Experimental Investigation of Concrete Containing Marble Powder as Partial Replacement of Cement

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Abstract

In this paper an experimental investigation is carried out to compare the strength characteristic of conventional concrete with the concrete replaced with marble powder as partial replacement of cement. The work is carried out with M20 and M30 grade concrete with w/c ratio of 0.55 and 0.45 respectively as a control specimen and the cement is replaced by marble powder in the range of 0%, 5%, 10%, 15% and 20% by weight of cement. For all the mixes compressive, split tensile and flexural strengths are determined at 28 days. The results of present investigation indicate that marble powder incorporation showed the significant improvements in the compressive, split tensile and flexural strength of concrete up to 10% of replacement.

Keywords: Marble Powder (MP), Compressive Strength, Split Tensile Strength, Flexural Strength, Workability

I. INTRODUCTION

Cement is the back bone for global infrastructural development. In 2010 it is estimated that global production of cement is about 3.3 billion tons. It is observed that 0.87 ton of CO_2 is emitted for every ton production of cement, such that 7% of the world`s CO_2 emission is attributable to Portland cement industry. Because of the significant contribution to the environmental pollution and to the high consumption of natural resources like limestone etc, due to which sustainability of cement industry is under threat, hence we cannot produce cement in more quantity there is a need to economize the use of cement. The practical available solution to economize cement is to replace cement with supplementary cementitious material. Waste marble powder is generated as a by-product during cutting of marble. The waste is approximately in the range of 20% of the total marble handled. The amount of waste marble powder generated at the site every year is in the range of 250-400 tones. The marble cutting plants are dumping the powder in any nearby pit or vacant spaces, near their unit. This leads to serious environmental and dust pollution and occupation of vast area of land also leading to contamination of the underground water reserves. Leaving the waste materials to the environment directly can cause environmental problems. Hence the reuse of waste material has been emphasized. Waste can be used to produce new products or can be used as admixtures so that natural resources are used more efficiently and the environment is protected from waste deposits. By using marble powder partially in place of cement we can achieve the economy because of low cost of this material. By using this we can reduce the demand for cement we can also reduce the wastage of marble powder, saving in abundant open space for storage or dumping.

II. MATERIALS

A. Cement

Ordinary Portland cement confirming to IS 12269-1987[6] was used. Ultratech cement 53 grade procured from single source, properties of which are tested in the laboratory are shown in Table 1.

Table – 1
Physical properties of cement

SI. No	*Properties*	*Test Results*	*Requirement as per IS : 12269-1987*
1	*Specific gravity*	*3.15*	--------
2	*Normal consistency*	*32 %*	--------
3	*Fineness*	*2 %*	*Should not exceed 10% by weight*
4	*Initial Setting Time*	*70 minutes*	*Not less than 30minutes*
5	*Final Setting Time*	*260 minutes*	*Not more than 600minutes*

B. Fine Aggregate (FA)

Locally available river sand belonging to zone-II of IS 383-1970[7] is used in the present investigation, the various test results for fine aggregate are as shown in Table 2.

Table – 2
Sieve analysis and physical properties of fine aggregate

SI. No	*Sieve Size*	*Cumulative % finer for sand*
1	*4.75mm*	*99.20*
2	*2.36mm*	*91.80*
3	*1.18mm*	*76.80*
4	*600µ*	*35.30*
5	*300µ*	*8.30*
6	*150µ*	*2.40*
7	*Specific gravity=2.61*	
8	*Bulk density=1704.6 kg/m³*	

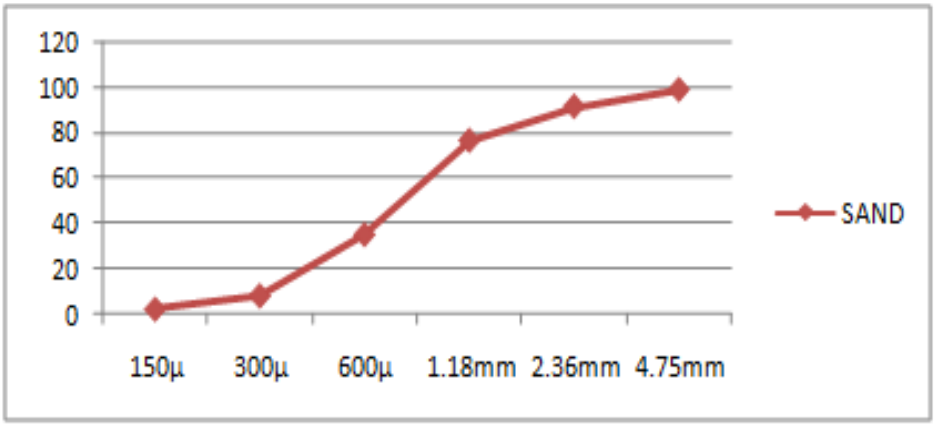

Fig 1: Sieve analysis result

C. *Coarse Aggregate (C.A)*

The coarse aggregate available from local crusher were used. Only one size fraction i.e 20 mm down size basalt coarse aggregate confirming to IS 383-1970[7] were used. The various test results for coarse aggregate are as shown in Table 3.

Table – 3
Sieve analysis and Physical properties of coarse aggregate

SI. No	*Sieve Size*	*Cumulative % passing for basalt aggregate*
1	*40mm*	*100*
2	*20mm*	*82.50*
3	*12.5mm*	*21.80*
4	*10mm*	*7.25*
5	*4.75mm*	*3.10*
6	*Specific gravity=2.8*	
7	*Bulk density=1480Kg/m³*	

D. *Marble Powder (M.P)*

The marble powder required was brought from the local stone polishing unit, in this experimental study marble powder passing IS 90 micron sieve is used and having specific gravity 2.91. The chemical composition of cement and marble powder is shown in table 4.

Table - 4
Chemical composition of cement and marble powder (X-ray analysis spectrometry)

Constituents	*Cement in %*	*Marble powder in %*
Cao	*36.60*	*26.28*
Al_2O_3	*2.96*	*14.22*
Fe_2O_3	*2.33*	*6.84*
SiO_2	*22.40*	*22.61*
MgO	*2.95*	*5.55*

III. METHODOLOGY

A. *Mix Design*

Mix design is carried out by IS 10262:2009[8] for M_{20} and M_{30} grade concrete yielded a mix proportion as shown in Table 5.

Table – 5
Mix Proportions

Grade of Concrete	*W/C*	*Cement*	*FA*	*CA*
M_{20}	*0.55*	*1*	*2.119*	*3.556*
M_{30}	*0.45*	*1*	*1.588*	*2.901*

B. Casting and Testing

For each mix three cubes of 150mm x 150mm x 150mm in size, three cylinders of 150mm diameter and 300m height and three prisms of 100mm x 100 x 500mm were cast using steel moulds. The caste specimens were kept in ambient temperature for 24 hours. After 24 hours they were demoulded and placed in water for curing. Cubes were used to determine the compressive strength, cylinders were used to determine the split tensile strength, and prisms were used to determine the flexural strength of concrete after 28 days of curing.

IV. RESULTS & DISCUSSION

A. Workability Characteristics

1) Compaction Factor Test

It is observed from the compaction factor test the workability of concrete was decreased with the increase in dosages of marble powder. The result is shown in table 6 and same data is presented in fig 2

Table – 6
Result of Compaction factor test

Replacement of cement by marble powder (MP)	*Compaction factor values for M_{20} grade concrete*	*Compaction factor values for M_{30} grade concrete*
0%	*0.91*	*0.878*
5%	*0.898*	*0.862*
10%	*0.879*	*0.849*
15%	*0.856*	*0.831*
20%	*0.846*	*0.823*

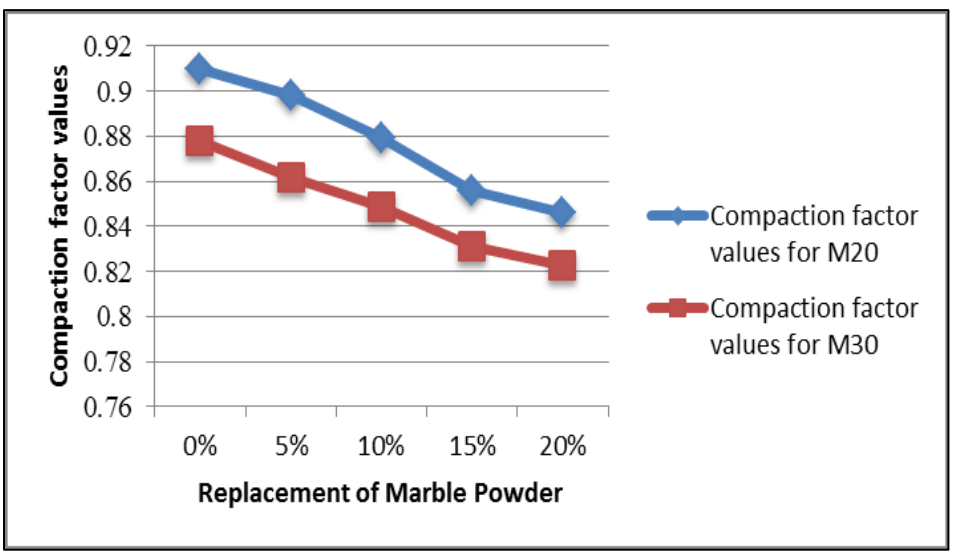

Fig. 2: Replacement of marble powder v/s Compaction factor

B. Compressive Strength Test

From the test results of compressive strength for M_{20} and M_{30} grade concrete, it is found that the strength increases with the increase in dosages of marble powder. It is found that the optimum percentage replacement of cement by marble powder which showed the maximum strength for M_{20} and M_{30} grade concrete is 10%.

After 28 days of curing the compressive strength of M_{20} grade concrete increases from 27.69 N/mm^2 to 33.14 N/mm^2 and for M_{30} grade concrete increases from 38.48 N/mm^2 to 42.40 N/mm^2 for 10% replacement of cement by marble powder. It is found that there was 20 % and 10% increment in compressive strength for M_{20} and M_{30} grade concrete respectively.

The results of compressive strengths of M_{20} and M_{30} grade of concrete for various percentage replacement of cement by marble powder are shown in table 7 and the same data is presented in fig 3.

Table – 7
Compressive strength of concrete

Replacement of cement by marble powder (MP)	*Compressive strength in N/mm²*	
	M_{20}	*M_{30}*
0%	*27.69*	*38.48*
5%	*30.19*	*40.55*
10%	*33.14*	*42.40*
15%	*28.01*	*38.59*
20%	*24.85*	*34.12*

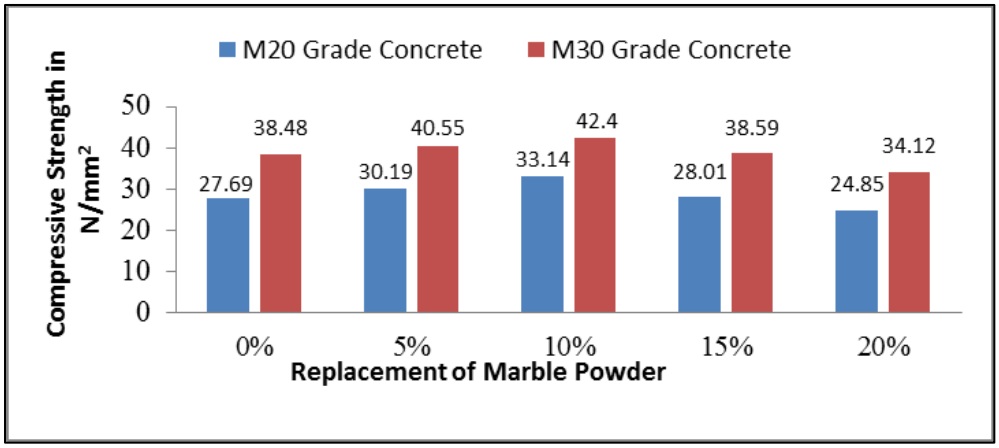

Fig. 3: Compressive strength test results for M_{20} and M_{30} grade concrete for various percentage replacement of MP

C. *Split Tensile Strength Test*

From the test results of split tensile strength for M_{20} and M_{30} grade concrete, it is found that the strength increases with the increase in dosages of marble powder. It is found that the optimum percentage replacement of cement by marble powder which showed the maximum strength for M_{20} and M_{30} grade concrete is 10%.

After 28 days of curing the split tensile strength of M_{20} grade concrete increases from 2.22 N/mm² to 2.78 N/mm² and for M_{30} grade concrete increases from 2.85 N/mm² to 3.54 N/mm² for 10% replacement of cement by marble powder. It is found that there was 25 % and 24% increment in split tensile strength for M_{20} and M_{30} grade concrete respectively.

The results of split tensile strengths of M_{20} and M_{30} grade of concrete for various percentage replacement of cement by marble powder are shown in table 8 and the same data is presented in fig 4.

Table – 8
Split tensile strength of concrete

Replacement of cement by marble powder (MP)	*Split tensile strength in N/mm²*	
	M_{20}	*M_{30}*
0%	*2.22*	*2.85*
5%	*2.39*	*3.16*
10%	*2.78*	*3.54*
15%	*2.26*	*3.02*
20%	*1.84*	*2.74*

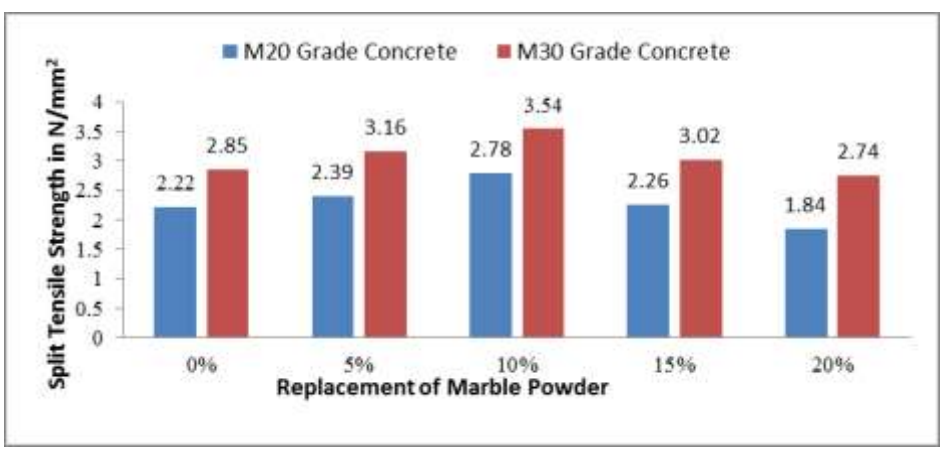

Fig. 4: Split tensile strength test results for M_{20} and M_{30} grade concrete for various percentage replacement of MP

D. Flexural Strength Test

From the test results of flexural strength for M_{20} and M_{30} grade concrete, it is found that the strength increases with the increase in dosages of marble powder. It is found that the optimum percentage replacement of cement by marble powder which showed the maximum strength for M_{20} and M_{30} grade concrete is 10%.

After 28 days of curing the flexural strength of M_{20} grade concrete increases from 3.22 N/mm^2 to 3.85 N/mm^2 and for M_{30} grade concrete increases from 3.92 N/mm^2 to 4.71 N/mm^2 for 10% replacement of cement by marble powder. It is found that there was 20 % increment in flexural strength for both M_{20} and M_{30} grade concrete respectively.

The results of flexural strength of M_{20} and M_{30} grade of concrete for various percentage replacement of cement by marble powder are shown in table 9 and the same data is presented in fig 5.

Table – 9
Flexural strength of concrete

Replacement of cement by marble powder (MP)	*Flexural strength in N/mm^2*	
	M_{20}	*M_{30}*
0%	*3.22*	*3.92*
5%	*3.45*	*4.32*
10%	*3.85*	*4.71*
15%	*3.30*	*4.12*
20%	*3.06*	*3.53*

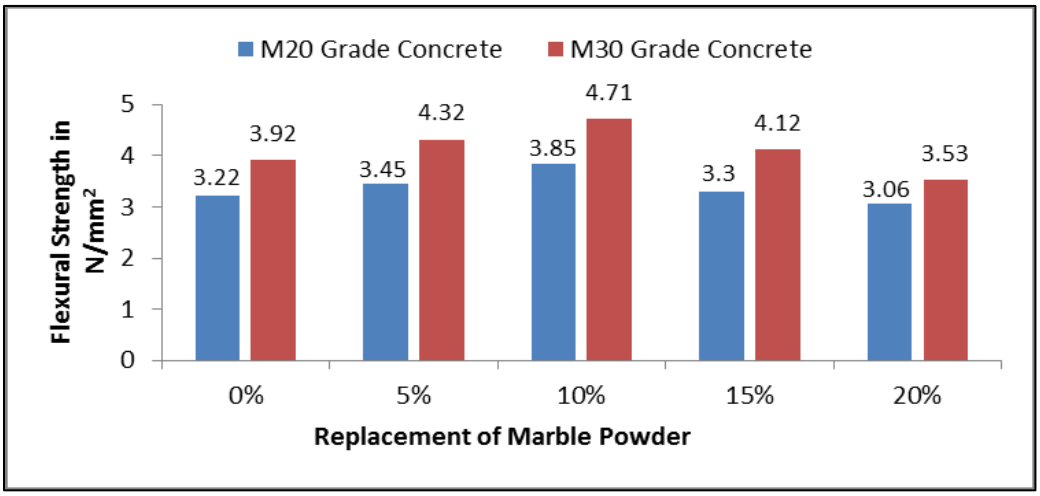

Fig. 5: Flexural strength test results for M_{20} and M_{30} grade concrete for various percentage replacement of MP

V. CONCLUSION

1) The optimum percentage replacement of cement by marble powder is 10% by weight which showed increment in compressive, split tensile and flexural strength for both M20 and M30 grade concrete.
2) The workability of concrete decreases with the increase in dosage of marble powder
3) It is found that there was 20% increment in compressive strength for M20 and 10% increment in compressive strength for M30 grade concrete
4) It is found that there was 25% increment in split tensile strength for M20 and 24% increment in split tensile strength for M30 grade concrete.
5) It is found that there was 20 % increment in flexural strength for both M20 and M30 grade concrete respectively.
6) We have put forth a simple step to minimize the costs for construction with usage of marble powder which is freely or cheaply available.

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