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Experimental Studies on Partial Replacement of Fineaggregate by using Marble Waste Powder in Concrete

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Abstract— In this experimental study, the effects of using waste marble powder (WMP) as a fine material on the mechanical properties of the concrete has been investigated. For this purpose four different series of concrete mixtures were prepared by replacing the fine sand (passing 4.75 mm sieve) with waste marble at proportions of 0%, 10%, 20%, 30%, 40%, and 50% by weight. In order to determine the effect of the WMP on the workability was found from slump test. Tests for compressive strength were carried out on specimens at the age of 1, 7, 14, 28, 56 and 90 days. The split tensile strength and bond strength tests were also carried out at the age of 28 days. The test results were compared with the results of specimen prepared after control mix. The result is that the mass which is 40% of total marble quarried has reached as high as millions of tons. From this study it was concluded that 50% replacement of cement by fly ash contribute reasonable strength along with 20% of silica fume.

Keywords— High volume fly ash, Compressive strength, Split tensile strength, Bond strength, Superplaticizes, Concrete Grade and Silica fume.

I. INTRODUCTION

Concrete is well known heterogeneous mix of cement, water and aggregates. The admixtures may be added in in concrete in order to enhance some of the properties ties desired specially. In its simplest form, concrete is a mixture of paste and aggregates. Various materials such fly ash are added to obtain concrete of desired property. The character of the concrete is determined by quality of the paste. The key to achieving a strong, durable concrete rests in the careful proportioning, mixing and compacting of the ingredients.

Marble has been commonly used as a building material since the ancient times. During the cutting process about 25% the original marble mass is lost in the form of dust. The marble sludge was obtained in wet form as an industrial by product directly from the deposits of marble factories, which forms during the sawing, shaping and polishing processes of marble in factories region.The wet marble sludge was dried up prior to the preparation of the samples. The dried material was sieved through a 4.75 mm sieve and finally the marble dust was obtained to be used in the experiments as fine sand aggregate. In this paper the effect of using marble powder and granules as constituents of fines in concrete by partially reducing quantities of cement as well as other conventional fines has been studied in terms of the relative workability & compressive as well as tensile strength.

In this study an attempt has been made to explore the extent of replacing fine aggregate with waste marble powder. The strength variations of hardened concrete and the workability of fresh concrete for the mixes prepared with the partial replacement of cement with the above said waste marble powder combinations are discussed.

II. MATERIALS

The various materials used in the work are disussed with their properties as follows

A. Cement

Ordinary Portland Cement of 53 grade was used in this study.The oxide composition limits of OPC (Neville, 1995) [2] are given in Table 1.

Table.1

Chemical Composition	Content in percent
CaO	60-67
SiO_2	17-25
Al_2O_3	3-8
Fe_2O_3	0.5-6
MgO	0.5-4
Na_2O	2-3.5
SO_3	2-3.5

B. Fine Aggregate

The fine aggregate taken for this work is the locally available natural river sand and it was collected and cleaned for impurities.Sand particles passing through IS sieve 4.75mm were used in this work. It was tested in the laboratory as per specifications recommended by IS:383-1970[4]. The specific gravity and finess modulus of fine aggregate were determined and they were 2.52 and 2.62 respectievely.

C. Coarse aggregate

Crushed angular granite stones of maximum particle size 20 mm were used as coarse aggregate. The material were col-

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lected and cleaned for impurities. Particles of nominal size 20 mm were used and tested in the laboratory as per specifica-tions recommended by IS:383-1970[4]. The specific gravity and fineness modulus of fine aggregate were determined and they were 2.69 and 6.8 respectively.

D.Waste marble powder

Marbles is granulose. Marble sludge powder was obtained in wet form directly taken from deposits of marble factories. Wet marble sludge powder must be dried before the sample preparation. Marble dust was sieved from 4.75mm sieve. The high content of CaO confirmed that the original stones were Marble and limestone. The dust was also tested (NP 85) to identify the absence of organic matter, thus confirming that it could be used in concrete are produced by metamorphism of limestone and dolomite. The contain inter looking grains of calcite or dolomite minerals and hence their structure is said to mixtures.

III. METHODOLOGY

The various methods followed to prepare the specimens and the tests on fresh and hardened concrete are discussed under the following topics.

A. Mixture Proposition

The minimum concrete grade recommended by IS 456: 2000 is M20. It is widely used in all ordinary structures in India. The minimum required characteristic strength is 20 N/mm2 (IS: 456 2000)[8]. The target mean strength is determined using the guidelines issued by Durocrete mix design manual. The target mean strength is calculated as 28.25 MPa. Hence M30 is consi-dered in this work for further study. A control concrete mix having compressive strength of 30MPa after 28 days was de-signed. No admixtures were added to the control mix. The preliminary mix design was carried out based on the recom-mendations of ACI committee 211.4R-93 and IS : 456 - 2000.The additional trial was carried out to optimize the level of workability and cohesiveness of fresh concrete by adding a sulphonated naphthalene based super plasticizer as a chemical admixtures. Fourteen types of mixes were prepared and as-signed different identification notations. Such notations and the quantities of materials required for one meter cube of dif-ferent concrete mixes are summarized in Table 3. Six mixtures have been prepared by replacing cement with waste marble powder by 10%, 20%, 30%, 40%, and 50% of mass and mixes are designat-ed as M1,M2,M3,M4,M5 and M6

Table 2

Mix id	w.m.p %	Cement kg	W.M.P kg	Fag Kg	Cag kg	Water kg
M1	0	5.4	0	6.9	19.6	2.6
M2	10	5.4	0.69	6.21	19.6	2.6
M3	20	5.4	1.38	5.52	19.6	2.6
M4	30	5.4	2.07	4.83	19.6	2.6
M5	40	5.4	2.76	4.14	19.6	2.6
M6	50	5.4	3.45	3.45	19.6	2.6

B. Prepartion and testing of specimens

The weighed ingredients were mixed in concrete mixture ma-chine. Steel moulds were used to prepare test specimens. Suit-able mould releasing agent was applied over the inner surface of the mould to get undamaged test specimens. The test spe-cimens for compression test is cube of size 100 x 100 x 100 mm and for Split tension test is cylinder of dia 150 mm and height 300 mm. The fresh concrete mix was filled in the moulds in three equal layers and each layer was well com-pacted using table vibrator. All top surfaces of the specimens were leveled using finishing trowel before the initial setting time of the concrete .The test specimens were covered with wet gunny bags after setting time. All the specimens were de-moulded and immersed in water for curing after 24 hours of casting. The specimens were taken out of curing tank after 3,7 and 28 days of curing for tests.

C. Experimental Tests

Tests were conducted both on fresh and hardened concrete. The various tests conducted are discussed as below.

D.Fresh Concrete

The concrete must have workability such that compaction to maximum density is possible (Neville, 1995)[2]. As the com-paction involves in later strength of the concrete, a good com-paction must be arrived. The workability of a concrete can be determined from some of the fresh concrete properties such as slump, unit weight and fresh concrete temperature. They were determined according to Indian standard specifications IS: 1199-1959[9]. The various test conducted and results obtained from these tests on fresh concrete are summarized in Table 3.

Table 3

S No.	Mix ID	Slump (mm)	Temperature (°C)
1	M1	22	25
2	M2	21	27
3	M3	19.5	29
4	M4	17	29
5	M5	15	27
6	M6	13.5	27

E. Compressive strength

Compressive strength tests were done on 150 x 150 x 150 mm cube specimens in compression testing machine of capacity 200 kN. The ultimate load taken by the specimen was taken for consideration. The concrete specimens were tested at different ages of 1 day, 3, 7, 28, 56 and 90 days. The compressive strength of specimens of different age is summarized in Table. 4

Table 4

S No.	Mix ID	Compressive strength(N/mm^2)	
		7 days	28days
1	M1	18.92	28.57
2	M2	21.56	28.95
3	M3	18.25	29.25
4	M4	15.52	27.40
5	M5	14.15	25.12
6	M6	16.10	23.25

F. Split tensile strength test

It is very difficult to measure the tensile strength of concrete directly. The split tensile strength is simple to perform and gives more uniform results than other tension tests. Strength determined in the splitting test is believed to be closer to the true tensile strength of concrete (Shetty, 2005)[11]. Split ten-sile strength tests were done on 150 mm dia and 300 mm high cylindrical specimens in compression testing machine of ca-pacity 200 kN. The cylindrical concrete specimens were tested at the age of 28 days for split tensile strength with diametric compression. The ultimate load taken by the specimen was taken for consideration. The split tensile strength of specimens is summarized in Table 5.

Table 5

S No.	Mix ID	Split tensile strength(N/mm^2)	
		7 days	28days
1	M1	1.55	2.10
2	M2	1.69	2.15
3	M3	1.80	2.20
4	M4	1.62	1.95
5	M5	1.59	1.92
6	M6	1.52	1.85

IV. RESULT AND CONCLUSION

The slump tests,compressive strength test and split tensile strength test of the concrete mix have been tested. The discussion on its results is as follows.

A. Slump Test

The slump of values of various mixture proportions provides an idea about the various workable limits of the proposed mixtures. The control mix and the mix 10FA are highly worka-ble. The mixes containing further increased percentage of fly ash have medium workability. MixM1 has high workability. The slump value of mix M2 is also highly workable. The slumps of other mixes have slump magnitude of medium workability. The mix M6 has got minimum slump value. The comparison of slump values of all proposed mixes is graphi-cally shown in Fig.1.

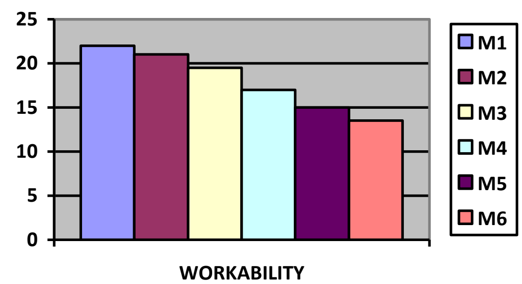

Fig.1

B. Compressive Strength Test

The compression strength values provide information about the development gradient of concrete strength and the devel-opment of early strengths. The compressive study analysis has been made under five time intervals. A maximum compres-sive strength was developed in the mix M3.The compression strength is mini-mum in M6 mix. The mix M2 behaves different by attaining early compression strength in 3 days and attaining comparatively less compression strength in 90 days. The comparison of compression strength of all proposed mixes is diagrammatically shown in Fig-2

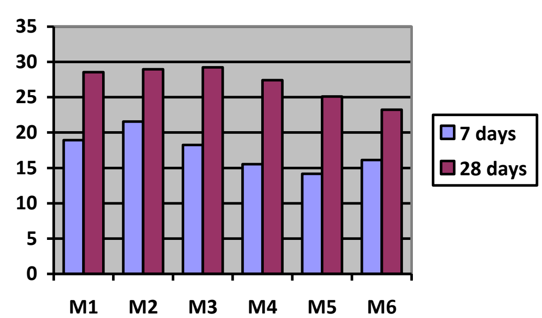

Fig 2

C. Split Tensile Strength Test

The results of splitting tensile strength of the concrete speci-mens of this study provide necessary informations about the role of fly ash and silica fumes in enhancement of tensile strength of concrete. There is no change in the tensile strength of specimens prepared in control mix and in mix M1. With the further addition of fly ash in the other mixes, increasing split tensile strength were obtained. The rate of increase in tensile strength is observed further high in the specimens pro-portioned with waste marble powder. A maximum tensile is obtained in the mix M3. The tensile strength of all the specimens were graphically presented in Fig.3

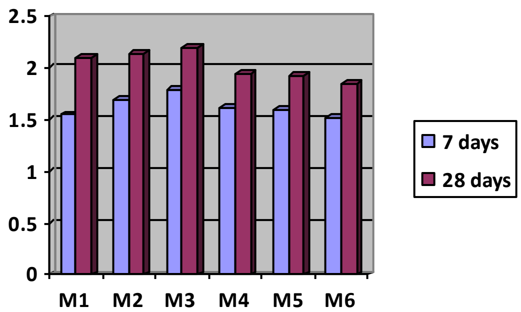

Fig 3

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