Partial Replacement of Cement by Marble Powder and Fly Ash as an Additive in Concrete

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Abstract- *Cement is widely used material in construction industry. So, it would be helpful if we find any waste material which replaces cement partially so that quantity of cement is reduced and production of concrete also become economical. This study majorly focuses on the behavior of the strength when waste marble powder is used in concrete. For this study, marble powder is collected from Jigani Industrial Area. It is observed that, marble powder actively takes part in hydration process and helps in improving mechanical properties of concrete. Marble powder is replaced in varying percentages of 5, 10, 15, 20 and 25 by weight of cement. It is noticed that, the strength increases up to 15% replacement and optimum value is obtained at 15% replacement. Beyond 15% replacement level, sudden decrease in the strength was observed. So, fly ash is used as an additive after this level in the percentages of 5 and 10 by weight of cement. For 20 and 25% of replacement if 10% fly ash is added, the strengths obtained are nearly equal to that of conventional concrete.*

Keywords- marble dust powder, cement, compressive strength, split tensile strength, fly ash

I. INTRODUCTION

Cement is a construction material used worldwide. Cement in concrete produces necessary binding property. The production of cement is costlier and requires more energy when compared to other materials in concrete. Cement production contributes to excess carbon di oxide emission and causes environment pollution.

Due to increase in demand for construction projects it would be helpful if we find a material which can replace cement up to a certain percentage [5]. This is not only economical but also reduces environmental pollution.

In developing countries, recycle and reuse of waste materials is adopted in order to use the natural resources effectively. Marble powder is one such available waste material.

Marble is a stone obtained from transformation of sedimentary rock. The main chemical composition of marble is $CaCO_3$. More amount of powder is generated during cutting of marble into required shapes. India stands in the second position in the production of marble powder across the world. The production of marble waste is estimated around 3Mt annually [3]. The waste marble powder slurry is subjected to sedimentation and then the sediments are dumped away. On drying it forms dust and poses serious health hazards and environmental pollution [4] . Usage of this material in construction industries would facilitate to guard the environment.

The main of our study is to check the variation in strength of concrete by using marble powder as partial replacement.

II. EXPERIMENTAL STUDY

An experimental study was planned to check the variation in strength of concrete by replacing cement with marble powder and fly ash as an additive. The first step in the experiment was to find the initial values of all the materials used. For the study, marble powder was obtained from Jigani industries and Class 'C' fly ash was obtained from Kanakpur industrial area. The chemical composition of marble powder and fly ash is shown in table 1 and 2 respectively.

Table 1. Chemical components of marble dust powder

Components	**Weight (%)**
Calcium oxide (CaO)	68.6
Magnesium Oxide (MgO)	22.13
Silicon di oxide (SiO_2)	3.89
Aluminium Oxide (Al_2O_3)	2.785
Iron Oxide (Fe_2O_3)	0.603
Di chromium tri oxide (Cr_2O_3)	0.24
Zinc oxide (ZnO)	0.20
Titanium oxide (TiO)	0.549

Table 2. Chemical components of Class 'C' fly ash

Components	**Weight (%)**
Silicon di oxide (SiO_2)	53.39
Aluminium Oxide (Al_2O_3)	16.07
Iron Oxide (Fe_2O_3)	13.05
Calcium oxide (CaO)	6.33
Magnesium Oxide (MgO)	5.48
Sulphur Trioxide (SO_3)	1.06
Sodium Oxide (Na_2O)	1.59

The initial tests were conducted on each material and the results are shown in following tables

Table 3. Properties of cement

Tests	**Results**
Specific gravity	3.1
Normal Consistency	30%
Initial setting time	50min
Final setting time	600min

Table 4. Properties of fine aggregate

Tests	**Results**
Specific gravity	2.65
Fineness	3.18
Moisture Content	1.35%

Table 5. Properties of coarse aggregate.

Tests	**Results**
Specific Gravity	2.74
Moisture Content	0.5%

The specific gravity of marble powder and fly ash was found to be 2.64 and 2.81 respectively. Based on the values of initial tests, mix design was calculated for **M40 grade** concrete using IS: 10262- 2012[17] .

III. RESULTS AND DISCUSSION

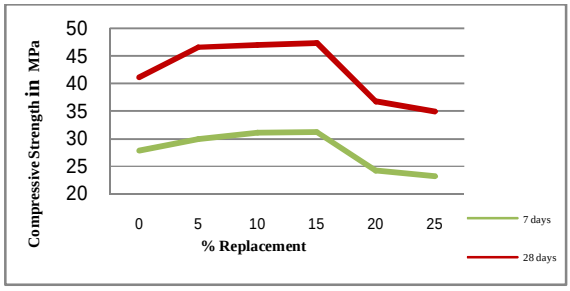

FIG 1. COMPRESSIVE STRENGTH TEST RESULTS OF CONCRETE WITH MARBLE DUST

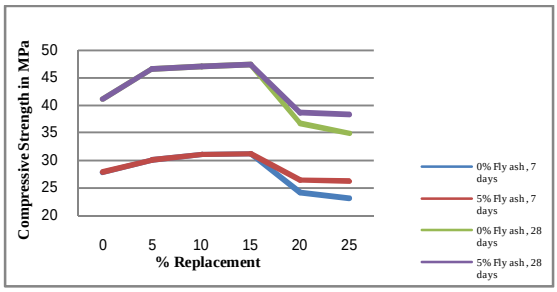

FIG 2. COMPRESSIVE STRENGTH TEST RESULTS OF CONCRETE WITH MARBLE DUST & 5% FLY ASH

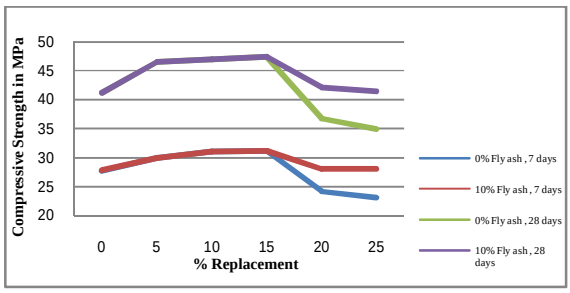

FIG 3. COMPRESSIVE STRENGTH TEST RESULTS OF CONCRETE WITH MARBLE DUST& 10% FLY ASH.

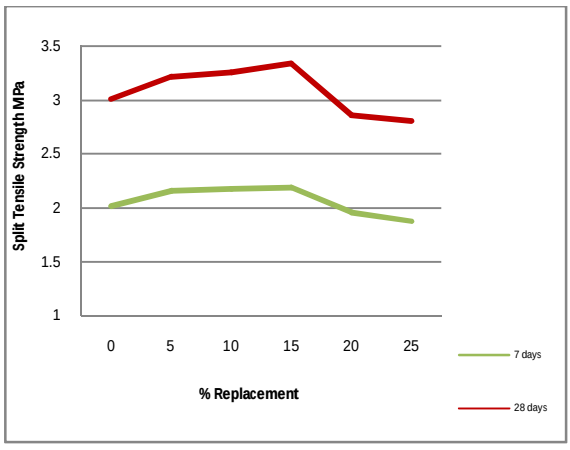

FIG 4. SPLIT TENSILE STRENGTH TEST RESULTS OF CONCRETE WITH MARBLE DUST

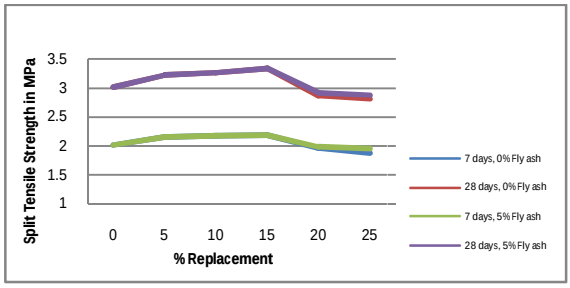

FIG 5. SPLIT TENSILE STRENGTH TEST RESULTS OF CONCRETE WITH MARBLE DUST& 5% FLY ASH.

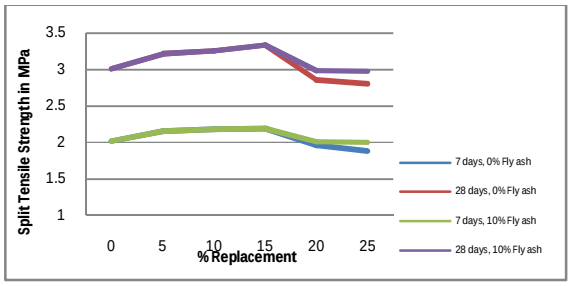

FIG 6. SPLIT TENSILE STRENGTH TEST RESULTS OF CONCRETE WITH MARBLE DUST& 10% FLY ASH.

Variation of compressive strength and the split tensile strength of specimens by replacement of cement with marble powder for the curing period of 7 & 28 days. Three specimens were tested for compressive and split tensile strength. From the graph it is inferred that compressive strength of concrete with marble powder is increased considerably for 7 and 28 days of curing up to certain percentage of replacement of cement with marble powder compared to conventional cubes, increase in strength is observed up to 15% replacement of marble powder and strength got decreased for further increase in percentage of marble powder. Maximum percentage increase in compressive strength compared to conventional specimens is obtained for 15% replacement and it is found to be 12.5% and 15.2% for 7 and 28 days of curing respectively. Maximum percentage increase in split tensile strength compared to conventional specimens is obtained for 15% replacement and it is found to be 8.41% and 10.96% for 7 and 28 days of curing respectively. It was observed that there is a decrease in strength for 20% and 25% replacement .In order to increase the strength for higher percentage fly ash is added as an additive in percentage by weight of cement.

The reduction in strength after 15% is mainly due to the decrease the cement content which leads to the decrease in the C_2S and C_3A content [5] which are responsible for strength of concrete and also due to the incapability of marble powder to fill in the minute voids which arise during the process of hydration because of their unsuitable chemical composition and fineness being greater than cement. The variation in strength based on curing period is due to the improvement of particle packing of concrete by fine marble powder. The continuous treatment of water makes the fine marble particles to get into the void spaces which reduce the amount of air voids balancing the reduction in strength due to the reduction of cement. The inclusion of fly ash has increased the C_2S and C_3A content which eventually caused the increase in the compressive strength of cubes.

IV. CONCLUSION

The following conclusions can be made from the results obtained during the research:

1. The strength of conventional concrete was found to be 41.15MPa
2. The result of the study indicate that up to 15% replacement the strength was found to increase and then there is a decrease in strength for 20% and 25% replacement.
3. By using fly ash as an additive in proportions of 5 and 10% by weight of cement for 20% and 25% marble powder replacement, it was found that the strength values are nearly equal to conventional concrete.
4. We conclude that 15% replacement can be done using marble powder alone. By using fly ash, up to 25% replacement can be achieved.

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