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Effect of Partial Replacement of Fine Aggregate by Marble Powder on the Fresh and Hardened Properties of SCC

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Abstract – Self-compacting concretes (SCC) are highly fluid concretes that can flow and be placed in formwork under their own weight without the requirement of internal or external energy. This fluidity is obtained with the use of high paste volume and super plasticizer. The paste of SCC is made principally of cement, which is the most expensive component of concrete. As a result, the production cost of SCC is higher than conventional concrete. However, to make the manufacture of SCC more practical and economical, the binder is often a binary, ternary even quaternary compound: Portland cement mixed with mineral additions. The primary aim of this work is to study the effect of incorporating marble powder as a partial replacement to Fine aggregate. Assessment of Hardened properties was limited to Compressive and flexural strength. Two types of curing (ponding and polythene curing) were adopted for the study. The mix design adopted was M30.Out of the various % replacements, the optimum % replacement of marble powder was found to be 20% and performed well in both fresh and hardened properties. Optimum compressive strength with water curing at 28 days is 38 N/mm^{2}and for polythene curing is 29 N/mm^{2}The obtained results revealed the possibility of replacing fine aggregate with 20% marble powder and also polythene curing can be adopted in water scarce areas.

Index Terms – Super plasticizers, Portland cement, Marble powder, Compressive strength, Flexural strength.

1. INTRODUCTION

Self-compacting concrete (SCC) has been described as "the most revolutionary development in concrete construction for several decades". Originally developed to offset a growing shortage of skilled labour, it has proved beneficial economically because of a number of factors. The Self-consolidating concrete (SCC) was first developed in Japan in the late 1980. Over the last decades, SCC as a new generation of high-performance concrete has been known as a significant progress in concrete industry and consequently considered as the subject of extensive research studies. SCC's unique property gives it significant constructability, economic and engineering advantages. Moreover, SCC can be pumped to a great distance and increases the speed of construction. Changes to mix design or placing of the material can lead to the modifications of the porous structure and consequently permeability of the material. The fines content of SCC is higher than in normally-vibrated concrete (NVC) and the absence of compacting lowers the risks inherent in the process, either from excessive vibration or from insufficient vibration.

The concrete industry is constantly looking for supplementary material with the objective of reducing the solid waste disposal problem. Leaving the waste materials to the environment directly can cause environmental problem. Hence the reuse of waste material has been emphasized. A high volume of marble production has generated a considerable amount of waste materials; almost 70% of this mineral gets wasted in the mining, processing and polishing stages which have a serious impact on the environment. The processing waste is dumped and threatening the aquifer. Therefore, it has become necessary to reuse these wastes particularly in the manufacture of concrete products for construction purposes. In the dry season, the dust dries up, floats in the air, flies and deposits on crops and vegetation. In addition, the deposition of such generated huge amount of fine wastes certainly creates necrotic ecological conditions for flora and fauna changing landscapes and habitats. The accumulated waste also contaminates the surface and underground water reserves.

Today we are faced with an important consumption and a growing need for aggregates because of the growth in industrial production, this situation has led to a fast decrease of available resources. The worldwide consumption of sand as fine aggregate in concrete production is very high, so maximum areas are facing acute shortage of good quality of sand and by using waste marble powder in SCC we can overcome this situation. Effect of waste marble powder in SCC has been investigated by experimental tests on SCC without marble powder and with varying quantities of marble powder by replacing the sand partially.

2. MATERIAL USED

2.1 Cement

Ordinary Portland Cement (OPC) of 53 grade conforming to IS 12269 – 1987 was used in the study which has specific gravity of 3.15 and standard consistency 34%.

2.2 Fine Aggregate

M- Sand passing through 4.75mm IS sieve was used in the study with fineness modulus of 2.673 and specific gravity 2.61.

2.3 Coarse Aggregate

Crushed granite stones obtained from local quarries were used as coarse aggregate with fineness modulus of 3.30 and specific gravity 2.77 . The maximum size of coarse aggregate used was 12.5 mm.

2.4 Marble Powder

Marble is a metamorphic rock resulting from the transformation of a pure limestone. The purity of the marble is responsible for its colour and appearance. It is white if the limestone is composed solely of calcite (100% $CaCO_3$). The specific gravity of marble powder is 2.5.

2.5 Water

Water is an important ingredient of concrete as it actively participates in the chemical reaction with cement. Water fit for drinking is generally considered fit for making concrete. Water should be free from acids, oils, alkalies, vegetables or other organic impurities. The pH of water taken is between6–7.

2.6 Super Plasticizer

High Range Water reducing admixture (HRWRA) or Super plasticizer is an important constituent in the production of SCC to achieve self-compatibility and flowability. The HRWRA helps in achieving excellent flow at low water content. Ceraplast 300 is used for the present study, with a specific gravity of 1.09.

3. METHODOLOGY

Based on the Indian Standard (IS: 10262 – 1982), design mix for M30 grade of concrete was prepared by partially replacing fine aggregate with five different percentages by weight of marble powder (0%, 10%, 20%, 30%, 40%). The concrete cubes of size 100x100x100 mm and beams of size 100x100x500 mm were casted. The six specimens of cube and two specimens of beam of each mix were prepared. After 48 hrs the specimens were removed from the mould subjected to water curing for 7 & 28 days and polythene curing for 28 days. After curing the specimens were tested for compressive strength and flexural strength.

Figure 1 : Images of Moulds

Figure 2 : Water curing Figure 3 : Polythene curing

Table No.1: Details of Replacement of Sand by Marble Powder as Fine Aggregate

Sl No.	Cement	Sand	Marble Powder	Aggregate
1	100%	100%	0%	100%
2	100%	90%	10%	100%
3	100%	80%	20%	100%
4	100%	70%	30%	100%
5	100%	60%	40%	100%

Table No.2: Mix Proportion for concrete M30

Mix %	W/C ratio	Water	Cement	F.A	C.A	S.P	M.P
0	0.40	2.713	6.784	15.38	11.88	140	0
10	0.40	2.713	6.784	13.84	11.88	140	1.54
20	0.40	2.713	6.784	12.30	11.88	140	3.08
30	0.40	2.713	6.784	10.77	11.88	140	4.61
40	0.40	2.713	6.784	9.23	11.88	140	6.15

Figure 4 : Images of specimens

4. TEST RESULTS

4.1 Slump Test

Slump test is the most simple and common test used for finding the flowability of the concrete. Flowability of self compacting concrete is defined as the ability of the concrete to flow freely in a horizontal surface in the absence of obstacles without segregation. It also gives an assessment of filling ability. As per EFNARC guidelines, the average diameter should be between 650 and 800mm. All the tests were conducted on all the mixes before casting of specimen.

Figure 5 : Slump cone test

Table No.3: Slump test results

Mix ID	Slump Flow Dia (mm)	Time Flow (sec)
M1+0%	670	2.3
M1+10%	683	2.8
M1+20%	695	3
M1+30%	-	-
M1+40%	-	-

4.2 Compressive Strength

Compression strength test is the important and most common test conducted. Compressive strength of concrete is a measure of its ability to resist static load. As per IS: 516-1959, the compression test can be carried out on specimens cubical or cylindrical in shape. Table4.2 shows the compressive strength of self compacting concrete containing varying percentage of waste marble powder and Fig.4.1 shows the graphical representation of compressive strength.

Figure 6 : Compression testing machine

Table No.4: Compressive strength results

Mix ID	Compressive Strength (N/mm^2)		
	Water Curing		Polythene Curing
	7day	28day	28day
M1+0%	21	33	25
M1+10%	25	36	27
M1+20%	25	38	29
M1+30%	19	31	22
M1+40%	18	29	19

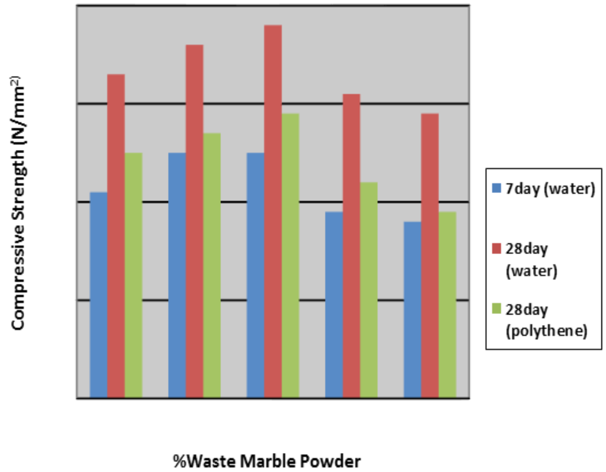

Figure 7 : Average compressive strength of different percentage of waste marble powder

4.3 Flexural Strength

Flexural strength test was carried out as per IS 516: 1959 in PCC beam specimen. The specimens are tested after 28 days of water curing and two specimens were tested for each mix Table 4.4 shows the flexural strength at different replacements of waste marble powder and Fig.4.3 shows the graphical representation of flexural strength.

Figure 8 : Universal testing machine

Table No.5: Flexural strength results

Mix ID	Flexural Strength, 28 day (N/mm^2)
M1+0%	4.9
M1+10%	5.575
M1+20%	5.85
M1+30%	4.35
M1+40%	4.72

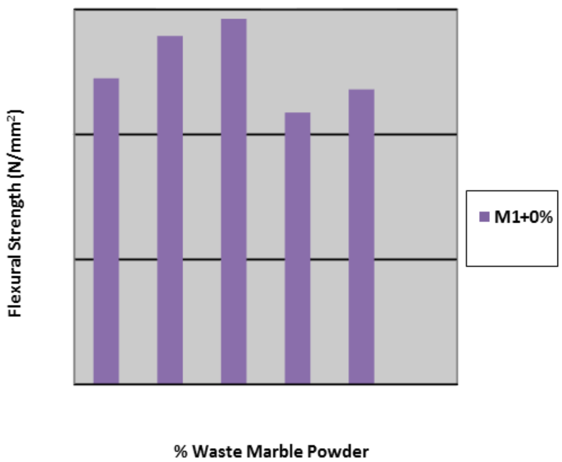

Figure 9 : Average flexural strength of different percentage of waste marble powder

5. CONCLUSION

Based on the study conducted, the following conclusions were made:

- In the present investigation, waste marble powder is partially replaced for sand. The powder content of waste marble powder increases the filling ability and workability of SCC.
- Compressive strength increased with increase in % replacement of marble powder.
- Optimum % of fine Aggregate replacement by Marble powder is found to be 20%.
- Optimum compressive strength with water curing at 28 days is 38 N/mm2 and for polythene curing is 29 N/mm2 .
- In water scarce areas, polythene curing can be used effectively in achieving required compressive strength.
- It can be concluded that marble powder can be effectively utilized in preparing SCC replacing fine aggregate with marble powder.
- It is observed that, inclusion of marble powder increase the flow properties of SCC

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