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An Economical, Eco friendly and Technical Assessment of Cement Replaced by Marble Dust in Permeable Concrete

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Abstract -The main objective of this project is to investigate the possibility of utilizing waste marble dust (MD) in cement and permeable concrete production. The research work was divided into four sections. The first section deals with the properties of cement modified with marble dust (marble dust blended cement), whereas the second section discusses the properties of concrete contained marble dust as a cement replacement. The replacement ratios which have been studied were 0.0%, 5.0%,, 10.0% , and 15% by weight. Water to powder ratio (w/p) or water to cement ratio (w/c) were 0.35 and 0.40 in case of cement replacement. Physical, mechanical and chemical properties of cement and concrete modified with marble dust were investigated. The third section this introduction to permeable concrete roads reviews its applications and engineering properties, including environmental benefits, structural properties, and durability. The fourth section deals with checking of compressive strength of traditional permeable concrete and cement replaced by marble dust in permeable concrete. Checking economy of cement replaced by marble dust in permeable concrete.

Key Words- *Economy, Strength, Durability, Eco friendly.*

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I. INTRODUCTION

In general, the industry of dimensional marble stone has contributed to the development of more environmental problems due to waste generation at different stages of mining and processing operations. Waste generation continues from mining process to completed product and is about 50% of mineral mined; the dried slurry product is less fine. 90% of the particles are below 200 m. Depending on the type of process involved, the sludge generated is equal to between 20% and 30% of the weight of the marble stone worked. Leaving the waste materials to the environment directly can cause environmental problems. Hence, many countries have been working on how to reuse the waste material so that they reduced hazards to the environment. Among these waste materials, waste marble dust, where it is a byproduct of marble processing factories.

Permeable concrete road is a unique and effective means to meet growing environmental demands. By capturing rainwater and allowing it to seep into the ground, Permeable concrete is instrumental in recharging groundwater, reducing storm water runoff, and meeting U.S. Environmental Protection Agency (EPA) storm water regulations. In fact, the use of Permeable concrete is among the Best Management Practices (BMP) recommended by the EPA—and by other agencies and geotechnical engineers across the country—for the management of storm water runoff on a regional and local basis. This road technology creates more efficient land use by eliminating the need for retention ponds, swales, and other storm water management devices. In doing so, Permeable concrete has the ability to lower overall project costs on a first-cost basis. In Permeable concrete, carefully controlled amounts of water and cementitious materials are used to create a paste that forms a thick coating around aggregate particles. A Permeable concrete mixture contains little or no sand, creating a substantial void content. Using sufficient paste to coat and bind the aggregate particles together creates a system of highly Permeable, inter connected voids that drains quickly. Typically, between 15% and 25% voids are achieved in the hardened concrete, and flow rates for water through Permeable concrete typically are around 480 in./hr (0.34 cm/s, which is 5 gal/ft2/ min or 200 L /m2/min), although they can be much higher. Both the low mortar content and high porosity also reduce strength compared to conventional concrete mixtures, but sufficient strength for many applications is readily achieved. While Permeable concrete can be used for a surprising number of applications, its primary use is in pavement. This report will focus on the pavement applications of the material, which also has been referred to as porous concrete, Permeable concrete, no-fines concrete, gap-graded concrete, and enhanced-porosity concrete. Reuse of marble dust in Permeable concrete as cement replacement.

Table I.I
Chemical composition and physical properties of cement and mineral admixtures

Chemical analysis (%)	Portland cement	Marble Dust
CaO	63.6	52.45
SiO2	19.49	1.29
Al2O3	4.54	0.39
Fe2O3	3.38	0.78
MgO	2.63	0.54
SO3	2.84	-
K2O	0.58	0.11
Na2O	0.13	-
Specific gravity	3.13	2.71
Blaine fineness (cm2/g)	3387	5190

Chemical composition of cement and marble dust nearly equal hence we can replace cement by marble dust in Permeable concrete.

II. OBJECTIVE OF STUDY

The specific objectives of this study:

a. To study the strength properties of permeable concrete for replaced cement by marble dust for different percentage of replacement.
b. To study the permeability properties of permeable concrete for replaced cement by marble dust for different percentage of replacement.
c. To find out economical and optimum percentage of replaced cement by marble dust.

III. LITERATURE REVIEW

a. A Study has been conducted by Prof. P.A. Shirule et al Described the feasibility of using 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 behavior.
b. A study has been conducted by 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.
c. A research project on the freeze-thaw durability of pervious concrete mix designs at Iowa State University (ISU) has recently been completed (Schaefer et al. 2006). The results of this study have shown that a strong, durable pervious concrete mix design that will withstand wet, hard- freeze environments is possible. The strength is achieved through the use of a small amount of fine aggregate (i.e., concrete sand) and/or latex admixture to enhance the particle-to-particle bond in the mix. The preliminary results were reported in Kevern et al. (2005). The recent work has been limited to laboratory testing and to only a few mixes using two sources of aggregates. Preliminary laboratory testing has shown the importance of compaction energy on the properties and performance of the mixes, an issue that has direct bearing on the construction technique used to place the materials in the field. Additional laboratory and field testing is necessary to establish minimum mix design properties and determine optimum construction techniques.
d. A recent study at Purdue University (Olek et al. 2003) has shown that pervious concrete (termed enhanced porosity concrete in the Purdue University study) can reduce tire-pavement interaction noise. Tests conducted in Purdue University's Tire-Pavement Test Apparatus showed reduced noise levels above 1,000 hertz (Hz) and some increase in noise levels below 1,000 Hz. The increased porosity of pervious concrete increased mechanical excitation and interaction between the tire and pavement at frequencies below about 1,000 Hz and at frequencies above about 1,000 Hz; the air pumping mechanics that dominate at such frequencies are relieved by the increased porosity leading to decreased high-frequency noise levels. Several pervious concrete pavements have been constructed in Europe, and pervious concrete has been shown to be promising in reducing tire-pavement noise and wet weather spray.
e. 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 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 behavior.

IV. RESEARCH METHODOLOGY

a. Slump Cone test:

Table IV.I
Test results of slump cone test

% of marble dust	0%	5%	10%	15%
Slump in mm	12	10	9	7

b. Weighing of materials:

The quantities of cement, each size of aggregate and water for each batch shall be determined by weight to an accuracy of 0.1 percent of the total weight of the batch.

c. Mixing Concrete:

The concrete shall be mixed by hand or preferably in a laboratory mixer in such a manner as to avoid loss of water or other materials. Each batch of concrete shall be of such a size as to leave about 10 percent excess after molding the desired number of test specimens. For this investigation concrete mixed by laboratory mixer.

d. Mix proportion:

Materials: Cement grade = 53 PPC, Course aggregate = 20mm, Waste marble dust.
Proportion for M20 permeable concrete =1:4
Water cement ratio= 0.35 to 0.4

e. Size of test specimen:

Compression test:
For compression test, specimens cubical in shape and size of 150 X 150 X 150mm shall be used.

f. Compaction of Concrete:

Cubes are filling in tree layers. Compaction is done by tamping rod by 25 storks at each layer.

Photo IV.I
Compaction is done by tamping rod.

g. Curing:

The test specimens shall be stored in a place free from vibration, in moist air of at least 90 percent humidity and at temperature of 27 $\pm$ 2° C for24 hours + 1/2 hour from time addition of water to the dry ingredients. After this period the specimens shall be marked to the dry ingredients. After this period the specimens shall be marked and removed from moulds and unless required for test within 24 hours, immediately submerged in clean, fresh water.

h. Testing of Specimens:

1) Test for compressive strength of concrete (IS:456-2000)

The compressive strength of concrete is one of the most important and a useful property of concrete. In most structural application concrete is implied primarily to resist compressive stress. In this investigation plain cement concrete cubes and fiber reinforced concrete cubes (with randomly placed and 1/3rd placed fiber) were tested on compression testing machine of capacity 2000 KN. The load is applied to opposite sides of specimen.

The load at which the control specimen ultimately fails is noted.

The compressive strength is calculated by

Compressive strength = $\frac{P}{A}$ in MPa

Where, P = Cube compressive load causing failure in N.
A = Cross sectional area of cube in mm^2.
No. of cube tested for different percentage of fiber content.
The average of no. of specimen strength is calculated and it is taken as compressive strength of one set.

Photo IV.II
Compressive Test

2) Test for permeability of permeable concrete:

Permeability is a measure of the ability of a material (typically unconsolidated material) to transmit fluids. The permeability can be determined by percolation rate. Percolation rate is expressed by gallons/ft2/minute or liter/m2/minute. Percolation rate can be determined experimentally by using a simple device called a permeameter. The time needed for percolation of known volume of water through the sample is measured and the coefficient of permeability can be expressed.

V. RESULTS

a) Technical assessment:

1) Compressive test results:

Table V.I
Test results for 7 days

Replacement in Percentage	0%	5%	10%	15%
Average Results in KN/M^2	6.33	5.13	5.11	3.14

Table V.II
Test results for 14 days

Replacement in Percentage	0%	5%	10%	15 %
Average Results in KN/M^2	13.55	12.59	11.95	9.6 6

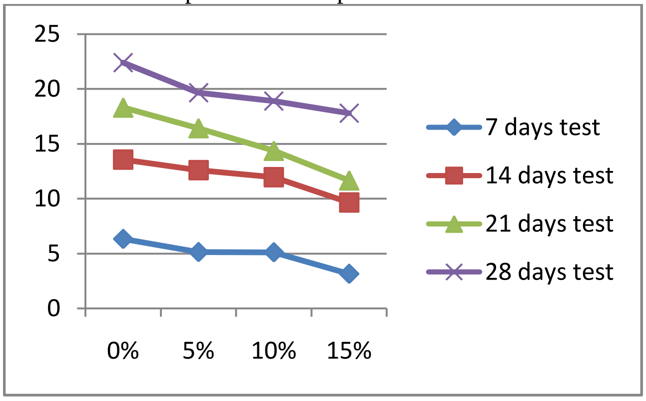
Table V.III
Test results for 21 days

Replacement in Percentage	0%	5%	10%	15%
Average Results in KN/M^2	18.31	16.43	14.37	11.67

Table V.IV
Test results for 28 days

Replacement in Percentage	0%	5%	10%	15%
Average Results in KN/M^2	22.40	19.66	18.89	17.78

Graph V.I
Graph shows comparative results



b) Eco friendly assessment:

1) Permeability test results:

Permeability is a measure of the ability of a material (typically unconsolidated material) to transmit fluids. The permeability can be determined by percolation rate. Percolation rate is expressed by gallons/ft2/minute or liter/m2/minute.

Table V.V
Test results for permeability

Replacement in Percentage	0%	5%	10%	15%
Average permeability in liter/m2/minute	150	143	138	133

c) An Economical assessment:

1) Rate for M20 traditional concrete cement :

Cement required for $1M^3$ = $403kg/M^3$ as per proportion (1:1.5:3)
Rate for 1kg cement = 5.4 Rs./Kg (PPC 53 grade)
Amount required for cement $1M^3$quantity= 2176.2 Rs/M^3

2) Rate for M20 Permeable concrete: (for 0% replacement)

Cement required for $1M^3$ quantity=504Kg/M^3as per proportion (1:4)
Rate for 1 kg cement =5.4 Rs/kg (PPC 53 grade)
Amount required for cement $1M^3$quantity= 2721.6 Rs/M^3

3) Rate for M20 Permeable concrete: (for 5% replacement)

Cement required for $1M^3$ quantity= 479Kg/M^3as per proportion (1:4)
Rate for 1 kg cement =5.4 Rs/kg (PPC 53 grade)
Amount required for cement $1M^3$quantity= 2586.6 Rs/M^3

4) Rate for M20 Permeable concrete: (for10% replacement)

Cement required for $1M^3$ quantity= 453Kg/M^3as per proportion (1:4)
Rate for 1 kg cement =5.4 Rs/kg (PPC 53 grade)
Amount required for cement $1M^3$quantity= 2448 Rs/M^3

5) Rate for M20 Permeable concrete: (for15% replacement)

Cement required for $1M^3$ quantity=428Kg/M^3as per proportion (1:4)
Rate for 1 kg cement =5.4 Rs/kg (PPC 53 grade)
Amount required for cement $1M^3$quantity= 2312 Rs/M^3.

VI. CONCLUSIONS

This study is concluded that we can replace cement by marble dust from 5% to10% in permeable concrete. 5% replacement of cement by marble dust in permeable concrete can gives better results than 10% and 15%.10% replacement of cement by marble dust can be considerable in permeable concrete.5% replacement of cement by marble dust in permeable concrete is saved around 135 Rs/M^3 concreting and 10% replacement of cement by marble dust in permeable concrete is saved around 274 Rs/M^3concreting. 5% and 10% replacement having good permeability and reuse of marble dust can be done in this concrete hence it is Eco friendly.

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