Research Article

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Strength Characteristics of Self-compacting Concrete partially replaced with Waste Marble Powder

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ABSTRACT

Self-compacting concrete is one of the most revolutionary developments in concrete research; this concrete is able to flow and fill the most congested places of the formwork without vibration. The properties of self-compacting concrete after the replacement of fine aggregate with waste marble powder at different percentages (0, 10, 20, 30, 40 and 50%) have been investigated in this work. The waste marble powder, finer than 4.75 mm, was used for the replacement of fine aggregate. With the increment in the dosage of waste marble powder, the workability of self-compacting concrete has increased. For the dosage of 30%, the properties observed were better than other dosages. The compressive strength tests were conducted at different mix proportions and the highest compressive strength was found at 30% dosage at 7-day and 28-day ages.

Keywords: Self-compacting concrete; Waste marble powder; Workability.

1. INTRODUCTION

The ability of self-compacting concrete lies not only in its high deformability mix but also in its resistance to segregation between coarse aggregate and mortar when the concrete flows through the confined zone of reinforcing bars (Arivalagan S, 2013). Self-compacting concrete (SCC) is an innovative concrete that does not require vibration for placing and compaction. It is able to flow under its self-weight, completely filling formwork, and has the ability to achieve full compaction. SCC is one of the most revolutionary developments in the field of concrete research. This concrete is able to flow and fill the most restricted places of the formwork without vibration (Zoran Grdic *et al.* 2008). SCC is a new category of high-performance concrete characterized by its ability to spread into a heavily reinforced area under its self-weight without the need for vibration and has excellent deformability and high resistance to segregation. There are numerous advantages of using SCC: (i) fast placement of concrete (ii) better consolidation around the reinforcement (iii) easily placed in thin-walled elements with limited access (iv) improves the quality, durability and reliability of concrete structures and (v) ease of placement results in cost-saving through a reduction in equipment and requirement of labor (Aggarwal Paratibha *et al.* 2005). SCC is an innovative development in the field of conventional concrete, which requires high binder content to increase its segregation resistance (Mahajan Sumit and Singh Dilraj, 2013). SCC can be defined as fresh concrete which possesses superior flowability and under-maintained stability. SCC was first developed in Japan in 1988 in order to achieve durable concrete structures by improving quality in the construction process (Goodier C I, 2003). SCC has the unique capacity of consolidation under its self-weight.

2. MATERIALS AND METHODS

Cement: Ordinary Portland Cement (OPC) of 43 grade and Shree brand conforming to IS- 8112-1989 were used throughout this research. The normal consistency of this cement was 28%. The physical properties of used cement are given in Table 1.

Fine aggregate: Locally available sand of River Ramganga conforming to IS: 383-1970, Zone-II, was used throughout this research. Specific gravity, bulk density and fineness modulus of used sand were 2.6, 1774 kg/m^3 and 3.18, respectively.

Coarse aggregate: Locally available crushed stone aggregates conforming to IS: 383-1970, of 10 mm maximum size was used as coarse aggregate throughout this research. Specific gravity, bulk density and fineness modulus of used coarse aggregate were 2.7, 1483 kg/m^3 and 6.45, respectively.

Waste marble powder: Waste marble powder was collected from the locally available manufacturing unit in Moradabad, U.P., India. It was initially in wet slurry form; by exposing it to sunlight and sieving by IS 4.75 mm sieve before mixing (Fig. 1), it was used in dry form. The physical properties of waste marble powder are given in Table 2.

Water: Potable water for mixing and curing concrete specimens was used throughout the research.

Superplasticizer: Sika Viscocrete 20-HE was used in this research. It is a revolutionary high-range water content reducer based on polycarboxylate ether (PCE). It has been developed for the production of concrete of high early strength and magnificent workability requirements.

SCC MIX DESIGN: Okamura method (Rational mix design method) was used for the mix design of self-compacting concrete. Okamura and Ozawa (2000) proposed a simple mix proportioning system assuming a general supply from ready-mixed concrete plants. The coarse and fine aggregate contents were fixed so that self-compatibility can be achieved easily by adjusting the water-powder ratio and super-plasticizer dosage. The coarse aggregate content in concrete was fixed at 50 % of the solid volume, whereas the fine aggregate content was fixed at 40% of the mortar volume. The water-powder ratio in volume was assumed at 0.9 to 1.0 depending on the properties of the powder. The dosage of the super-plasticizer and the final water-powder ratio were determined so as to ensure self-compatibility.

In the present study, M-30 grade of SCC was used for all experimental work. All the tests of SCC in the hardened state were performed in the present study.

Table 1. Physical properties of cement

S. No.	Characteristic	Experimental values	Codal Requirement (IS: 8112-1989, OPC 43 grade specifications)
a	The fineness of cement (% retained on IS 90-micron sieve)	4.83%	10%
b	The soundness of cement (By Le-Chatelier method)	0.9 mm	Not more than 10 mm
c	Initial setting time	65 min	Not less than 30 min
d	Final setting time	224 min	Not more than 600 min
e	Compressive strength (7 days)	23.5 N/mm^2	16.0 N/mm^2
f	Compressive strength (14 days)	34.8 N/mm^2	22 N/mm^2
g	Compressive strength (28 days)	45.0 N/mm^2	43 N/mm^2

Table 2. Physical properties of waste marble powder

S. No.	Characteristic	Result
a	Colour	White
b	Form	Powder
c	Odour	Odourless
d	Specific gravity	2.68

3. RESULTS AND DISCUSSION

In this study, hardened properties of self-compacting concrete were investigated by using waste material (powder of waste marble) at six replacement rates for the fine aggregate. Compressive strength tests were carried out to determine the mechanical properties of hardened concrete at 7- and 28-days age.

3.1 Mix proportions of SCC with Waste Marble powder

We have cast 30 cubes of SCC with or without waste marble powder at different percentages for the age of 7 days. Five cubes were used for each mix, *viz*, 0, 10, 20, 30, 40 and 50% powder of marble powder. Each cube was tested for 7 days compressive strength. 30 cubes were also cast for 28 days of the same percentages of waste marble powder. These mix proportions were given in Table 3.

Table 3. Mix proportions of SCC with Waste marble powder

S. No.	% of Fine aggregate	% of Waste marble powder	No. of cubes for 7 days compressive strength	No. of cubes for 28 days compressive strength
1	100%	0%	5	5
2	90%	10%	5	5
3	80%	20%	5	5
4	70%	30%	5	5
5	60%	40%	5	5
6	50%	50%	5	5
	Total		30	30

3.2 Comparison of Compressive Strength at 7 days for all the samples

All the samples of SCC with waste marble powder at different proportions were compared and it has been found that there was an increase in compressive strength with the increase in the percentage of waste marble powder up to 30%. Then, there was a decrease in compressive strength at 40 and 50%, which is given in Table 4. The graphical representation of the average compressive strength of SCC with waste marble powder is given in Fig. 1.

Table 4. Comparison of Compressive strength at 7 days for the samples

Sample No.	Percentage of Waste marble powder in SCC	The average value of compressive strength at 7 days of 5 samples, in MPa
1	0%	17.465
2	10%	17.798
3	20%	18.117
4	30%	18.269
5	40%	15.560
6	50%	15.001

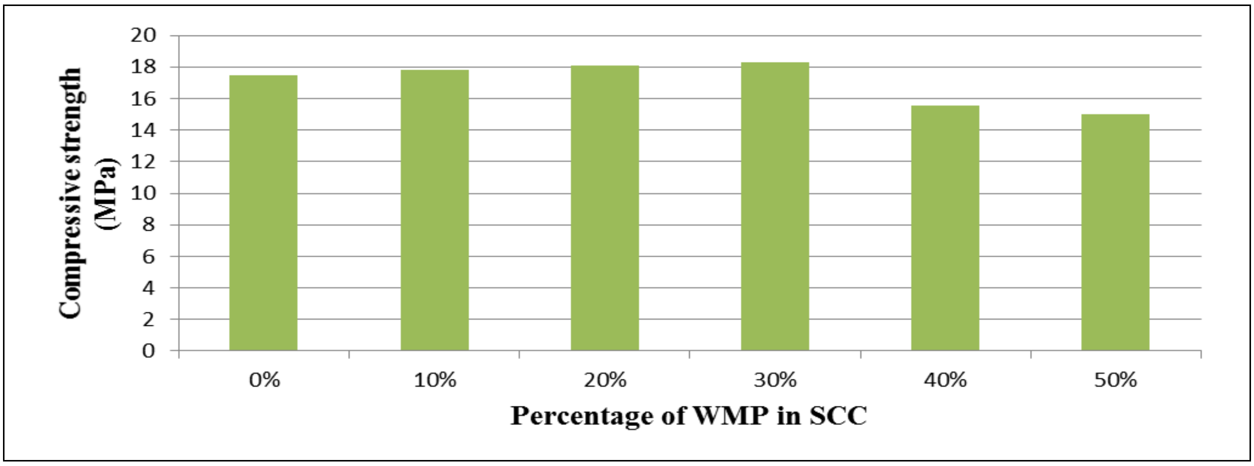

Fig. 1: Comparison of compressive strength at 7 days for all the samples

3.3 Comparison of Compressive Strength at 28 days for all the samples

All the samples of SCC with waste marble powder at different proportions were compared and it has been found that there was an increase in compressive strength with the increase in the percent of waste marble powder up to 30%; then, there was a decrease in compressive strength at 40 and 50%.

The graphical representation of the comparison of compressive strength at 28 days between all the samples of SCC with waste marble powder is given in Fig. 2:

Table 5. Comparison of compressive strength at 28 days for all the samples

Sample No.	Percentage of Waste marble powder in SCC	The average value of compressive strength at 28 days of 5 samples, in MPa
1	0%	31.230
2	10%	32.68
3	20%	33.159
4	30%	33.703
5	40%	32.977
6	50%	30.32

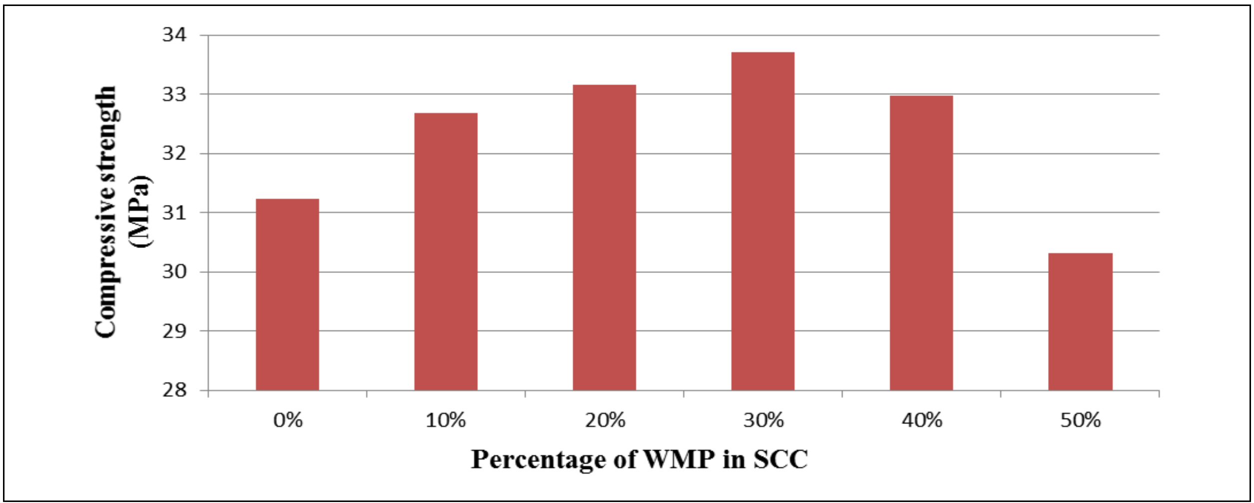

Fig. 2: Comparison of compressive strength at 28 days for all the samples of SCC

4. CONCLUSION

From the present study, the following conclusions may be drawn:

1. The results of compressive strength (hardened properties) have shown significant performance differences; higher compressive strength has been obtained for waste marble powder replacement. The highest compressive strength has been found at 30% waste marble powder replacement as compared to other mixes at 7 days age and helps the environment by using old construction waste.
2. The highest compressive strength has also been found at 30% powder of waste marble replacement as compared to other mixes at 28 days age.

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CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

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