EXPERIMENTAL STUDIES ON SUSTAINABLE CONCRETE INCLUDING MARBLE DUST AND RICE HUSK ASH

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Abstract - *Since ancient times, marble has been commonly utilised as a building material. The industry's disposal of Marble Waste, which consists of marble fragments and very fine powder, is currently one of the world's most pressing environmental issues. Rajasthan, which is renowned for its marble deposits, produces 95 percent of the nation's total marble production. Rice husk ash (RHA) is a paddy industry by-product. Rice husk ash is a highly reactive pozzolanic substance generated from the controlled combustion of rice husk. Partially substituting Marble Waste Powder (MWP) for natural fine aggregate and rice husk ash for cement. The destructive tests on hardened concrete included compressive strength test 7,28, and 56 days of curing according to IS: 516 1959. Flexural strength on beam at 28 days of curing according to IS: 516 1959, and split tensile strength on cylinder at 28 days of curing according to IS: 5816 1999. This study describes the impact of varied quantities of MWP and RHA on the mechanical properties of concrete, such as compressive strength, flexural strength, and split tensile strength, as they pertain to the behaviour of concrete made with cement containing a combination of MWP and RHA. The findings of the test were compared to conventional concrete mix.*

***Key Words*:** Marble Waste Powder (MWP), Rice Husk Ash (RHA), Mechanical properties, Conventional concrete, Sustainable.

1. INTRODUCTION

Concrete is the most prevalent man-made building material in the world. It is produced by combining cementitious ingredients, water, aggregate, and sometimes admixtures in the appropriate amounts. Since the price of cement has grown due to higher production costs or more demand, there is an urgent need to replace it in whole or in part with less expensive alternatives. Due to the abundance of raw materials, concrete's superior strength and durability, inexpensive production and maintenance costs, adaptability in forming diverse shapes and limitless structural possibilities when combined with steel reinforcement, concrete is a popular building material. Nevertheless, cement, which is an essential component of concrete, presents a significant obstacle for the sector. The manufacture of cement is an energy-intensive operation, and the emission of carbon dioxide during cement production raises environmental issues. Furthermore, there are a growing number of instances in which cement causes concrete to deteriorate under hostile climatic circumstances. These issues have prompted the consideration of reducing cement usage and the expansion of research into the possibilities of boosting strength and durability via the use of mineral admixtures. This results in a rise in the usage of cementitious substances that can partially replace Portland cement. Mineral admixtures are used to counteract the detrimental effect of calcium hydroxide (CH) formed during cement hydration in concrete. These mineral admixtures generate a lower proportion of carbon monoxide than Ordinary Portland cement (OPC).This study deals with utilisation of rice hush ash and marble waste powder in concrete mix. Deepankar et al (2016) investigated the influence of marble dust in concrete. Comparing test findings, it was discovered that marble powder enhanced the mechanical qualities of concrete by partially replacing sand and cement in predetermined amounts. Mohammedan (2012) investigates the effect of different percentages of marble powder and silica fume as a partial substitute for cement on mortar. In order to improve the qualities of concrete, Aliabdo et al. (2014) investigated the use of marble powder in place of cement or sand. It demonstrates that replacing sand has superior results to replacing cement. Ankit et al. (2019) investigated replacing varying proportions of ordinary Portland cement with RHA to produce concrete with strengths and qualities that were comparable to and satisfactory compared to those of conventional concrete. The replacement percentages, which range from 5% to 15%, are chosen at intervals of 2.5%. The cast concrete was tested under compression at various ages, and the results were compared with those of regular concrete of the same grade. It was determined that the results were comparable.

2. MATERIALS USED IN THIS WORK

Ordinary Portland cement (OPC) 53 grade is used in this study. Table 1 presents the results of experiments on cement. Locally sourced river sand is used (grade III) as per IS 383:2016 specifications. 20 mm size of natural coarse aggregate is utilised in this study. Marble waste powder is taken from local marble seizing unit. Rice hush ash (RHA) is collected from Perundurai, India. potable water is used mixing and curing of concrete specimens as per the specifications IS 456:2000. Properties of all materials are listed in Table 2.

Fig-1 Sample of Rice husk ash

Fig-2 Marble waste powder

Table -1: Tests on OPC 53 grade cement

Test conducted	Obtained values	Standard value
Normal consistency (%)	32	-
Initial setting time (minutes)	41	Not less than 30 min
Final setting time (minutes)	218	Not greater than 600 min
Fineness (%)	3.54	<10
Specific gravity	3.15	-

Table -2: Properties of materials

Properties	Fine aggregate	Coarse aggregate	Marble waste powder	Rice husk ash
Specific gravity	2.62	2.81	2.90	2.81
Bulk density(kg/m3)	1698	1425	1218	925
Fineness modulus	2.6	7.32	2.34	-

3. MIX PROPORTION OF CONCRETE MIX

For M30 grade, a trial mix has been developed with an assumed compaction factor of 0.80 in accordance with IS 10262 - 1982. The trial mix, which has a water cement ratio of 0.45, is 1:1.4:2.8. RHA is partially replaced for cement by different amounts (0 to 25%), while MWP is partially replaced for natural fine aggregate by varying amounts (0 to 25%). Five trail mixes have been developed and are referred to as mix A, mix B, mix C, mix D, and mix E. the mix proportions of each mix and materials required per m3 is listed in Table 3.

Table-3: Materials required per m^3

MIX ID	Mix combination	C kg/m3	CA kg/m3	FA kg/m3	MWP kg/m3	RHA kg/m3	Water Litres/m3
CM	control mix	413	1190	600	-	-	186
Mix A	RHA5%+MWP5%	392.35	1190	570	30	20.65	186
Mix B	RHA10%+MWP10%	371.70	1190	540	60	41.30	186
Mix C	RHA15%+MWP15%	351.05	1190	510	90	61.95	186
Mix D	RHA20%+MWP20%	330.40	1190	480	120	82.60	186

Mix E	RHA25%+MWP25%	309.75	1190	450	150	103.25	186
C- CEMENT, CA- COARSE AGGREGATE, FA- FINE AGGREGATE, MWP- MARBLE WASTE POWDER, RHA- RICE HUSK ASH							

4. EXPERIMENTAL INVESTIGATION

4.1 Testing of specimens

After the appropriate period of curing, cast specimens were tested to a series of mechanical strength tests, including compressive strength, split tensile strength, and flexural strength.

4.1.1 Compressive strength, splitting tensile strength and modulus of rupture of specimens

The compressive strength test was performed in accordance with IS 516:1959Cube specimens of 150 mm x 150 mm x 150 mm were utilised. The tests were carried out in a compression testing machine with a capacity of 1000 KN. The compressive strength of a specimen is calculated by dividing the specimen's ultimate load by its cross-sectional area. Experimental test setup for compressive strength test is depicted in Figure 3. The diameter and length of cylindrical specimens employed are 150 mm and 300 mm, respectively. The cylinder was split along its centre plane parallel to the edge throughout the test, and the compressive load was applied to the adjacent edges. The test was conducted in accordance with IS 5816:1999. Prism specimens with dimensions of 150 mm x 150 mm x 500 mm are used to measure the flexural strength of concrete. The test was performed in accordance with IS 516:1959. Figure 4 depicts the setup for loading the flexure test specimen. Table 4 summarises the test results of mechanical strength properties.

Fig-3 Testing of compressive strength **Fig- 4** Test set up for modulus of rupture

Table-4: Test findings of mechanical strength tests

Mix ID	Compressive strength (MPa)			Splitting tensile strength (MPa)	Modulus of rupture (MPa)
	7d	28d	56d	28d	28d
CM	21.12	34.25	38.56	3.41	6.20
Mix A	22.98	36.29	39.32	3.52	6.85
Mix B	23.11	37.80	40.23	3.68	7.10
Mix C	23.82	39.07	41.11	3.84	7.12
Mix D	23.15	38.85	40.89	3.90	6.74
Mix E	22.98	37.21	39.45	3.40	6.70

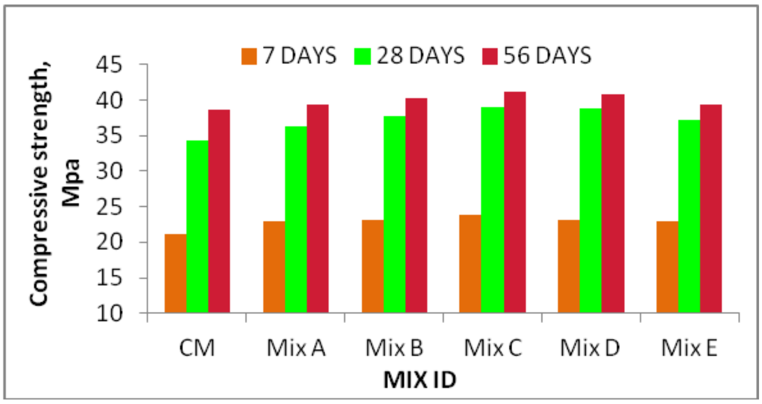

Chart-1: Variation in compressive strength of different specimens

4.1.2 Test findings on mechanical strength properties

Figure 4 shows the results of compression strength tests performed on various concrete mix combinations, including RHA and MWP, after 7, 28, and 56 days of curing. The compressive strength values at 28 days ranged from 36.29 MPa to 39.07 MPa. Among the other mixes, Mix ID (Mix C) attained the highest compressive strength. At day 56, mix C had strength of 41.11 MPa. It is 6.20% increased the strength when compared with control mix. The strength gradually decreased after mix C. At 56 days, it was observed that the specimen containing RHA with pozzolanic characteristics increased compressive strength. Splitting tensile strength of various specimens at 28 days curing are presented in Table 3. Split tensile strength values of cylindrical specimens ranged between 3.52 MPa to 3.90 MPa. while the control mix had a strength of 3.41 MPa. The split tensile strength of Mix D was 3.90 MPa. 14.36 % of split tensile strength was increased than control mix. Table 3 summarizes the findings of flexural tensile strength measurements performed on beam specimens of M30 grade concrete. After curing for 28 days, the flexural strength of beams was examined. Maximum flexural strength was recorded at the combination of (15%) MWP and (15%) RHA, and the strength increased by 14.83 percent compared to control concrete after 28 days of curing.

5. CONCLUSIONS

From the above results, the following conclusions can be made:

- For various mix proportions, the compressive strength of concrete increases as the percentages of marble waste powder and rice husk ash increase up to 15% replacement of cement.
- The highest 28-day split tensile strength was produced with a mixture of 20% marble waste powder and 20% rice husk ash, which was marginally higher than control concrete.
- Maximum flexural strength at 28 days was attained with a mixture of 15% marble waste powder and 15% rice husk ash.
- It has been determined that rice husk ash is superior to other materials such slag, fly ash, and silica fume. RHA, which is reach in amorphous silica, is effective as a pozzolanic material in this investigation.
- Due to RHA's low specific gravity, which results in a decrease in density of concrete, its addition lessens the structure's dead load.
- When disposing of extra MWP and RHA, the use of rice husk ash and marble waste powder helps to reduce environmental contamination.

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