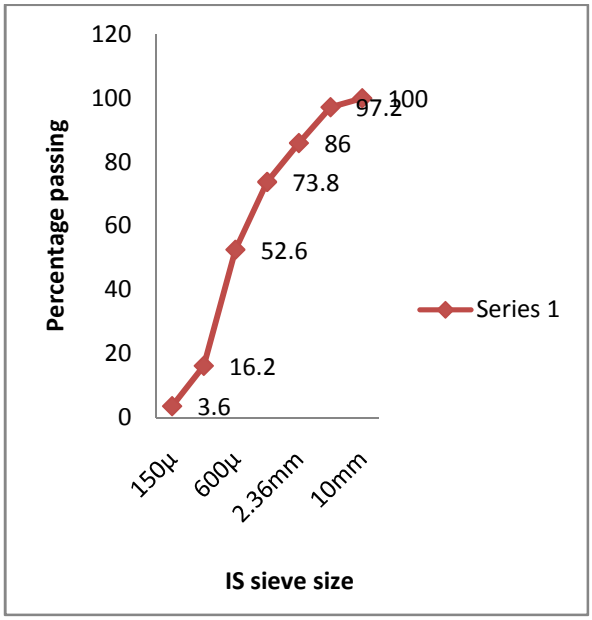

Fig. 1 Particle size distribution curve of fine aggregate

Coarse aggregate in this study, coarse aggregate having maximum size 20mm was used.

Properties of Coarse Aggregate
Table 2

Properties	Value Obtained
Fineness Modulus	6.85
Specific Gravity	2.71
Water Absorption	1.32%

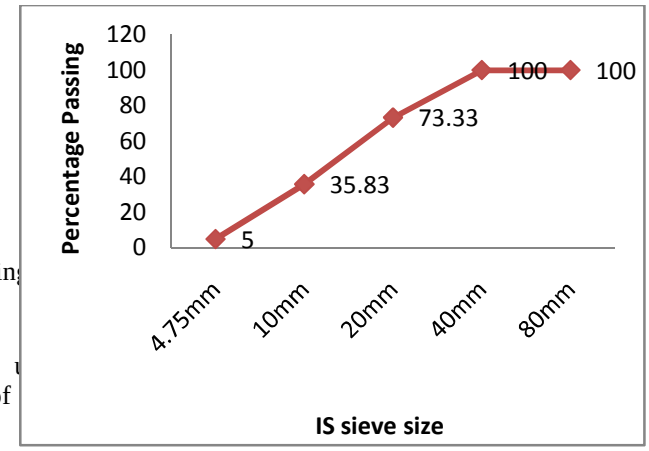

Fig. 2 particle size distribution curve of Coarse aggregate

Marble powder properties are presented in table 3

Properties	Value Obtained
Specific Gravity	2.60
Water Absorption	0.80%

Fly ash the specific gravity of fly ash has been taken 2.2.

4. OBJECTIVE

To study the influence of partial replacement of cement with marble powder and fly ash and compare it with the compressive strength of ordinary M20 concrete. This study has been carried out at (0% 5% 10% 15% 20% 25%).

5. EXPERIMENTAL INVESTIGATION

The experimental program is planned to quantify the compressive strength, flexural strength, split tensile strength and workability using waste marble powder and fly ash as partial replacement at various percentage levels will be used in the investigation to observe the effects of different marble powder and fly ash levels in contributing the compressive, flexural and spilt tensile strength at various ages of curing. Concrete cubes of size 150mm x150mm x 150mm were casted. 72 cubes were casted for determination of compressive strength. After 24 hours the specimens were de moulded and subjected to water curing. The compressive test carried out by compressive testing machine. Splitting tensile test and flexural test were

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carried out by universals testing machine. Before testing the cubes were air dried for 2 hours. Crushing loads were noted and average compressive strength of 6 specimens is determined at 14 and 28 days. For splitting tensile strength cylindrical moulds of size 150 X 300 mm and for flexural test concrete beam of size700X150X150 mm was used throughout the investigation. Workability of each batch of concrete mix was determined by caring out slump test. The test was carried out as per specification conforming IS 1199- 1959. Slump measured was recorded in terms of millimeters.

The compressive strength was determined at the ages of 14, 28 days where as splitting tensile strength and flexural strength were carried out at the ages of 28 days. A total number of 72 cubes, 15 cylindrical specimens and 15 beam specimens were casted for carrying out compressive strength, splitting tensile strength and flexural strength of concrete. The cement was replaced with fly ash and marble powder by different proportions of (5% 10% 15% 20% 25%).

6. RESULTS AND DISCCUSION

Fresh concrete was tested using slump cone test to find the workability of control concrete and concrete of combination of fly ash and marble powder with partial replacement of cement.Fig. 3 shows the effects of addition of fly ash and marble powder on workability of concrete. It was observed that fly ash and marble powder increases the workability of concrete up to 28% as compared to control concrete. The test was carried out as per specifications conforming IS: 1199- 1959. Slump measured was recorded in terms of millimeters.

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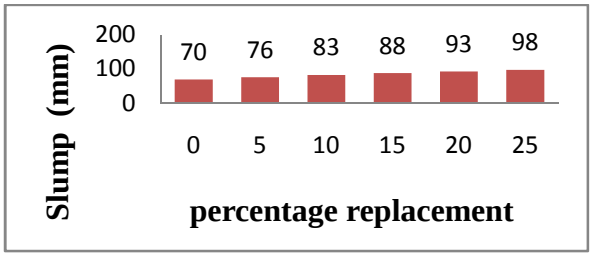

Fig. 3 Slump values at different replacement levels

6.1TESTS ON HARDENED CONCRETE

Tests were done as per following codes of Bureau of Indian standards. The tests for compressive strength on cubes were measured at 14 and 28 days of curing as per IS: 516- 1959, tests for flexural strength on beams was measured at 28 days of curing as per IS: 516- 1959, and tests for split tensile strength on cylinder was measured at 28 days of curing.

6.1.1 Compressive Strength Test: Compressive strength was carried out at the ages of 14 and 28 days. The results are shown in fig 4 and 5.

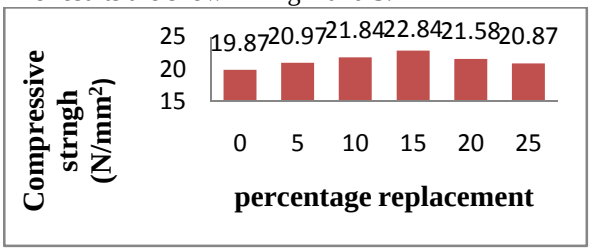

Fig. 4 - 14 days compressive strength

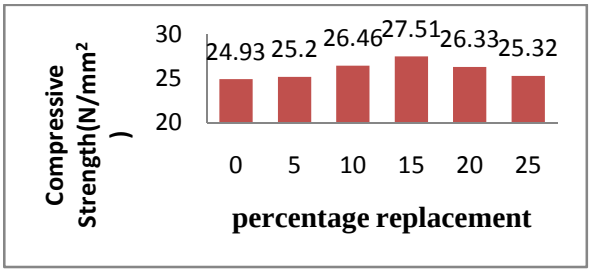

Fig. 5 - 28 days compressive strength

From experimental results it is observed that up to 15% replacement of cement with (11.25% FA + 3.75% MP) strength of concrete increases after that it decreases.

6.2.2 Splitting tensile and Flexural strength has been investigated at the ages of 28 days. The results are presented in fig. 6 and fig. 7

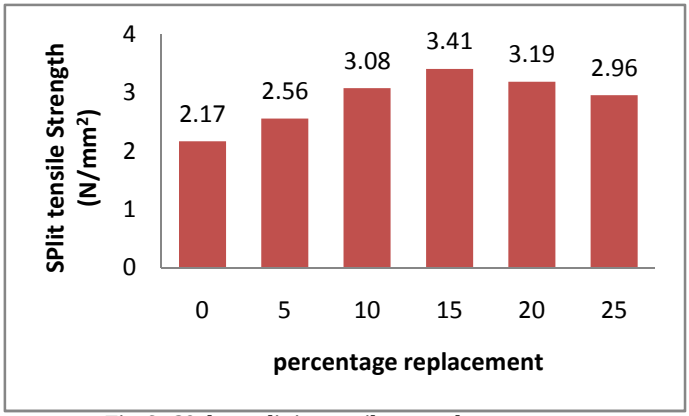

Fig. 6 - 28 days splitting tensile strength

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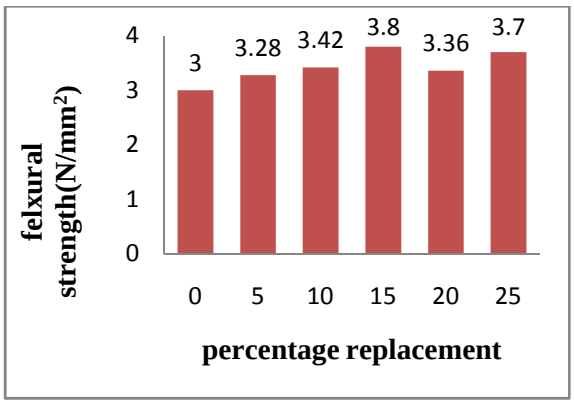

Fig. 7 - 28 days flexural strength

The maximum splitting tensile strength and flexural strength was obtained at 15% replacement of cement with (11.25% FA + 3.75% MP), beyond that both showed reduction

7. CONCLUSION

(1) The workability of concrete increases continuously when there is increase in the amount of fly ash and Marble powder. This is due to the fact that fly ash and Marble powder being spherical shape, small, fine particle that require very low content of water to mix with free lime.

(2) The compressive strength of concrete reaches highest, when the cement has been replaced by 15% (11.25% FA + 3.75% MP). This is due to the fact that the fly ash acts as pozzolonic material and it combines with free lime to CSH, which imparts strength to the concrete.

(3) The split tensile strength of cylinder is maximum when cement is replaced up to 15% (11.25% FA + 3.75% MP), further any addition of waste material decreases split strength.

(4) The flexural strength of concrete increases mainly due to increase of fly ash and Marble powder up to 15% (11.25% FA + 3.75% MP)

(5) Replacement of cement with fly ash and Marble powder also proves eco friendly as it utilizes the industrial waste which creates the large dumping problems**.**

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