Study on Properties of Concrete by Using Marble Waste Material as A Partial Replacement of Fine Aggregate and Coarse Aggregate

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***Abstract*- In recent years, the increase in consumption of fine aggregate has lead to a fast decline in available natural resources. However, a high volume of the industrial production has generated a considerable amount of waste materials which have a number of adverse impacts on the environment. It is better to use waste material as a replacement of fine aggregate to overcome the demand of fine aggregate and also used waste material to reduce the adverse effects on environment. Nowadays, marble industries are producing a lot of marble waste. Marble contains silica and alumina as well as lime which is similar to fine aggregate. In this dissertation the work should be on strength of concrete by using marble waste as a partial replacement of fine aggregate. The cost of marble waste coarse aggregate is also less compared to natural coarse aggregate. It has to replace marble fine aggregate and marble course aggregate as a replacement of natural fine aggregate and coarse aggregate to reduce the overall cost and shortage of construction material.**

***Index Terms*- fine aggregate, coarse aggregate, marble waste aggregate**

1. INTRODUCTION

The concrete is a most important material for construction industry. As a fast growth of infrastructure development the demand of concrete is increasing day by day. To fulfill this demand there is of need continuous supply of ingredients of concrete. Concrete is mainly made up of cement, fine aggregate, coarse aggregate and water. It is very important to find such material to reduce the demand of natural fine aggregate. Generally fine aggregate is an ingredient of concrete which has function of filling the pores between the particles of coarse aggregates in concrete. There is need to find any waste material which can be used as a filler material in inside concrete. In this study marble waste material used as a partial replacement of fine aggregate and coarse aggregate to overcame the shortage of fine aggregate. There is large amount of marble waste generated from industries which has production related to marble material. Marble powder is a source which causes a lot of problems to the environment. So it is necessary to maximum utilization of marble waste in range of sectors, especially the construction, glass industries would help to save the environment. The marble waste principally consist of boulders that are used as aggregates relying upon the sizes, and also the fine powder that isn't employed regionally and drops directly into the streams, wells, watersheds that are then washed away by the rainwater.

2. LITERATURE REVIEW

GENERAL:

This chapter provides a detail review of prior work on marble waste, which serves as the foundation for this dissertation work. This chapter includes the description of different experimental studies of replacement of cement and aggregate by marble waste material. This review is conducted to get sense of the work that has been done in the field around the world. It is an important aspect of understanding the work that has been done on this issue. This literature review is done to identify the research gap. The main objective of the literature review was to develop basic understanding of marble waste properties. From the various experimental studies, some of the research papers are shown as below.

1) Tahir Ali and Anuj Sachar **"**Performance on Partial Replacement of Fine Aggregate with Marble Dust Powder**"** ISSN: 2347-5552, Volume-10, Issue-3, May 2022 **[1]**In the paper the workability of concrete found out by replacing the marble dust with fine aggregate in the proportion of 0%, 15%, 20%, 25% and 30% by weight of fine aggregate. They determined the consistency by using the process referring to the IS 4031: part 4. The workability and compressive strength of concrete had been determine by replacing the marble dust with fine aggregate in the proportion of 5%, 15%, 25%, 35%, 45%, 50% and 100% by weight of fine aggregate.

2) Sudarshan D. Kore, A.K. Vyas **"**Impact of marble waste as coarse aggregate on properties of lean cement concrete**"** ELSEVIER Case Studies in Construction Materials 4 (2016) 85–92 **[2]**In this research paper mainly focus on the replacing natural coarse aggregate with marble waste coarse aggregate. Author has taken mix design of M10 grade of concrete. And he starts the replacing marble waste aggregate from 20% to 100%. The author has perform the compaction factor test, compressive strength test, acid attack and permeability test of durability.

3)T Naga Sai Sree Saran, T Venkat Das "Experimental Investigation onConcrete with Partial Replacement of Fine Aggregate by Marble Dust Powder." ISSN: 2277-3878, Volume-7, Issue-6C2, April 2019 [6]. In this research paper the author has study on the replacement of fine aggregate of concrete with marble dust powder. the author has find out the compressive strength split tensile strength and durability test of concrete by replacing the fine aggregate by marble dust powder in proportion of 10%, 20%, 30% , 40% , 50%.

Research Gap

According to above literature review, researchers had replaced cement, fine aggregate and coarse aggregate individually in different proportion. Replacement of both fine and coarse aggregate with marble waste material is yet to study in the research papers.Various parameters such as compressive strength, split tensile strength, Sorptivity and acid attack test of concrete by replacing marble waste material with both fine and coarse aggregate together is yet to study.

Need of Present Study

Study is basically to use marble waste material in concrete to overcome the shortage of natural fine aggregate. Reduce the environmental pollution happens due to open dumped marble waste and use it in concrete as one of its ingredient. The study is required to compare the overall cost of concrete by using marble waste material.

Objective of work

To study the properties of fresh and harden concrete by replacement of natural fine aggregate and coarse aggregate with marble waste. To study durability of concrete by replacement of natural fine aggregate and coarse aggregate with marble waste. To study suitability of marble waste material to reduce the cost of construction.

Scope of work

To determine the compressive strength and the split tensile strength of concrete cube and cylinder specimen at 7 days and 28 days with replacement of fine and coarse aggregate with marble fine and marble coarse aggregate by proportion of 10%-10%, 10%-20% ,10%-30%, 10%-40% , 20%-10%, 20%-20%, 20%-30%, 20%-40% respectively.

To perform Sorptivity test and acid attack test of durability on concrete specimen with replacement of fine aggregate and coarse aggregate with marble fine aggregate and marble coarse aggregate each by 10%-10%, 10%-20% ,10%-30%, 10%-40%.

3. MATERIAL PROPERTIES

This chapter is an introduction to the materials and their properties, used in the study. Properties of material used in this study were obtained either by testing of the material as per relevant BIS standards or were taken from the users manuals provided by the manufacturers.

3.1 CEMENT

Ordinary Portland cement used in this study fulfills the requirement of Bureau of Indian standards BIS: 8112-1989 [7]. The initial and final setting time, consistency and compressive strength of cement are shown in Table 1.

3.1 Fine aggregate

Sand was collected from Banes River, Rajasthan. The sand used in this study was conforming to grading zone II of BIS: 383- 1960 [6]. The results of specific gravity and water absorption of sand are presented in Table 2.

3.2 Coarse aggregate

Crushed stone aggregate used in this study was used from a nearby quarry. Specific gravity and water absorption of coarse aggregate are presented in Table 3. The nominal maximum size of coarse aggregate used was 20 mm.

3.4 Marble fine & coarse aggregate

Marble waste used in this study was nearby Rajnagar area and crushed in to crusher. Specific gravity and water absorption of marble aggregate are presented in Table 2 and 3. The particle size distribution of marble aggregate and conventional coarse aggregate is been determined. It can be seen that water absorption of marble aggregate is about 10% of that of natural conventional aggregate.

3.5 Water

The amount of water in concrete controls many fresh and hardened properties in concrete including workability, compressive strengths, permeability and water tightness, durability and weathering, drying shrinkage and potential for cracking. The role of water is important here to accelerate this hydration process by adding 23%-25% of the cement volume. It produces 15% of water cement paste called gel to fill the voids in the concrete.

Table 1: Properties of cement

Test	Result obtained
Initial setting time	107 minutes
Final setting time	205 minutes
Avg. comp. strength at 28 days	56.16 N/mm^2
Specific gravity	3.15

3.6 Specific gravity test procedure

Specific gravity of aggregate is the ratio of the weight of given volume of aggregates to the weight of equal volume of water. Take about 500 g of sample and place it in the pycnometer and weigh. Pour distilled water into it until it is full. Eliminate the entrapped air by rotating the pycnometer on its side, the hole in the apex of the cone being covered. Wipe out the outer surface of pycnometer and weigh it (W4). Transfer the contents of the pycnometer into a tray, care being taken to ensure that all the aggregate is transferred. Fill the pycnometer with distilled water to the same level. Find out the weight (W2). Drain water from the sample through alter paper. Place the sample in oven in a tray at a temperature of 100°C to 110°C for 24 hours, during which period, it is stirred occasionally to facilitate drying. Cool the sample and weigh it (W3). Weight of pycnometer noted as (W1)

Table 2: Properties of natural and marble fine aggregate[IS 2386:1963]

Properties	Natural fine aggregate	Marble fine aggregate
Specific gravity	2.64	3.05
Water absorption	0.80 %	0.2 %
Sieve analysis	Zone II as per IS 383	Zone II as per IS 383

Table 3: Properties of natural and marble coarse aggregate[IS 2386:1963]

Properties	Natural coarse aggregate	Marble coarse aggregate
Specific gravity	2.91	2.77
Water absorption	0.55 %	0.40 %
Aggregate impact value	7.37 %	10.73 %

4. EXPERIMENTAL STUDTY

4.1 Mix Design of M25 Grade Concrete Quantity Per m^3 For Different Mix

Mix no.	Replacement (FM%-CM %)	Cement (kg)	Fine aggregate (kg)	Coarse aggregate (kg)	Marble Fine agg. (kg)	Marble Coarse agg. (kg)
MW1	(0% - 0%)	340	656.04	1259.7	0	0
MW2	(10% - 10%)	340	590.43	1133.73	75.79	122.43
MW3	(10% - 20%)	340	590.43	1007.76	75.79	244.86
MW4	(10% - 30%)	340	590.43	881.79	75.79	367.29
MW5	(10% - 40%)	340	590.43	755.82	75.79	489.72
MW6	(20% - 10%)	340	524.83	1133.73	151.58	122.43
MW7	(20% - 20%)	340	524.83	1007.76	151.58	244.86
MW8	(20% - 30%)	340	524.83	881.79	151.58	367.29
MW9	(20% - 40%)	340	524.83	755.82	151.58	489.72

5. TEST RESULTS & DISCUSSION

5.1 Slump Test of Workability

Mix No.(M25)	Proportion	Slump value (mm)
MW1(Control)	(0%-0%)	75 mm
MW2	(10%-10%)	80 mm
MW3	(10%-20%)	80 mm
MW4	(10%-30%)	95 mm
MW5	(10%-40%)	110 mm
MW6	(20%-10%)	90 mm
MW7	(20%-20%)	95 mm
MW8	(20%-30%)	110 mm
MW9	(20%-40%)	125 mm

Discussion: The workability of concrete increases with the increase in marble waste fine and coarse aggregate content due to less water absorption of marble waste aggregate.

5.2 Compressive Strength Test Results: [IS code 516-2021]

Mix no.	**Proportion (FM%-CM %)**	**Average compressive strength of concrete (N/mm^2)**	
		At 7 days	**At 28 days**
MW1	(0% - 0%)	19.70 N/mm^2	35.66 N/mm^2
MW2	(10% - 10%)	17.27 N/mm^2	30.97 N/mm^2
MW3	(10% - 20%)	16.65 N/mm^2	29.12 N/mm^2
MW4	(10% - 30%)	16.23 N/mm^2	28.69 N/mm^2
MW5	(10% - 40%)	15.71 N/mm^2	26.62 N/mm^2
MW6	(20% - 10%)	11.73 N/mm^2	20.84 N/mm^2
MW7	(20% - 20%)	10.33 N/mm^2	17.67 N/mm^2
MW8	(20% - 30%)	9.81 N/mm^2	17.08 N/mm^2
MW9	(20% - 40%)	9.09 N/mm^2	16.72 N/mm^2

5.3 Split Tensile Strength Test Results: [IS code 516-2021]

Mix no.	**Proportion (FM%-CM %)**	**Average compressive strength of concrete (N/mm^2)**	
		At 7 days	**At 28 days**
MW1	(0% - 0%)	2.12 N/mm^2	3.50 N/mm^2
MW2	(10% - 10%)	1.93 N/mm^2	2.90 N/mm^2
MW3	(10% - 20%)	1.68 N/mm^2	2.65 N/mm^2
MW4	(10% - 30%)	1.62 N/mm^2	2.51 N/mm^2
MW5	(10% - 40%)	1.53 N/mm^2	2.39 N/mm^2
MW6	(20% - 10%)	1.39 N/mm^2	2.33 N/mm^2
MW7	(20% - 20%)	1.33 N/mm^2	2.29 N/mm^2
MW8	(20% - 30%)	1.28 N/mm^2	2.21 N/mm^2
MW9	(20% - 40%)	1.2 N/mm^2	2.15 N/mm^2

Figure: Casting and Testing of Concrete Cubes and Cylinders

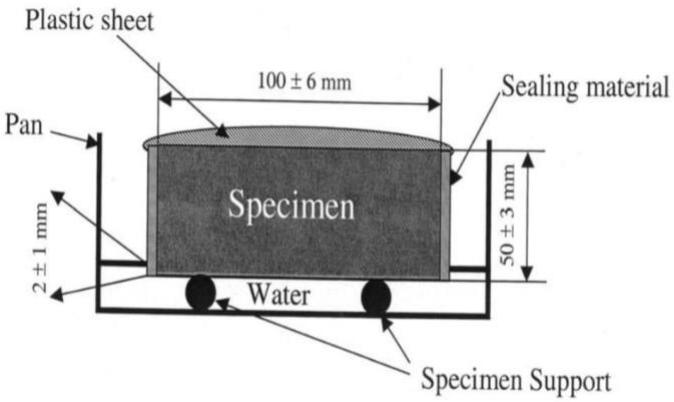
5.4 Durability Test Results

5.4.1. Sorptivity Test: [ASTM 1585-13]

When only one surface of a specimen is exposed to water, the Sorptivity test method is used to measure the rate of water absorption by cement concrete by measuring the increase in mass of a specimen as a function of time as a result of water absorption. The Sorptivity test specimen is of 100 ± 6 mm diameter Disc with a length of 50 ± 3 mm.

Test Procedure.

To calculate water absorption, measure the mass of the sealed specimen to the nearest 0.01 gram and record it as the initial mass. Place test specimens in the chamber at a temperature of 50 ± 20 C for 3 days. After that place Specimens in pan and Fill the pan with tap until the water level will reach 1 to 3 mm above the top of the support device, and then place the support device at the bottom. For the duration of the testing, keep the water level 1 to 3 mm above the top of the support device. Take a time and date when you first came into touch with water. The first point should be 60 seconds long, after that the second should be 5 minutes long. The measurement of mass must be taken within 10 minutes, 20 minutes 30 minutes, and 60 minutes from the first contact of the specimen with water. Then after take measurements of mass at an interval of one hour, up to 6 hours. After the initial 6 hours, take measurements of mass once in a day for the next seven days, at least 24 hours apart. Take the final measurement at day seven. Using a wet paper towel or cloth, wipe away surface water. Invert the specimen after blotting to remove excess water so that the wet surface does not come into contact with the balance pan. Measure the mass to the nearest 0.01 gram within 15 seconds of removing it from the pan. Replace the specimen on the support device as soon as possible, and start the timing device.



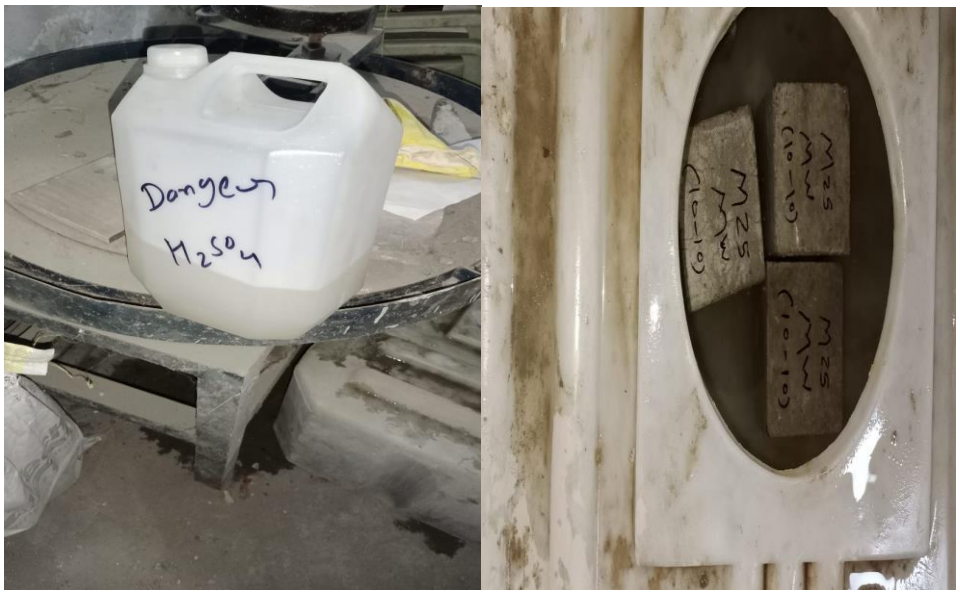
5.4.2. Sorptivity Test Results: [ASTM 1585-13]

Mix no.	Proportion (FM%-CM%)	Sorptivity value at 7 days (water absorption (mm))
MW1	(0% - 0%)	5.6291 mm
MW2	(10% - 10%)	5.4380 mm
MW3	(10% - 20%)	4.8226 mm
MW4	(10% - 30%)	4.3805 mm
MW5	(10% - 40%)	4.2235 mm

Discussion: as per the above table the sorptivity value of concrete will decrease with increasing the proportion of marble waste.

5.4.3 Acid Attack Test: [ASTM C1898-20]

Acid attack is a chemical breakdown mechanism in which hydrogen ions attack Concrete. In this test sulphuric acid solution quantity has been taken as 5 % of water quantity for curing which is capable of chemically reacting with concrete. The standard cube samples of size 150 mm x 150 mm x 150 mm were immersed in water for normal curing. After 28 days of immersion the cube specimens were then immerge in sulphuric acid solution for the period of 28 days to identify the acid resistance of concrete at 56 days in terms of weight reduction and strength reduction of concrete.



5.4.4. Acid Attack Test Results: [ASTM C1898-20]

MIX Description (FM% -CM%)	Initial (Wt) (kg)	Final (Wt) (kg)	Weight loss (%)	Compressive strength at 28 days (N/mm^2)	Compressive strength after 56 days in Solution (N/mm^2)	Compressive strength loss (%)
Mix-1 MW(0%- 0%)	8.14	7.75	4.72	35.66	32.16	9.80
Mix-2 MW(10%-10%)	8.43	8.01	4.96	30.97	27.66	10.66
Mix-3 MW(10%-20%)	8.58	7.89	5.11	29.12	25.48	12.47
Mix-4 MW(10%-30%)	8.72	8.24	5.47	28.69	24.75	13.71
Mix-5 MW(10%-40%)	8.89	8.38	5.66	26.62	22.64	14.92

6. CONCLUSIONS

Workability of concrete is increases with increasing the proportion of marble waste fine and coarse aggregate. Maximum value of workability as per test result will occur at proportion of MW (20% - 40%).

Compressive strength of M25 grade concrete is more than 25 N/mm^2 up to replacement proportion of MW (10% - 40%). After that the value of compressive strength is start decreasing from the proportion of MW (20% - 10%). Hence we can replace marble waste at maximum proportion of MW (10% - 40%) To achieve compressive strength of M25 grade concrete.

Split tensile strength value of M25 grade concrete is more than 2.5 N/mm^2 up to replacement proportion of MW (10% - 30%). After that the value of split tensile strength is start decreasing from the proportion of MW (10% - 40%). Hence we can replace marble waste at maximum proportion of MW (10% - 30%) To achieve Split tensile strength of M25 grade concrete.

As per the result of Sorptivity test of durability the water absorption rate is decrease with increase in the proportion of marble waste because of less water absorption value of marble waste. Hence it shows good durability in terms of water absorption.

As per the acid attack test result of durability the acid resistance of concrete will decrease with increasing the proportion of marble waste.

The overall cost of construction decreases by replacing marble waste aggregate with natural fine and coarse aggregate comparatively.

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