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OPTIMUM PARTIAL REPLACEMENT OF CEMENT IN CONCRETE WITH WASTE MARBLE DUST IN CONJUNCTION WITH SUPER PLASTICIZERS

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ABSTRACT

Efforts have been made over years to make concrete production sustainable and environment friendly.Notion of new materials as substitute for the conventional materials have supported these efforts to a large extent. In the present investigation,marble dust obtained after processing of marble waste has been used as a filler material i.e. as replacement of fine aggregate. This study investigates the optimum partial replacement of cement in concrete with marble dust in conjunction with super-plasticizers. This investigation proved the feasibility of marble dust as an economic and eco-friendly replacement of cement. The slump and compressive strength of the concrete was improved when 5%, 10% & 15% of weight of cement was replaced with marble dust in preparation of M20 concrete. This paper provides the scope for more research that if the marble dust is used as a replacement of cement in conjunction with super-plasticizers ,the problem of sustainable, economical and environment friendly concrete can be resolved.

KEYWORDS: Marble dust, cement, super-plasticizers, workability, compressive strength

INTRODUCTION

The Ordinary Portland Cement (OPC) is one of the major ingredients used for the preparation of concrete. Unfortunately, production of cement leads to emission of large amounts of carbon-dioxide gas into the atmosphere, a major contributor for greenhouse effect and the global warming.Hence it is mandatory either to quest for another material or partly replace it by some other material. Delivering concrete in gigantic sum in manufacturing plants specifically impacts the greenhouse gasses discharge. Diminishments in getting great quality limestone specifically influence the creation of good quality concrete. Higher concrete substance of High Strength Concrete altogether influences the quality at the solidified state because of shrinkage and more noteworthy assessment of warmth of hydration. The expense of development moreover gets heightened further more leaving the waste materials to the environment straightforwardly can bring about natural issue. Henceforth the reuse of waste material has been referred. The progression of solid innovation can decrease the utilization of characteristic assets and vitality sources and decrease the weight of contaminations on environment. The utilization of the substitution materials offer cost lessening, vitality reserve funds, seemingly predominant items, and less dangers in the environment. All these issues can be minimized by fractional substitution of mechanical waste, for example, marble dust in cement. According to previous study, marble dust has cementing properties like high oxide calcium content & high Blaine fineness value which imparts the cohesiveness in concrete. Stone blocks are altered into smaller blocks in order to give them the desired shape and size. During the altering process of marbles, original marble mass is lost by 25% in the form of dust. Annually, 250-400 tons of Stone wastes are generated on site. The marble cutting plants are emitting the powder in any nearby pit or vacant spaces, near their unit although notified areas have been marked for disposing leading to serious environmental and dust pollution and covering vast area of land, especially after drying up of powder, so it is necessary to treat the marble waste quickly and use it in the construction industry. In India, the marble and granite stone processing is one of the most thriving industry the effects if varying marble dust contents on the physical and mechanical properties of fresh and hardened concrete have been investigated This project

describes the feasibility of using the marble sludge dust in concrete production as partial replacement of cement The compressive Strength of concrete was measured for 7 and 28 days.Super-plasticizers are the materials which delivers very high workability with a remarkable decrease in water content (at least 20%). These can be added to concrete mix to produce high slump flowing concrete. The effect of super plasticizers lasts only for 30to 60 minutes, depending on composition and dosage and is followed by rapid loss in workability. One of the important factors that govern the issue water–cement ratio during the manufacture of concrete, lower water-cement ratio leads to less capillary pores and also lower permeability and enhanced durability. Although Super plasticizer are essential to produce a truly high performance concrete (HPC) characterised by low water-cement ratio and workability level without high cement content. Concrete are being produced with w/c ratio of range 0.25 - 0.20, enables the production of highly durable high performance concrete. The workability also increases with an increase in the maximum size of aggregate. But smaller size aggregate provides larger surface area for bonding with the mortar matrix, which increases the compressive strength. For concrete with higher w/c ratio use of larger size aggregate is beneficial. High range super plasticizer was used in all the concrete mixes to achieve good workability. Super plasticizers are added to reduce the water requirement by 15 to 20% without affecting the workability leading to a high strength and dense concrete. To achieve the uniform workability, the admixture dosage was adjusted without changing the unit water content. This ensured the identical W/C ratio for a particular cementious content and the effect of pozzolanic material replacement can directly be studied on the various properties of concrete.

MATERIALS AND METHODS

In this experimental study, Ordinary Portland Cement (OPC 53), Coarse Aggregates, Fine Aggregates, Marble Dust, Super-plasticizers were used to prepare the concrete for the investigation of initial and final setting time using Vicat's apparatus, the slump value and the compressive strength was determined using slump cone & Universal Testing Machine respectively.

METERIALS:

The ordinary Portland cement of 53grade manufactured by the ULTRATECH Cement Company was used in the study, which is in accordance with IS 12269-1987.Having design strength for 28 days being a minimum of 53 MPa or 530 kg/sqcm.Fine aggregates are used to provide workability and uniformity in the concrete mix. The fine aggregate also enables the cement paste to hold the coarse aggregate particle in suspension. According to IS 383:1970 the fine aggregates has been classified in to four different zone, that is Zone-I, Zone-II, Zone-III, Zone-IV. Fine aggregates obtained from the local material supplier complying with specification of zone-II was used in the present study. Coarse aggregates is defined as aggregates which are retained on 4.75mm IS sieve. These aggregates cover major volume of concrete and contribute towards strength of concrete. Graded coarse aggregate are used for producing concrete & is described by its nominal size i.e. 40mm, 20mm, 16mm, 12.5mm etc. The coarse aggregate having nominal size of 20mm conforming to IS 383:1970 has been used in this study. Marble Dust in powder form is obtained by sawing and cutting of marbles in marble industries. This by-product having silica and calcium in major proportions shows some binding & cementious properties, making it suitable for replacement of cement in concrete production. Therefore in this experimental investigation, waste dust of marble was obtained from local industry, sieved by IS-90 micron sieve before mixing in concrete has been used for replacement of cement in different proportions in conjunction with super plasticizers. Super plasticizer used in this investigation is Sikament® 3070 NS. It is a dark brown liquid solution approved by IS 9103-1999, ASTM C494, IS 2645.Its chemical base consists of Modified Naphthalene Formaldehyde Sulphonate ,having relative density~1.15 kg/l at 25°C & pH value≥ 6.

METHODS:

***Initial and Final Setting time*:**

To enable concrete to be transported, placed and compactly laid in position properly, the initial setting time of cement should be sufficient.The initial setting time of cement is the time period in the process of hardening after which any cracks appearing do not reunite. The final setting is that stage when concrete has attained sufficient strength and hardness with which material attains strength to carry load.The initial and final setting time is calculated as per IS: 4031 (Part 5) – 1988. Apparatus used is Vicat's apparatus conforming to IS: 5513 – 1976.

Slump Cone Test:

This test is conducted to determine the workability of concrete. The apparatus consists of a cone of 10 cm top

diameter, 20 cm bottom diameter, & 30 cm height as shown in fig.3-16. It has two handles for lifting purpose. Concrete to be tested for its workability is placed in the cone. An even slump is termed as true slump, if one half of the concrete cone slides down it is called shear slump & if entire concrete cone slides down it is termed as collapse slump.

True slump obtained

Compressive Strength Test:

It is the measure of resistance of hardened concrete towards compression. It is the most important characteristic of concrete as the concrete structure experiences heavy compression, hence it is very important to determine tolerable limit of compressive load over concrete. This test is carried out by preparing cube specimen of size 150 mm X 150 mm X 150 mm in cubical moulds, cured for desired number of days and crushed under compression testing machine (CTM) or universal testing machine (UTM) to determine the tolerable load of the hardened concrete. This load then divided by the cross sectional area of the specimen gives the compressive strength of the concrete.

Testing of samples:

Testing machine consisting of two metal bearing plates is used and the specimen is placed between these plates.Testing machine is either manually or machine operated. After placing specimen in the machine load is applied at an approx. rate of of 140 kg/sq cm/min & the load at which concrete cube starts to fail is noted down as the ultimate load that concrete can bear. Then compressive strength is determined by finding the ratio of ultimate load & cross sectional area of specimen.

Sample tested under UTM of NITTTR lab

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Mix Proportions:

Following mix proportions for M20 grade of concrete at w/c ratio of 0.45 was opted. Super plasticizer was doped at 1.5 % by weight of cement. Cement was replaced by marble dust at 5%, 10%, 15% & 20% by weight of cement. For each percentage of replacement 6 cubes (3 for 7 days & 3 for 28 days) were prepared for testing.

Table 1. Mix proportions of materials

MIX (REPLA C-EMENT) %	CEMENT (Kg/m3)	FINE AGGREGATE (Kg/m3)	COARSE AGGREGATE (Kg/m3)	WATER (lit/m3)	MARBLE DUST (Kg/m^3)	SP (lit/m^3)
0%	373.38	609.6	1220.8	168.02	0	0
5%	354.71	609.6	1220.8	168.02	18.669	6.44
10%	336.04	609.6	1220.8	168.02	37.338	6.44
15%	317.373	609.6	1220.8	168.02	56.007	6.44
20%	298.70	609.6	1220.8	168.02	74.676	6.44

RESULTS AND DISCUSSION

The experimental result obtained from previously discussed methodology has been analysed. The investigation consists of testing of concrete for compression and workability. For testing of compression, five different samples of cube were prepared, each sample consisting of six specimens of cube. Out of these six samples 3 specimens are tested for 7 days compressive test, and 3 specimens are tested for 28 days compressive test. For determining workability, slump cone test is opted to determine the slump value of different mixes prepared by replacement of cement.

ANALYSIS OF SLUMP TEST

Following results of slump test were obtained for different mixes of concrete prepared by replacement of cement.

Table 2. Slump values of different mixes

S NO.	PERCENTAGE REPLACEMENT	SP DOSAGE	SLUMP VALUE
1.	0%	0%	90 mm
2.	5%	1.5%	96 mm
3.	10%	1.5%	105mm
4.	15%	1.5%	130mm
5.	20%	1.5%	135mm

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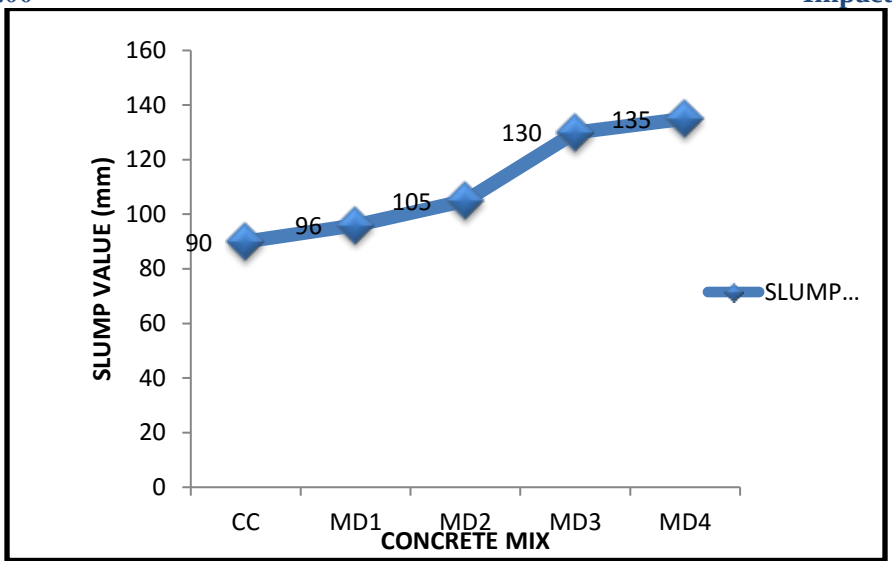
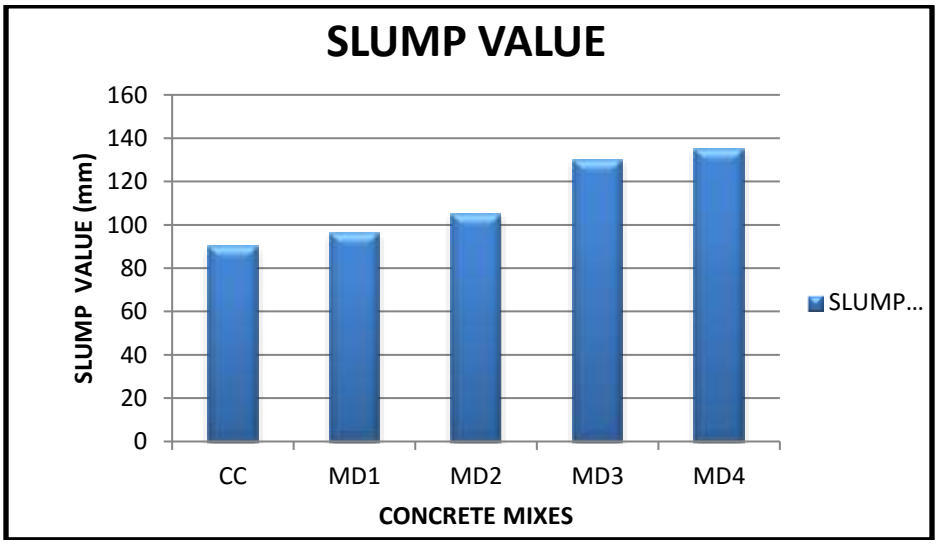


Graph representing slump value of different concrete mixes



Bar chart for slump value

Analysis of compressive strength:

Following nomenclature was adopted for testing of different types of mixes prepared by replacement of cement by 5%, 10%, 15%, & 20% of marble dust by weight of cement & doping 1.5 % of super plasticizer by weight of cement.

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Table 3. Types of mixes

TYPE OF MIX	% OF MARBLE DUST	SUPER PLASTICIZERS (% by weight of cement)
CC	0% (CONVENTIONAL CONCRETE)	0%
MD 1	5 %MARBLE DUST	1.5%
MD 2	10%MARBLE DUST	1.5%
MD 3	15%MARBLE DUST	1.5%
MD4	20%MARBLE DUST	1.5%

Table 4. Compressive strength of different mixes

S.NO	TYPE OF MIX	COMPRESSIVE STRENGTH (N/mm^2)		AVERAGE COMPRESSIVE STRENGTH (N/mm^2)	
		7 DAYS	28 DAYS	7 DAYS	28 DAYS
1.	CC	14.02	26.4	14.03	26.75
		13.86	27.11		
		14.22	26.75		
2.	MD1	19.91	33.33	19.37	29.83
		19.64	27.28		
		18.62	28.88		
3.	MD2	19.91	27.51	21.10	31.05
		21.84	30.17		
		21.5	32.48		
4.	MD3	21.73	33.95	22.83	33.71
		21.75	34.75		
		22.01	32.44		
5.	MD4	18.31	26.08	17.74	26.88
		17.34	28.35		
		17.60	26.22		

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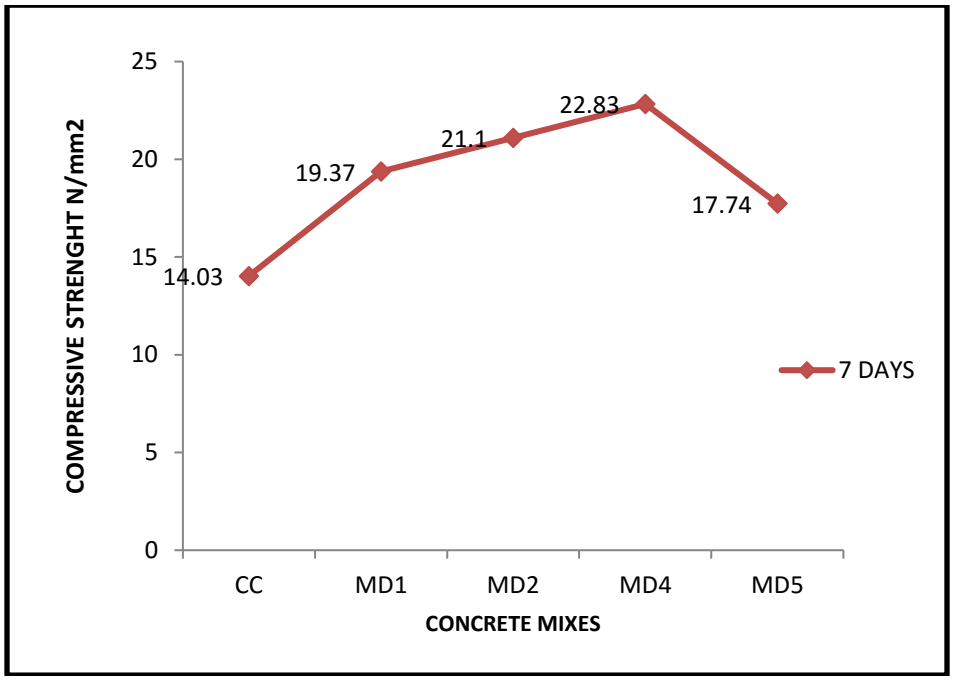
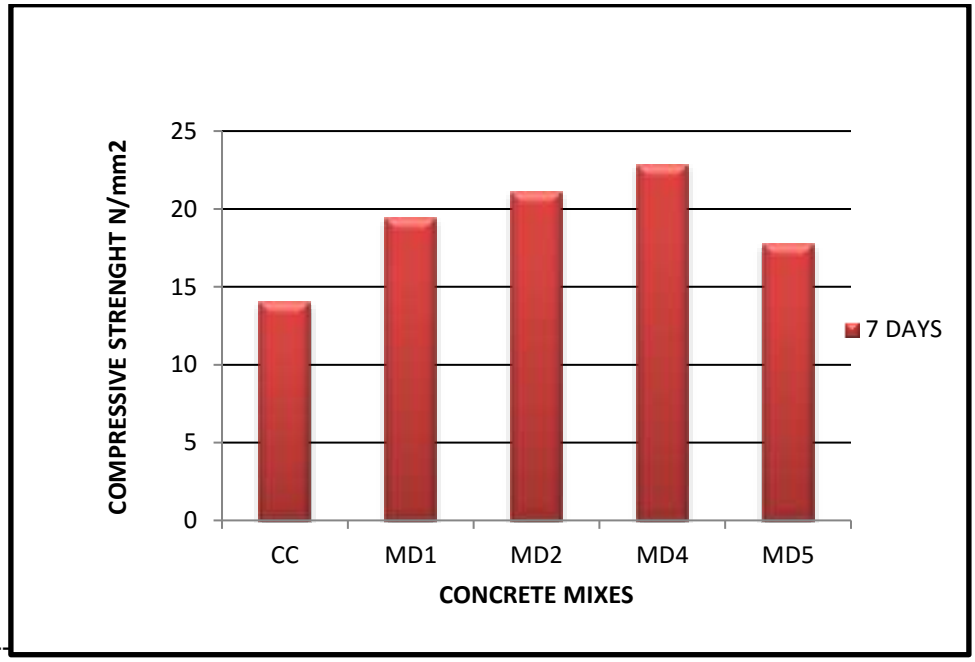


Graph representing 7 days compressive strength



Bar chart for 7 days cpomressive strength

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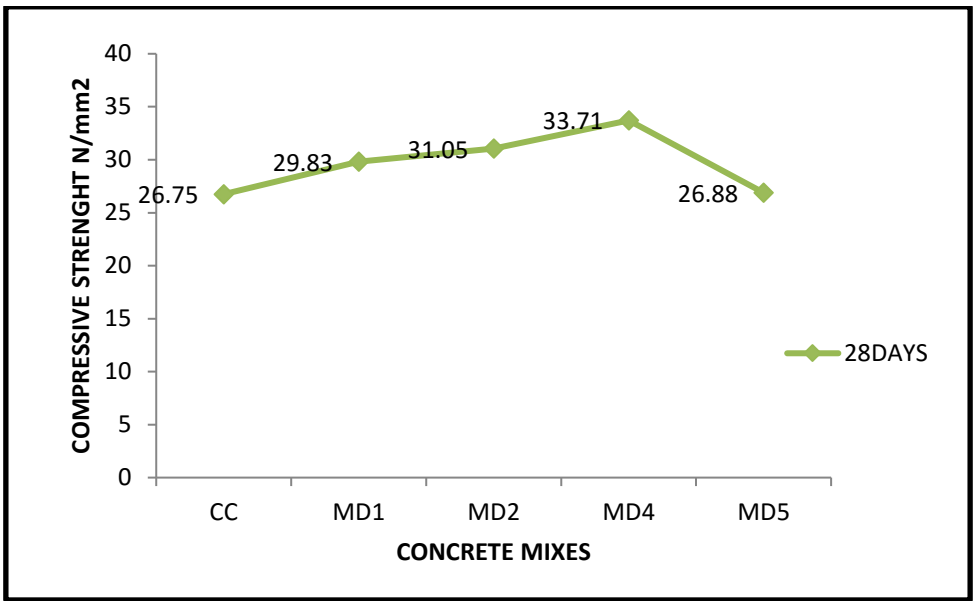
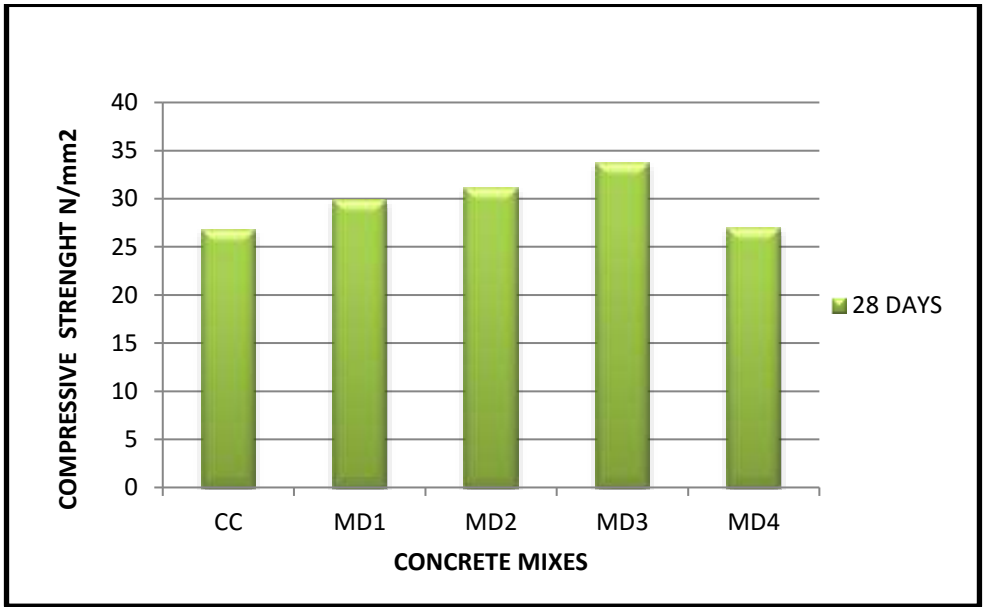


Graph representing 28 days compressive strength



Bar chart for 28 days compressive strength

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DISCUSSION:

From the above results of the experimental investigation usefulness of marble powder & super plasticizer as construction material was investigated. Various concrete cubes have been casted using these materials to investigate compressive strength and slump values.

The above results shows that replacement of 15 % of cement with waste marble powder and doping of super plasticizer at 1.5 % of weight of cement results into maximum compressive strength in the experiment as compared to 5%, 10% & 20% replacement of cement .

Slump values show linear increment with increase in percentage replacement of cement. At 15 % replacement, a slump of 130 mm was obtained, which commits to obtain a concrete with enhanced workability.

Following cost analysis per cubic meter of concrete was carried out:

No of cement bag for conventional M20 concrete = 373.38/50= 7.5 Bag.

15% replacement of cement By WMP = 15/100 X 373.38= 56.007 Kg/ m^3

Reduction in Cement Bag = 56.007 kg = 1.12 Bag (approx. 1 bag)

Cost of 1 bag Cement = Rs.300

Cost of reduced Cement Bag= 1X 300= **Rs.300**.

CONCLUSION

It was concluded from this study that Slump value of concrete tends to increase with increase in replacement percentage of cement. An increment of 44 % in slump value was found at 15% replacement of cement as compared to conventional concrete was observed. Though slump value of concrete further increases with increase in percentage replacement of cement in concrete. At 20 % replacement 50 % increment was observed.

It was concluded that compressive strength of concrete tends to increases with increase in replacement percentage of cement. Compressive strength of concrete increases up to 15 % replacement of cement with marble dust, after 15 % i.e. at 20% replacement compressive strength of concrete shows degradation. An increment of 61 % in compressive strength of concrete in 7 days compressive strength & 26 % in 28 days compressive strength as compared to conventional concrete was observed at 15 % replacement of cement with waste marble dust in concrete. Hence 15 % replacement was found to be the optimum percentage of replacement of cement with waste marble dust in conjunction with super plasticizers.

It was concluded that by replacing 15 % of cement by waste marble dust and adding super plasticizer at 1.5% by weight of cement, cost of 1 bag per m^3 of concrete i.e. 300 Rs (approx.) can be reduced.

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