A Study on Partial Replacement of Cement by Marble Dust in Rigid Pavement

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***Abstract*— An enormous amount of energy is consumed each year by the billion tonnes of cement produced around the world. Because cement manufacturing is the largest contributor of carbon dioxide to the atmosphere, demand is expected to decrease for a better environment. Various mineral additives such as silica fume, fly ash, and blast furnace slag have been used in concrete production, whereas marble dust can be used as a sand replacement as well as a cement replacement in concrete. The use of marble by-products as 100 percent substitutes for natural sand in concrete has been shown to improve the compressive strength and split tensile strength of the concrete. The primary goal was to investigate the effect of partial replacement of cement with marble dust powder and to obtain compressive strength, tensile strength, and flexural strength for 5%, 10%, 15%, 20%, and 25% replacement of cement with marble dust by weight.**

The workability, strength, and durability characteristics of concrete were examined.

***Index Terms*— Rigid, Strength, Marble Dust, Replacement, M30 Grade**

I. INTRODUCTION

Marble is a metamorphic rock that develops when limestone are subjected to extreme heat and pressure. Marble is mostly made up of calcium carbonate. Marbles are highly expensive stones that are used for decoration and other uses all over the world. It should be mentioned that marbles vary in color based on the environmental circumstances.

Marble dust is an important construction material and is commonly used in the following:

i. Use with cement: Marble dust is mixed with concrete, cement, or synthetic resins to create countertops, building stones, sculptures, floors, and a variety of other objects.

ii. Paint Filler: Marble Dust is mixed into some oil paints to reduce fluidity and stiffening.

iii. Synthetic Objects: Many synthetic objects are made with marble dust and are more commonly used than 100% solid marble objects.

iv. Use as Fillers: It is added to materials (plastics, composites, and concrete) to reduce the consumption of more expensive binders or to improve some properties of the mixtured material.

v. Other Applications: Aside from this, marble dust is used for a variety of purposes.

The billion tonnes of cement produced around the world consume a massive amount of energy each year. Because cement manufacturing emits the most CO2 into the atmosphere, demand is expected to fall.

II. OBJECTIVES OF THE STUDY

The primary goal was to investigate the impact of partial cement substitution with marble dust. Compressive strength, tensile strength, and flexural strength will be obtained for 5%, 10%, 15%, 20%, and 25% substitution of cement with marble dust by weight. The water cement ratio must be maintained constant during the project's research. The following were the main objectives of the research during the duration of the study:

1. To investigate the physical properties of marble dust.
2. To determine the particle size of marble dust.
3. Marble dust as a cement replacement material.
4. To investigate the impact of marble dust inclusion on the properties of concrete.

III. LITERATURE REVIEW

Jashandeep Singh and R.S Bansal in 2015 performed a study on the “Partial replacement of cement with waste marble dust with M 150 grade” and found that

adding up to 12% marble dust enhanced the overall strength of the concrete.

Aalok D et al 2014 also conducted a study on the partial substitution of cement with marble dust, concluding that for M25 concrete, there was a significant improvement in the strength of the concrete. Using the right quantity of dust resulted in a 50 percent boost in strength.

Rochak Pandey et al 2011 conducted a study on the partial substitution of cement in concrete using waste marble dust. According to them, it is highly beneficial to mix a little quantity of these waste materials with concrete in order to minimize the mess of pollution and, more significantly, they may be utilized to increase the strength of the materials.

Veena Pathan and Gulfam Pathan in 2014 have conducted a research on the significance of partial replacement of cement with waste marble dust. In their opinion the amount of marble dust added to the concrete add to compressive tensile and flexural strength of the concrete.

B. V.M. Sounthararajan et.al conducted study on the effect of lime concentration in MDP on the production of high strength concrete. Up to 10% marble dust was shown to be useful for increasing the strength of the concrete. According to their findings, adding a small amount of marble dust to concrete increased its strength by a factor of ten.

G.Latha in the year 2015 did Experimental Investigation on strength characteristics of concrete using Waste marble dust as cementitious material. According to her, adding marble dust to cement concrete improves everything, including improving the strength of the concrete and lowering environmental pollutants.

IV. EXPERIMENTAL STUDY

Selection of material and methodology are the first criteria for any type of experimental investigation. The summation of the experimental study is as:

A. Materials Used:

i. Ordinary Portland Cement:

In my research OPC Grade 43 of Brand Khyber and TCI Max were used for investigation. It was tested for its physical properties in accordance with Indian Standard specifications as follows

Properties of Cement

Properties	Values
Specific Gravity	3.12
Normal Consistency	29 %
Initial Setting Time	65 Minutes
Final Setting Time	275 Minutes
Fineness	330 Kg/m2
Soundness	2.5 mm
Bulk density	830-165 m3

ii. Fine Aggregates:

Fine aggregates are any natural sand particles obtained from the land through the mining process. Fine aggregates are made up of natural sand or crushed stone particles that are 14" or smaller. An S-curve characterizes the particle size distribution curve of the fine aggregate. The fine aggregate is well graded and has a particle size gradation that spans evenly from coarsest to finest.

iii. Coarse Aggregates:

Coarse aggregates are irregular broken stones or naturally occurring round gravels that are used to make concrete. For structural concrete, coarse aggregates consist of broken stones of hard rock such as granite and limestone (angular aggregates) or river gravels (round aggregates). Coarse aggregates are those that are larger than 4.75 mm in size. These aggregates are obtained from stone quarries and stone crushers and range in size from 4.75 mm to 800 mm.

iv. Marble Dust

Marble dust, being composed of calcium carbonate, will react with many acids, neutralizing the acid. It is one of the most efficient acid neutralization materials available. Marble dust is frequently used to neutralize acid in streams, lakes, and soils. It is also used in the chemical industry for acid neutralization. Anti-acid medications like "Tums" contain calcium carbonate, which is sometimes made from dusted marble. These medications can help people who have acid reflux or acid indigestion. In other pills, dusted marble is used as an inert filler. Marble dust with a passing velocity of 900 microns is used.

B. Testing Procedure

i. Casting and Curing:

The acceptance criteria of quality of0concrete is laid down in IS:456-2000. The criteria is mandatory and various provisions of the code have to be complied

before the quality of concrete is accepted. In all the samples, the 28-days compressive strength shall alone be the criterion for acceptance or rejection of the concrete. In order to get a relatively quicker idea of the quality of concrete, optional test for 7 days compressive strength of concrete be carried out. 6 Cubes of 1500x 150 x 150 mm size (the nominal size of aggregate does not exceed 38 mm) shall be cast, 3 for 7-days testing and 3 for 28-days testing. A set of 3 cubes (specimen) average strength will be a sample. The individual variation of a set of 3 cubes should0not be more than ± 15% of the average. If more, the test result of the sample is invalid.

The casted cubes were stored under shed at a place free from the vibration at a temperature 220 C to 330 C for 24 hours covered with wet straw or gunny sacking. The cubes were removed from the moulds at the end of 24 hours and immersed in clean water till the 7 or 28-days age of testing. The cubes were tested in the saturated and surface dry condition.

ii. Slump Test

Slump test is a laboratory or at site test used to measure the consistency of concrete. Slump test shows an indication of the uniformity of concrete in different batches.

iii. Compression Strength test:

The capacity of a material or structure to carry stresses on its surface without cracking or deflection is referred to as compressive strength. A material under compression tends to shrink in size, whereas a material under tension tends to lengthen in size. For any material, the compressive strength formula is the load applied at the point of failure to the cross-section area of the face on which the force was applied.

Compressive Strength = Load / Cross-sectional Area

iv. Split Tensile Strength Test:

For the splitting tensile strength test, cylinders of 1500mm diameter and 300mm length were cast and tested on a compression testing equipment in accordance with IS: 5816-1999.

v. Flexural Strength Test

Flexural strength of concrete, also known as Modulus of rupture, is an indirect measure of unreinforced concrete's tensile strength. The modulus of rupture may alternatively be defined as the measure of the extreme fibre stresses when a part is bent.

V. RESULTS OBTAINED

Sample 1: M30 Grade Concrete and 0 % Marble Dust.

Table 1

Case 1	Compressive Strength Test Results After			Tensile Strength Test Result After			Flexural Strength Result	Slump Value
M30 Grade Concrete and 0 % Marble Dust.	*7 Days*	*14 Days*	*30 Days*	*7 Days*	*14 Days*	*30 Days*	5.63 Mpa	74 mm
	23.2 N/mm^2	26.2 N/mm^2	38.1 N/mm^2	3.66 N/mm^2	3.77 N/mm^2	4.47 N/mm^2		

Sample 2: M30 Grade Concrete and 5 % Marble Dust.

Table 2

Case 2	Compressive Strength Test Results After			Tensile Strength Test Result After			Flexural Strength Result	Slump Value
M30 Grade Concrete and 5 % Marble Dust.	*7 Days*	*14 Days*	*30 Days*	*7 Days*	*14 Days*	*30 Days*	5.55 Mpa	74 mm
	26.2 N/mm^2	27.3 N/mm^2	35.3 N/mm^2	3.62 N/mm^2	3.72 N/mm^2	4.65 N/mm^2		

Sample 3 : M30 Grade Concrete and 10 % Marble Dust.

Table 3

Case 3	Compressive Strength Test Results After			Tensile Strength Test Result After			Flexural Strength Result	Slump Value
M30 Grade Concrete and 10 % Marble Dust.	*7 Days*	*14 Days*	*30 Days*	*7 Days*	*14 Days*	*30 Days*	5.93 Mpa	74 mm
	25.75 N/mm^2	31.11 N/mm^2	42.8 N/mm^2	3.86 N/mm^2	4.33 N/mm^2	4.88 N/mm^2		

Sample 4: M30 Grade Concrete and 15 % Marble Dust.

Table 4

Case 4	Compressive Strength Test Results After			Tensile Strength Test Result After			Flexural Strength Result	Slump Value
M30 Grade Concrete and 15	*7 Days*	*14 Days*	*30 Days*	*7 Days*	*14 Days*	*30 Days*	6.32 Mpa	63 mm
		31.2	45.1					

% Marble Dust.	28 N/mm^2	N/mm^2	N/mm^2	4.15 N/mm^2	4.75 N/mm^2	5.16 N/mm^2		

Sample 5: M30 Grade Concrete and 20 % Marble Dust.

Table 5

Case 5	Compressive Strength Test Results After			Tensile Strength Test Result After			Flexural Strength Result	Slump Value
M30 Grade Concrete and 20 % Marble Dust.	*7 Days*	*14 Days*	*30 Days*	*7 Days*	*14 Days*	*30 Days*	5.85 Mpa	60 mm
	26.62 N/mm^2	30.1 N/mm^2	42.78 N/mm^2	3.95 N/mm^2	4.57 N/mm^2	4.82 N/mm^2		

Sample 6: M30 Grade Concrete and 25 % Marble Dust.

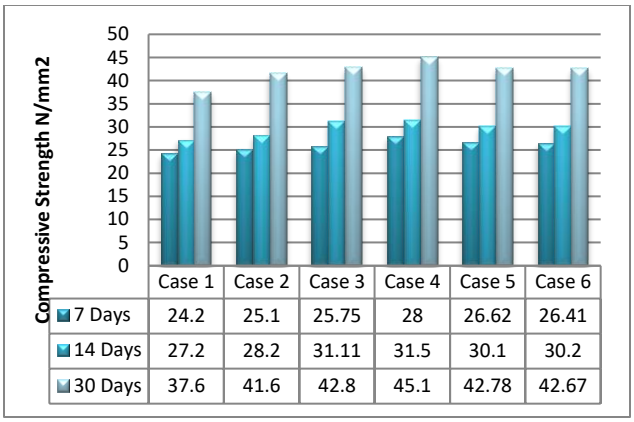
Table 6

Case 6	**Compressive Strength Test Results After**			**Tensile Strength Test Result After**			**Flexural Strength Result**	**Slump Value**
M30 Grade Concrete and 25 % Marble Dust.	***7 Days***	***14 Days***	***30 Days***	***7 Days***	***14 Days***	***30 Days***	5.13 Mpa	58 mm
	26.41 N/mm^2	30.2 N/mm^2	42.67 N/mm^2	3.79 N/mm^2	4.59 N/mm^2	4.69 N/mm^2		

VI. DISCUSSION

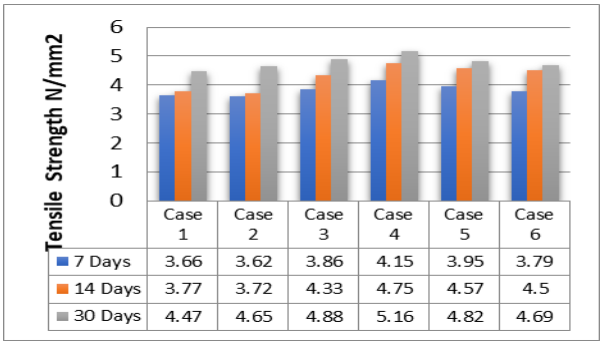
a. General: Based on the study, the analysis of the characteristics of concrete, namely the, workability, strength, and durability are made which prompted the use of marble, dust as a partial replacement, material by 0, 5, 10, 15, 20, and 25 percent with M30 concrete.
b. Workability: It is observed from the test results, that, the compactor factor increased with the increase in the level of replacement up to 15%. There was decrease in slump also.
c. Compressive Strength: The compressive strength at 7, 14 and 3 days is increasing with the, increase in the replacement, level of cement with, marble, dust up to 14.80% replacement at which the, compressive strength 14.51% higher compared, to conventional concrete.

Comparative Analysis of Compressive Strengths
Figure 1



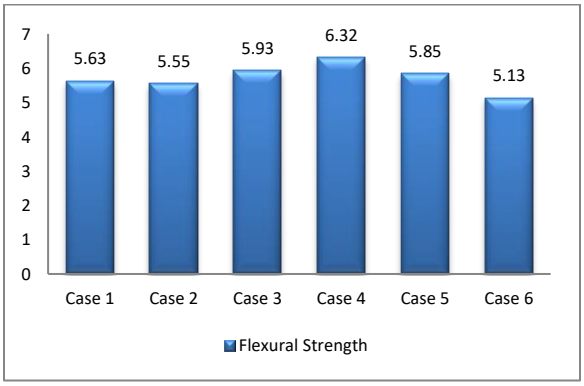
Tensile Strength
The tensile strength is increasing with the increase, in the replacement level of cement with marble dust up to 15% replacement.

Comparative Analysis of Tensile Strengths
Figure 2



Flexural Strength
The flexural strength of concrete increases upto 20% replacement level and the maximum is recorded for 15% replacement level and is found 7.1% more, than the normal concrete.

Comparative Analysis of Flexural Strengths
Figure 3



VII CONCLUSION

1. During the research it was, found that marble dust, increases the cohesiveness of the concrete.
2. It was evident that, around 15 % or something in the, range is very useful in increasing, the strength of concrete. Marble dust can easily, be used as a admixture, for strength purposes.
3. Marble dust, with 15 % showed overall, good values of compressive, and tensile strengths.
4. Marble dust or any, other waste, materials can, be used with conventional materials to increase the strength of the materials, and at the same time, environmental mess can be reduced

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