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An Experimental Investigation on Strengths Characteristics of Concrete with the Partial Replacement of Cement by Marble Powder Dust and Sand by Stone Dust

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ABSTRACT
The present work is directed towards developing a better understanding on strengths characteristics of concrete using marble dust powder as a partial replacement of cement. The Dissertation work is carried out with M_{30} grade concrete for which the marble powder is replaced by 0%, 5%, 10%, 15%, 20% by weight of cement. For all the mixes compressive, flexural and split tensile strengths are determined at different days of curing. In addition to this, sand is replaced with stone dust (SD) by 10%, 20% and 30% along with cement is replaced with MP by 0%, 10% and 20% by weight for M_{30} grades of concrete. Only 3 cubes were casted for various percentage replacements of sand with SD and cement with MP for 7days and 28 days. The results of the present investigation indicate that marble dusts incorporation results insignificant improvements in the compressive, flexural and split tensile strengths of concrete upto 10% of replacement and also the results of the present investigation indicate that stone dusts and marble dust incorporation results insignificant improvements in the compressive strengths of concrete upto 20% of SD and 10% of MP of replacement.
Keywords: RMP, MP, SD, compressive, flexural and split tensile strengths.

I. INTRODUCTION

It is generally known that, the fundamental requirement for making concrete structures is to produce good quality concrete. Good quality concrete is produced by carefully mixing cement, water, and fine and coarse aggregate and combining admixtures as needed to obtain the optimum product in quality and economy for any use. 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 advancement of concrete technology can reduce the consumption of natural resources, energy sources and lessen the burden of pollutants on environment. This project describes the feasibility of using the marble powder in concrete production as partial replacement of cement by weight. In INDIA, the marble processing is one of the most thriving industry. The effects of marble powder on properties of fresh and hardened concrete have been investigated. Test results show that this industrial bi-Product is capable of improving hardened concrete performance up to 10%.

II. LITERATURE REVIEW

A. A Study has been conducted by **Prof. P.A. Shirule et al** [1] Described the feasibility of using the marble sludge dust in concrete production as partial replacement of cement. 3 cubes and 3 cylinders were casted for 7 days and 28 days. Final strength of cubes and cylinders were examined after 7 days and 28 days of curing. They conducted the tests using compression testing machine to test the compressive strength of cubes and split tensile strength of cylinders. The materials like, Portland Pozzolona cement of Birla gold 53 grade conforming to IS 269-1976 and IS 4031-1968 were adopted in this work. The aggregate used in this project is mainly basalt rock which comes under normal weight category and sand giving good workability. Marble powder was collected from the dressing and processing unit in Jalgaon. It was initially in wet form (i.e. slurry); after that it is dried by exposing in the sun and finally sieved by IS-90 micron sieve before mixing in concrete. They concluded that the optimum percentage for replacement of marble powder with cement is almost 10% cement for both cubes and cylinders. Hence a simple step to minimize the costs for construction with usage of marble powder which is freely or cheaply available. [1]

B. A Study has been conducted by **Mohammad S. Al-Juhani et al** .Proposed a gainful utilization of waste marble powder as a part substitute of limestone in a cement plant. This research describes attempts to define the compositions of waste-based mixtures and the corresponding processing conditions suitable to the production powder based cements. Also, this study assesses the properties of the final product after incorporating waste marble powder, Waste Marble Powder specimens. The raw material was provided by a local company and then these materials were milled and sieved through 75µm sieve size and conducted tests on Sieve analysis, compressive test. In conclusion, it was found that the Waste Marble specimens were found to contain the expected cementitious phases and a good agreement was obtained between the characterizations techniques used. Test results show that this WMP based cement is capable of improving hardened concrete performance up to 16%, enhancing fresh concrete behaviour. [2]

C. V.M shelke Prof. P.Y.pawde et al To study the influence of partial replacement of cement with marble powder, and to compare it with the compressive strength of ordinary M30 concrete. and also trying to find the percentage of marble powder & silica fume replaced in concrete that makes the strength of the concrete maximum. Now a day's marble powder has become a pollutant. So, by partially replacing cement with marble powder, and proposing a method that can be of great use in reducing pollution to a great extent. In this investigation a series of compression tests were conducted on 150mm, cube and 150mm x 300mm, cylindrical specimens using a modified test method that gave the complete compressive strength, using silica fume of constant 8% with and without marble powder of volume fractions 0, 8, 12, & 16% on Ordinary Portland cement concrete. [3]

D. A Study has been conducted by **Hanifi Binici et al (2007)** found that marble dust concrete has higher compressive strength than that of the corresponding lime stone dust concrete having equal w/c and mix proportion. The results indicated that the Marble dust concrete would probably have lower water permeability than the lime stone concrete. Typically**,** concrete made with marble dust obtained during polishing and cutting of marble in factories will attain higher strength than conventional concrete for 28 days curing period**.** Marble waste concrete is also expected to be equally durable compared to conventional concrete. Marble waste when used in concrete increases the amount of water required to produce given slump, this may be due to increased surface area in dust compared to sand. The overall workability value of marble dust concrete is less compared to conventional concrete. [4]

Points Observed from the Literature Review: The optimum percentage for replacement of marble powder with cement and it is almost 10% cement for both cubes and cylinders and a simple step to minimize the costs for construction with usage of marble powder which is freely or cheaply available. Waste marble powder based cement is capable of improving hardened concrete performance up to 16%, enhancing fresh concrete behaviour.

III. EXPERIMENTAL PROGRAMME

A. Materials

Cement: Ultra-tech (OPC 53 grade) cement from a single batch is used throughout the course of project work. The properties of the cement used are shown in the Table 1 below.

Table 1: Physical properties of OPC

Sl. No.	Properties	Chart Result
1.	Specific Gravity	3.10
2.	Setting time in minutes Initial setting time Final setting time	 130min. 195min.
3.	Soundness: By-Le Chatrlier	0.5mm
4.	Normal consistency	29.7%
5.	Compressive Strength 28 days	 71.3Mpa

Fine Aggregate: The source for fine aggregate used is from natural river bed, the details regarding test conducted on it are as given in table 2 and table 3 below.

Table 2: Sieve analysis of fine aggregate

I.S. Sieve size in mm	Weight retained (gm)	Correction	Corrected weight	Cumulative wt retained	Cumulative percentage wt. retained	Cumulative % passing
4.75	25	+0.5	25.5	25.5	2.55	97.45
2.36	29	+0.58	29.58	55.08	5.508	94.50
1.18	209	+4.18	213.18	268.26	26.826	73.18
600µ	317	+6.34	323.34	591.60	59.16	40.84
300µ	350	+7.0	357	948.60	94.86	5.16
150µ	50	+1.0	51.0	999.6	99.96	0.04

Table 3: Properties of Fine Aggregate

Fineness modulus of fine agg	Cumulative % wt retained / 100
Fineness modulus	288.86/100=2.88
Specific gravity	2.64
Water absorption	1%
Silt or clay content	0.5%
Bulk density	1700 kg/m^3
Grading	well graded (zone II)

Coarse Aggregate (C.A): The coarse aggregate used in this investigation is 20mm down size crushed aggregate and angular in shape. the details regarding test conducted on it are as given in table 4 and table 5 below.

Table 4: Sieve analysis of coarse aggregate

IS. Sieve Size(mm)	Weight retained (gm)	Cumulative wt retained	Cumulative percentage wt retained	Cumulative % passing
63	0	0	0	100
40	0	0	0	100
20	2000	2000	20	80
12.5	7580	9580	95.80	4.20
10.0	220	9800	98.0	2.0
8	120	9920	99.20	0.8
6.3	40	9960	99.60	0.4
4.75	20	9980	99.80	0.2
Pan	20	10000	-	0

Table 5: Properties of Coarse Aggregate

Fineness modulus of coarse agg	Cumulative % wt retained / 100
Fineness modulus	512.40/100 = 5.12
Specific gravity	2.72
Water absorption	0.5%
Impact Value	11.76%
Bulk density	1440 kg/m^3

Marble dust: Marble dust which is used in laboratory investigation was obtained during polishing and cutting of marble in factories.

Table 6: Properties of marble dust

Sl. No.	Test performed	Results
1.	Specific gravity	2.62
2.	Moisture content	1.5%
3.	Water absorption	2%
4.	Bulk density	1480
5.	Grading	Zone II
6.	Fineness modulus	2.68

Table 7: Chemical composition of Marble dust

Constituent	Marble dust (%)
SiO_2	62.48
Al_2O_3	18.72
Fe_2O_3	06.54
CaO	04.83
MgO	2.56
Na_2O	Nil
K_2O	03.18
TiO_2	01.21
Loss of ignition	00.48

Stone dust: It is the residue material which is the extraction of basalt rocks to form the fine particles less than 4.75mm through the IS sieve. Locally available stone dust was used in the present study for replacement of fine aggregate (sand).Different test such as sieve analysis values in Table 8 and different properties carried out in laboratory for stone dust are shown in Table 9.

Table 8: Sieve analysis of Stone Dust

I.S. Sieve size mm	Wt retained (gm)	Correction	Corrected weight	Cumulative wt retained	Cumulative % wt. retained	Cumulative % passing
4.75	27	+0.48	27.48	27.482	2.748	97.252
2.36	30	+0.54	30.54	58.022	5.802	94.198
1.18	212	+3.81	215.8	273.83	27.383	72.617
600 µ	313	+5.63	318.6	592.47	59.247	40.753
300 µ	340	+6.12	346.1	938.59	93.839	6.141
150 µ	60	+1.08	61.08	999.67	99.967	0.033

Table 9: Properties of Stone Dust

Fineness modulus of fine agg	Cumulative % wt retained / 100
Fineness modulus	310.994/100=3.109
Specific gravity	2.67
Water absorption	1%
Silt or clay content	0.5%
Bulk density	1500 kg/m^3
Grading	well graded (zone II)

Water: Water used for mixing should be free from injurious amount of deleterious materials. Potable water is generally considered satisfactory for mixing. In the present work potable tap water was used.

B. Casting and Curing of Control Specimen

For each mix three cubes of 150mm x 150mm x 150mmin 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 are used to determine the compressive strength of concrete for 7 days and 28 days. Three cylinder were used to determine the split tensile strength of concrete for 28 days. Three prisms were used to determine the Flexural strength of concrete for 28 days by two point bending test with a supporting span of 133.33mm, using universal testing machine of capacity 1000kN.

IV. RESULTS & DISCUSSION

Tests for Compressive Strength: The compressive strength of concrete for cubes, all mixes at 7 and 28 days of curing is presented in table 11. Only 3 cubes were casted for various percentage replacements of cement by MP. The result shows that the Compressive strength increased with addition of waste marble powder up to 10% replace by weight of cement and further any addition of waste marble powder the compressive strength decreases. The initial strength gradually decreases from 15%. At 10% there is 10.05% increase in initial compressive strength for 7 days and there is 14.14% increase in initial compressive strength for 28 days .In case of RMP 10%, the 7 day strength is found to be 30.447 N/mm^2 this is 68% of 28 days of curing strength. It is represented in Figure 1 which shows the Comparison and Effect of curing on compressive strength of M_{30} Grade of RMP.

Tests for split tensile strength: The split tensile strength of concrete for cylinders, all mixes at 28 days of curing is presented in table 12.Only 3 cylinders were casted for various percentage replacements of cement by MP. The Split Tensile strength of Cylinders are increased with addition of waste marble powder up to 10% replace by weight of cement and further any addition of waste marble powder the Split Tensile strength decreases. At 10% there is 19.61% increase in initial split tensile strength for 28 days. It is represented in Figure 2 which shows the Effect of curing on split tensile strength of M_{30} Grade of RMP

Tests for Flexural Strength: The flexural strength of concrete for prisms, all mixes at 28 days of curing is presented in table 13. Only 3 prisms were casted for various percentage replacements of cement by MP. The flexure strength of prisms are increased with addition of waste marble powder up to 10% replace by weight of cement and further any addition of waste marble powder the flexural strength decreases. At 10% there is 10.73% increase in initial flexure strength. It is represented in Figure 3 which shows the Effect of curing on Flexural strength of M_{30} Grade of RMP.

Tests for Compressive strength of Concrete using MP and SD Replacements: The compressive strength of concrete for cubes, all mixes at 7 and 28 days of curing is presented in table 14-16. Only 3 cubes were casted for various percentage replacements of sand with SD and cement with MP. At 20% SD and 10% MP there is 16.47% increase in initial compressive strength for 7 days. At 20% SD and 10% MP there is 15.23% increase in initial compressive strength for 28 days. It is represented in Figure 4-6 which shows the Comparison and Effect of curing on compressive strength of M_{30} Grade.

Workability Characteristics

Slump Cone Test

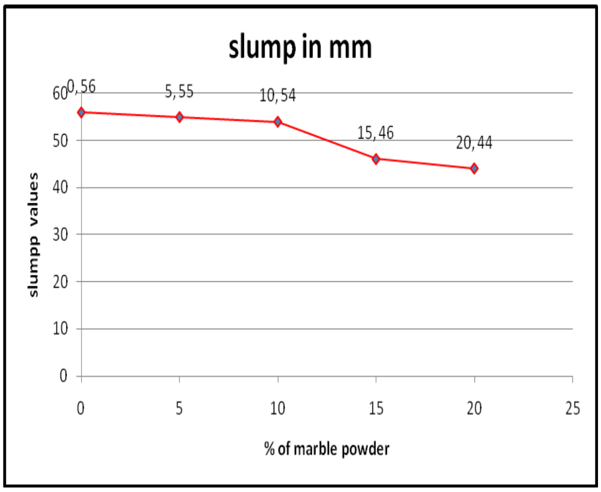
The slump cone is cleaned and the inside surface of the cone is oiled thoroughly. It is then placed on a level surface and placing the slump cone inside the sheet metal cylindrical pot of the consistometer. The concrete is then filled into the cone in four layers. Each layer is tamped 25 times with standard 16 mm tamping rod. After filling the cone completely, the initial height of the cone is noted, and then the cone is lifted without disturbing it. Final reading corresponding to the decrease in height of the centre of the slumped concrete is noted down as shown in Graph 1.

Compaction Factor Test

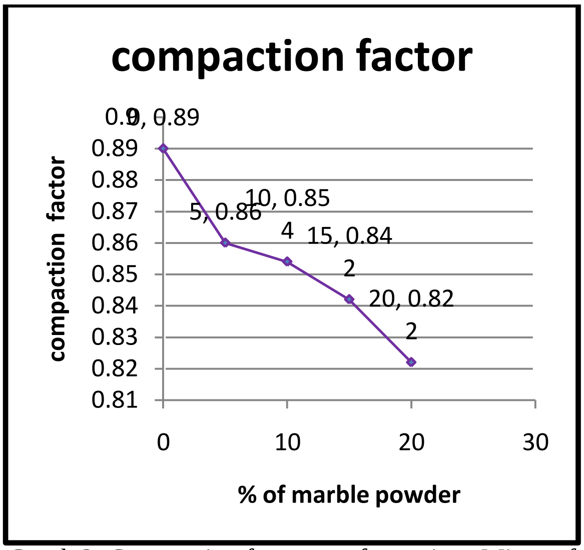
The degree of compaction, called the compaction factor, is measured by the density ratio i.e., the ratio of the density actually achieved in the test to the density of the same concrete fully compacted. Results shown in table 10 and Graph 2

Table 10: Results of Slump Cone Test and Compaction Factor Test

Specimen type for M_{30} grade concrete	**Slump (mm)**	**Compaction Factor**
0%	56	0.89
5% RMP	55	0.86
10% RMP	54	0.854
15% RMP	46	0.842
20% RMP	44	0.822



Graph 1: Slump values for various Mixes of M30 grade concrete



Graph 2: Compaction factor test for various Mixes of M_{30} grade concrete

Table 11: Compressive strength of Concrete using RMP

SI. NO	replacement of cement by MP	days of curing	Avg. Load (tested on 3 cubes)in tones	Compressive strength in N\mm2
1	0%	7-days	62.91667	27.431
		28-days	88	38.368
2	5%	7-days	64.58333	28.158
		28-days	94.25	41.093
3	**10%**	**7-days**	**69.83333**	**30.447**
		28-days	**102.5**	**44.69**
4	15%	7-days	57.58333	25.106
		28-days	84.41667	36.769
5	20%	7-days	53.83333	23.471
		28-days	80.41667	35.061

Table 12: Split Tensile Strength of concrete using RMP

SI. NO	replacement of cement by MP	days of curing	Avg. Load (tested on 3 cylinder)in tones	split tensile strength in N\mm2
1	0%	28-days	22.25	38.368
2	5%	28-days	24.25	41.093
3	**10%**	**28-days**	**27.66667**	**44.69**
4	15%	28-days	23.58333	36.769
5	20%	28-days	20.5	35.061

Table 13: Flexural strength of concrete using RMP

SI. NO	replacement of cement by MP	days of curing	Avg. Load (tested on 3 prisms)in tones	Flexural strength in N\mm2
1	0%	28-days	1.191	4.674
2	5%	28-days	1.304333	5.12
3	**10%**	**28-days**	**1.334**	**5.236**
4	15%	28-days	1.178667	4.627
5	20%	28-days	1.067	4.189

Table 14: Compressive strength of Concrete

SI. NO	replacement of cement by MP	days of curing	Avg. Load (tested on 3 cubes)in tones	Com strength in N\mm2
1	10% SD-0% MP	7-days	55.75	24.307
		28-days	82.58333	36.006
2	10% SD-10% MP	7-days	62.66667	27.413
		28-days	92.25	40.221
3	10% SD-20% MP	7-days	57.16667	24.924
		28-days	75.5	37.278

Table 15: Compressive strength of Concrete

SI. NO	replacement of cement by MP	days of curing	Avg. Load (tested on 3 cubes)in tones	Compressive strength in N\mm2
1	20% SD-0% MP	7-days	63.83333	27.837
		28-days	93	40.548
2	**20% SD-10% MP**	**7-days**	**66.75**	**29.103**
		28-days	**98.16667**	**42.8**
3	20% SD-20% MP	7-days	59.75	26.051
		28-days	88.5	38.583

Table 16: Compressive strength of Concrete

SI. NO	replacement of cement by MP	days of curing	Avg. Load (tested on 3 cubes)in tones	Compressive strength in N\mm 2
1	30% SD-0% MP	7-days	60.08333	26.196
		28-days	90.5	39.276
2	30% SD-10% MP	7-days	63.91667	27.867
		28-days	94.16667	41.056
3	30% SD-20% MP	7-days	22.58333	9.846
		28-days	78.33333	34.153

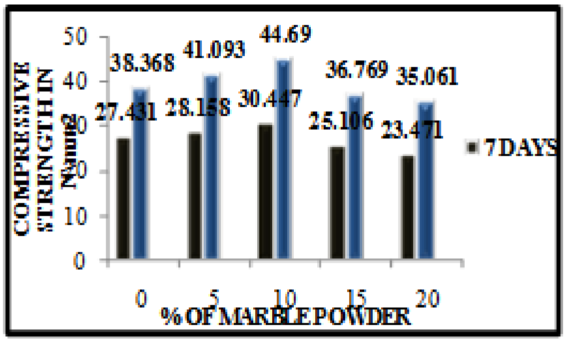


Figure 1: Comparison and Effect of curing on compressive strength at 28 days

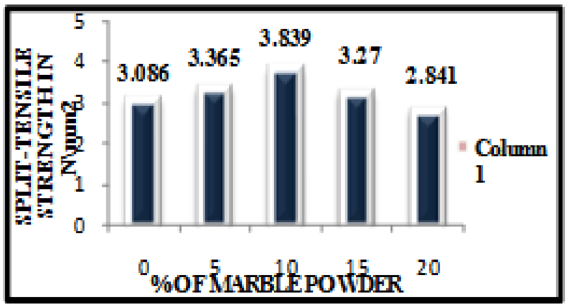


Figure 2: split tensile strength at 28 days

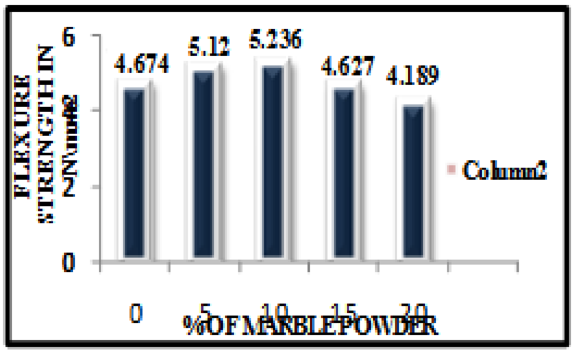


Figure 3: flexural strength at 28 days

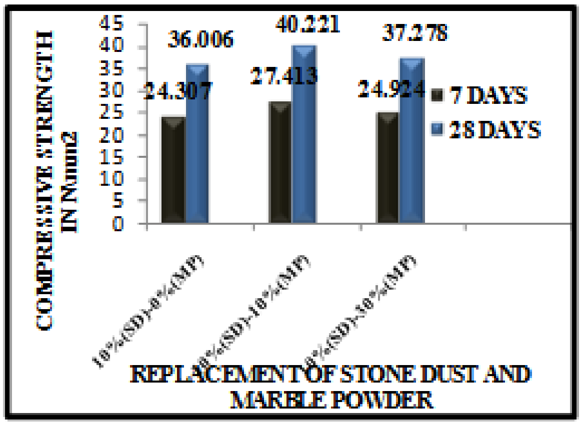


Figure 4: Compressive strength of Concrete at 7 and 28 days @ 10%

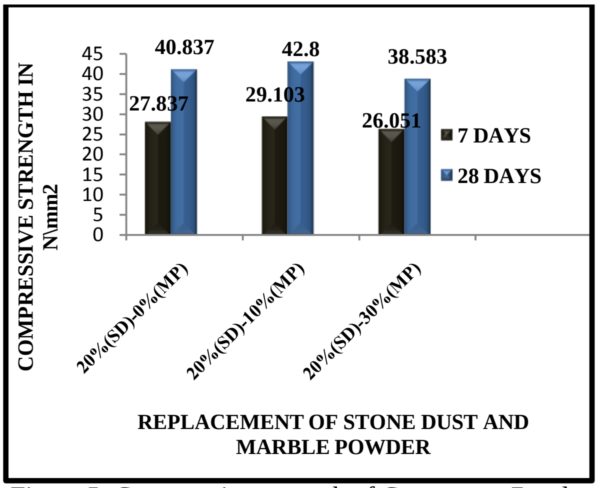


Figure 5: Compressive strength of Concrete at 7 and 28 days @ 20%

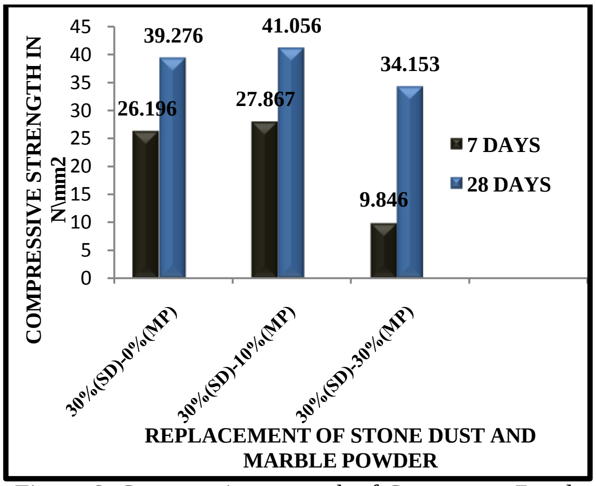


Figure 6: Compressive strength of Concrete at 7 and 28 days @ 30%

V. CONCLUSION

1. The Compressive strength of Cubes are increased with addition of waste marble powder up to 10% replace by weight of cement and

further any addition of waste marble powder the compressive strength decreases.

2. The Split Tensile strength of Cylinders are increased with addition of waste marble powder up to 10% replace by weight of cement and further any addition of waste marble powder the Split Tensile strength decreases.
3. The flexure strength of prisms are increased with addition of waste marble powder up to 10% replace by weight of cement and further any addition of waste marble powder the Split Tensile strength decreases.
4. Thus we found out the optimum percentage for replacement of marble powder with cement and it is almost 10% of the total cement for cubes, cylinders and prisms.
5. We have put forth a simple step to minimize the costs for construction with usage of marble powder which is freely or cheaply available.
6. There is a decrease in workability as the replacement level increases, and hence water consumption will be more.
7. Optimum percentage replacement of sand with SD and cement with MP is 20% and 10%.

VI. SCOPE FOR FURTHER STUDY

- In this investigation M_{30} grade of concrete is tested further work can be carried out by testing higher grades of concrete i.e.M_{35}, M_{40} etc.
- Flexure behaviour of larger size beams can also be studied
- The same work can be carried for replacement of cement with marble powder with 11%, 12%, 13%.

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