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A Comparative Study on Marble Dust as a Replacement Agent on Cement Concrete

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ABSTRACT- White Marble has been used as a material since from the past. The marble dust which is the residue of marble is very harmful and it needs good disposal efforts. Marble dust is a waste product formed during the production of marble about 25% of the original marble mass is lost in the form of dust. The highlights incorporated in this paper is that how we can use marble dust as a replacement agent. Use of marble dust as a replacement for fine aggregate in concrete is investigated. Marble has replaced fine aggregate at content levels of 0, 4, 8, 12, and 16 in concrete. Five different series of concrete mixtures were designed to investigate the various properties on Marble dust concrete. Gradual reduction in compressive strength was observed with the increase in the percentage of Marble dust. It also concludes that up to 4% of Marble slurry can be added into concrete mixes without considerable reduction in strength of concrete. Percentage of water absorption decreases as the % of marble aggregate increases. The objective of the study was to study the effect of partial replacement of fine aggregates with rubber aggregates on different percentages of Marble Dust aggregates to M25 mix. Utilization of Marble dust aggregates, which is a waste product, in concrete construction is economically viable and environmentally effective. The present work is based on the effect of addition of marble dust in Portland cement concrete.

KEYWORDS- Marble dust, Replacement agent, Cement concrete, Flexural strength.

I. INTRODUCTION

Concrete strength is greatly depending on properties of its ingredients and the mix design parameters [1,7]. Because aggregates represent the major constituents of the bulk of a concrete mixture, its properties affect the properties of final product. Due to the increasing awareness of the role played by aggregates used in the concrete the traditional view of some of the aggregates as inert filler is being seriously questioned. Aggregate was originally viewed as a material dispersed throughout the cement paste largely for economic reasons [10]. The aggregate is not truly inert and its physical, chemical and thermal properties may affect the functioning of the concrete [2,6]. Among many threats that affects the environment are the wastes, which are generated in the production process or discarded after a specific material ends its life time or the intended use [4]. Solid waste, liquid waste and gaseous waste are type of wastes. Some solid waste materials such as plastic bottles, papers, steel etc can be recycled without significant effect on the environment. The Crumb rubber (CR) is made by recycling rubber from automotive and truck scrap tires [3]. The size of particle ranging from 0.075mm to 4.75mm. Crumb rubber is made up of scrap tyres and different types of materials like steel and fibre. [5]. In the concrete mix crumb rubber constitutes a portion of the aggregate in the concrete mix. The crumb rubber is used with other type of inert contaminants such as rock, dust and glass. Recycling waste as useful material is a very important environmental management tool for achieving sustainable development [8]. Recycling waste without properly based scientific research and development may give many environmental problems greater than the waste itself [9]. In the context of India 6 million tonnes of waste is produced from marble industries due to grinding, cutting and processing. In India, (Tamil Nadu) is the state that produce hundreds of tonnes of waste in the environment per year. Marble dust causes a serious environmental concern. Marble dust cause a devastating effect on crops and forests. Our surrounding environment and habitat is highly disturbed due to this. The fine particles may also result in poor fertility of the soil and its adjoining area due to increase in alkalinity of the soil.

- Waste Marble Powder (WMP) an its consequences on the environment
- There are serious threats to our biological components of environment which includes physical, chemical and ecosystem of the environment.
- It adversely affects the productivity of land due to decreased porosity, water absorption, water percolation etc.
- When dried, it becomes air borne and cause severe air pollution. Introduces occupational health problems, it also affects machinery and instruments installed in industrial areas.
- Affecting quality of water during rainy season, and reducing storage capacities and damaging aquatic life.
- It adversely affects social and industrial activities of people since the heaps of powder remain scattered all round the country is an eye sore and spoil aesthetics of entire region.

II. OBJECTIVE OF THE STUDY

Use of industrial wastes and by products as an aggregate or raw material is of great practical significance developing building material components as substitutes for materials and

providing an alternative or supplementary materials to the housing industry in a cost effective manner and the conservation of natural resources. To dispose these hundreds to thousands of tonnes of powder, better techniques were employed. Therefore, the objective of this paper is to study the possibility to incorporate marble sawing powder wastes as a filler in concrete and also in brick products.

A. Scope Of Present Work

The scope of present experimental program are as follows:

- To study the effect of replacement of fine aggregate by Marble dust on compressive strength, after water curing of 7 days, 28 days and of water curing in M-35 grade of concrete.
- To study the effect of replacement of fine aggregate Marble dust on split tensile strength, after water curing of 28 days in M-35 grade of concrete. To study the effect of Marble dust on workability of concrete by performing slump test.

III. LITERATURE REVIEW

Marble dust is crushed or ground marble particles that can still be formed to make a solid object. Every year about 300 /400 tonnes of wate marble powder is generated. The dust is used in many more instances than marble itself because of its lower cost and versatility. To make cultured marble which is similar to true marble dust is used typically with cement or resins.

The marble cutting plants are dumping the powder in any nearby pit or vacant spaces, near their unit although notified areas have been marked for dumping. It causes serious environmental problems, pollution and occupied vast area of land after the powder dries up. (as shown in the figure 1)

Figure 1: Dumping of Marble dust

A. Origin

Marble dust is the residue of crushed marble. It is formed by the process of crystallisation of dolostone or limestone. The pressure present in the formation of marble destroys any other objects in the rock creating a dense, smooth rock. By using silt, clay and limestone in different amounts coloured marble is produced.

B. Identification

Marble dust is exactly having a fine powder texture, which resembles to the crushed limestone. Since marble is a harder, crystallized rock, the dust is not comprised of soft particles. The marble dust is slightly shimmer due to crystallisation and with the help of other colours like yellow, pink, green and it can be discolored due to impurities in the original marble.

C. Types

Marble dust originates from different countries with different names like Carrara marble dust from Italy, Pentelicus dust from Greece, and was used for many Greek sculptures and buildings.

D. Uses

The main and important uses of marble dust like it is used in cement concrete and synthetic resins Marble dust give an iridescent feel to the object because of the crystallized particles present in the dust from the marble. Synthetic marble objects made with marble dust are more commonly used than 100 percent solid marble objects. Marble dust is also used to make paint primer for canvas paintings, and as a paint filler.

E. Significance

Marble dust is often turned to be a another alternative for solid marble Not only can it look like the real thing, it's easier to transport than solid marble.

IV. MATERIAL PROPERTIES

A. Physical Properties- Table 1 is showing the physical properties of marble dust**.**

Table 1: Physical properties of marble dust

Color	White
Form	Powder
Odor	Odorless
Moisture Content (%):	1.59

B. ***Chemical Properties-*** Table 2 is showing the chemical properties of Marble dust

Table 2: Showing chemical properties of Marble dust

Oxide Compounds	Marble Dust (Mass %)
SiO2	28.35
Al2O3	0.42
Fe203	9.70
CaO	40.45
MgO	16.25
Density (g/cm3)	2.80

C. Marble Dust As Filler

As a filler marble dust is either used to produce new products or as an admixture. Due to this, the environment is saved from dumpsites of marble waste. Many studies have been conducted in literature with waste marble aggregate which is used as an admixture or sand, as well as its utilization in the mixture of asphaltic concrete (as shown in figure 2.)

Figure 2: Marble dust

In literature, waste marble dust (WMD) is replaced with fine aggregates passing through 1mm sieve. Till now there is no single study of the concrete prepared by WMD. Various studies related to the utilization of marble dust as a fine sand aggregate into the normal strength concrete have not reached a convincing conclusion. Investigations and studies related to WMD are necessary to evaluate the usages of this waste material. Current study is beneficial to evaluate and mitigate the environmental related issues.

D. In Industrial Brick

Marble dust is used in industrial sector. Use of industrial wastes and by products as an aggregate or raw material is of great practical significance. It provides an alternative or supplementary materials to the housing industry in a cost effective manner and the conservation of natural resources. The physical property the physical test of the bricks.

E. Substitute of Limestone in Cement

The waste marble products are used in cement industry as a replacement of limestone. The cement made up of free lime (as the result of its expansive reaction with ambient moisture). Some fluxing impurities (e.g. alkalis) present in the waste materials improve the overall reactivity of the mixture.

V. EXPERIMENTAL PROGRAMME

In this experimental study Marble Dust as partial replacement of Building aggregates are used and incorporating various percentages of Marble Dust is used. Following methodology is adopted to proceed the work. The main objective of testing was to know the behavior of Marble Dust with replacement of fine aggregate. The main parameters studied were split tensile strength, compressive strength and slump cone test. The materials used for the casting concrete samples along with tested results are described here with.

VI. MATERIALS USED

A. Cement

Ordinary Portland cement of Abuja Cement conforming to IS 269-1976 and IS 4031-1968 was adopted in this work. The cement used is of 53 mm grade. Cement is a fine, grey powder. Cement is produced by grinding Portland cement linker and a little amount of calcium sulphate up to 5%.

B. Fine aggregates

As we know the natural sand is available at most of the places and at a low price is used in case of construction works.. It has cubical or rounded shape with smooth surface texture.

C. Coarse aggregates

The coarse aggregates mainly made up of basalt rock is used to gives better results. 50% of the aggregate used are of 10-12 mm size and remaining 50% are of 20mm size. Dust and dirt from aggregates is removed and they are dried to surface dry condition.

D. Marble dust

Marble Dust powder was collected from Shriraj Engineers & consultants, Rajasthan. With the addition of Marble Dust, the physical properties of fresh and hardened concrete studied and compared. Marble Dust powder can be also used as coarse aggregate with the replacement of conventional cement content tor Coarse Aggregate (Panda K. et al 2012). Due to replacement of the aggregates by Marble Dust powder the weight was reduced.

E. Water

The water used to prepare concrete is free from silt, oil, sugar chloride and other organic matter. PH of water - 6.5 to 8.

F. Mix Design

Mix design is the method used to make a better and cohesive concrete using the different ingredients of concrete. Grade of concrete was taken as M35 and the mix design was done as per IS:10262-2009 and IS:456-2000. The water cement ratio was taken as 0.5 which should be the maximum for M35 grade under moderate condition

G. Methods of Concrete Mix Design

The various methods used for concrete mix design are: -

- ISI mix design method
- Trial and error method
- Road note No. 4 method
- USBR Mix Design method
- Minimum Void method
- Maximum density method

H. Batching Mixing and Casting of Specimens

During the batching, mixing and casting process a standard process is followed. Fine aggregates and coarse aggregates have accuracy in weights approximately 0.5gms The concrete mixture was prepared by hand mixing on a watertight platform. On watertight platform, the coarse and fine aggregates were mixed thoroughly. To this mixture, the cement was added. These were mixed to uniform colour. Clean and oiled moulds for each category were then placed on the vibrating table 3 respectively and filled in three layers. Vibrations were stopped as soon as the cement slurry appeared on the top surface of the mould.

For the first 24 hrs at standard temperature the specimen were allowed to remain in the steel mould. The Standard temperature during curing was 27+- 20 C.

I. Testing on Physical Properties of Material

J. Cement

K. Specific Gravity of Cement

Specific gravity or specific weight is defined as the ratio of density of a substance to the density of standard substance.

(Mass of a unit volume /Mass of the same unit volume) (as shown is figure 3)

VII. PROCEDURE

- Weight empty specific gravity bottle (W1)
- Fill half of the specific gravity bottle with cement and weight it (W2)
- Add kerosene oil in the specific gravity bottle and weight it (W3)
- Remove the water and kerosene oil from the specific gravity bottle and wash it thoroughly and dry it and fill with kerosene oil and then weight (W4).

Specific Gravity = (W2-W1)/
(W2-W1) -(W3-W4)
Therefore, specific gravity of cement = 3.15

Figure 3: Specific Gravity Bottle

VIII. STANDARD CONSISTENCY OF CEMENT

Consistency means how much water is required to make a workable paste of cement motar or cement concrete. In order to determine the correct proportion of water to cement is required to achieve proper strength while using cement in structure. This can be found out knowing standard consistency of cement paste. It is determined by Vicat's Apparatus (shown in figure 4)

- The sample of cement weighing 400gms is taken and mixed with weighed quantity of water. Total time of gauging is 3 to 5 min.
- Fill the Vicat's mould with paste and level it with a trowel.
- The plunger is lowered till it touches the surface of the cement.
- Release the plunger allowing it to sink into the paste.
- Note the reading on the gauge.
- Repeat the above procedure taking fresh samples of cement and different quantities of water until the reading on the gauge is 5 to 7 mm.

Standard Consistency (P) = W/ C× 100
P = (120/400) *100 = 30
P = 30%
Where: -P = Calculate percentage of water
W = Quantity of water added
C = Quantity of cement used

Figure 4: Vicat's Apparatus

IX. SETTING TIME

A. Initial Setting Time

It is defined as the time period from when the water is added to cement and the time up to which needle fail to penetrate in the vicat's mould 35mm-37mm from the top of the mould.

B. Procedure

- Prepare a paste of 400 grams of cement with 0.85 times the water required to a give a paste of standard consistency.
- The time of gauging in any case shall not be less than 3 minutes not more than 5 minutes and the gauging shall be completed before any sign of setting occurs.
- The time of gauging from the time of adding water to dry cement till the commencing to fill the mould.
- The Vicat's mould is filled with the paste and th top of mould is levelled.
- Slightly shake the mould to expel the air.
- During the mould is filled the hands of the operator and the blade only gauging trowel is used.
- Immediately place the test block with the non-porous resting plate, under the rod bearing the initial setting needle.
- Lower the needle and quickly release allowing it to penetrate in to the mould.
- In the beginning the needle will completely pierce the mould
- Repeat this procedure until the needle fails to pierce the mould for 5+0.5mm.
- Record the period elapsed between the times of adding water to the cement to the time when needle fails to pierce the mould by 5 + 0.5mm as the initial setting time

C. Final setting time

Final setting time is the time between which the water is added to cement and the time until which 1 mm needle makes an impression on the specimen in the mould.

D. Procedure

- Replace the needle of the Vicat's apparatus by the needle with an annular ring.
- Lower the needle and quickly release.
- The process should be repeated until an impression on the mould is made by annular ring.

- The time period may be noted after adding water to the cement to the time the annular ring face to make impression on mould.

X. SIEVE ANALYSIS OF AGGREGATES

Sieve analysis test is used for fine and coarse aggregates. The IS Code used is IS:2386(Part1)1963. The Sieve test is used for particle size distribution. The apparatus used are-

- Sizes of IS Sieves used – 75µm, 150µm, 300µm and 600µm. 1.18mm, 2.36mm, 3.35mm ,4.75mm, 6.3mm, 10mm, 12.5mm, 16 mm, 20mm ,25mm ,31.5mm ,40mm ,50 mm, 63mm, 80 mm.
- Balance or scale with an accuracy to measure 0.1 percent of the weight of the test sample.

A. Procedure

a) The sample was dried on a hot plate or in an oven at a temperature of 230OF (110OC). b) The air sample was weighed and sieved successfully on the appropriate sieves starting with the large.
c) Different sieves which are used were shaken on different clean tray until a trace passes. The time period is not less than 2 minutes. The shaking was done with a varied motion, left to right, backward and forward, circular, clockwise and anti-clockwise and with frequent jarring, so that the material is kept moving over the sieve surface in frequently changing directions.
d) Lumps of fine materials, if present, was broken by gentle pressure with fingers against the side of the sieve.
e) On completion of sieving, the material retained on each sieve, together with any material cleaned from the mesh.

B. Workability

The workability is defined as "the composite property of fresh concrete involving ease of placing and resistance to segregation is called workability". The proportions and properties of water, cement, aggregates, admixtures and other replaced materials affect the workability of concrete

C. Slump Cone Test

This test is used commonly in site work all over the world. The slump test does not measure the workability of concrete as slump test is a measure of consistency, and is very useful in detecting variations in the uniformity of mix of the nominal proportions. The mould for the slump test is frustum of cone, 300mm high. Slump cone test is placed on a smooth surface with the opening at the top, and is filled with concrete in three layers. Each layer is tamped 25 times with a standard 16 mm diameter steel rod, rounded at the end, and the top surface is stuck off by mean of sawing and rolling motion on the tamping rod.

XI. COMPRESSIVE STRENGTH TEST

The tests were conducted according to IS: 5l6-1959 (reaffirmed 1999). Specimens were taken out from the curing tank at the age of 7, 14 and 28 days and tested immediately on removal from the water and while they were still in the wet condition.
The specimens were tested on 2000 KN capacity CTM. The position of the cube was at right angles during testing. A load of 5 KN/sec is applied gradually and without shock till the specimen failure. The Compressive strength was found out. The Compressive strength test is the important test to determine the compressive strength of specimen. (as shown in figure 5)

Figure 5: Compressive Testing Machine

A. Split Tensile Strength

The test method covers the determination of splitting tensile strength of cylindrical concrete specimen. This method consists of applying diametric compressive force along length of cylindrical specimen. Loading induces tensile stresses on the plane on which the load is applied. Tensile failures occur rather than compressive failure. Ply wood strips are used so that the load is applied uniformly along the length of cylinder. The maximum load is divided by appropriate geometric factors to obtain splitting tensile strength. (as shown in Figure 6)
The splitting tensile strength was calculated as follows:
$\sigma\_sp = 2P/\pi ld.$

Where P = Max. Load at failure in N
l = Length of cylindrical specimen in mm
d = Diameter of cylindrical specimen in mm

Figure 6: Compression Testing Machine

XII. RESULTS

A. Slump Test

To determine the workability of fresh concrete this test is used. Slump test as per IS 1199-1959 is followed. From results it can be concluded that not much increase in slump value with the addition of Marble aggregates. The (Figure No.7) shown below gives the variation of slump value.

Table No. 3 Slump test

S.no	Trial Mix design (M25)	Percentage of marble dust	Slump values

01	Trial M1	0%	52
02	Trial M2	4%	55
03	Trial M3	8%	65
04	Trial M4	1.2%	68
05	Trial M5	1.6%	54

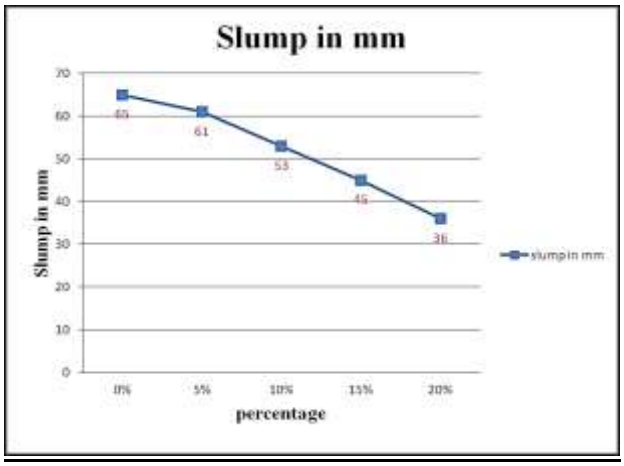

Figure 7: Slump Test

B. Split Tensile Strength Test

The various results for split tensile strength test shown in table 4 and Figure 8.

Table 4: Tensile Strength Test

Mix Design	Curing period	Load at failure (mm)	Split tensile strength
RM0	28 days	200	2.83
RM4	28 days	229	3.23
RM8	28 days	210	2.97
RM12	28 days	195	2.75
RM16	28 days	175	2.47

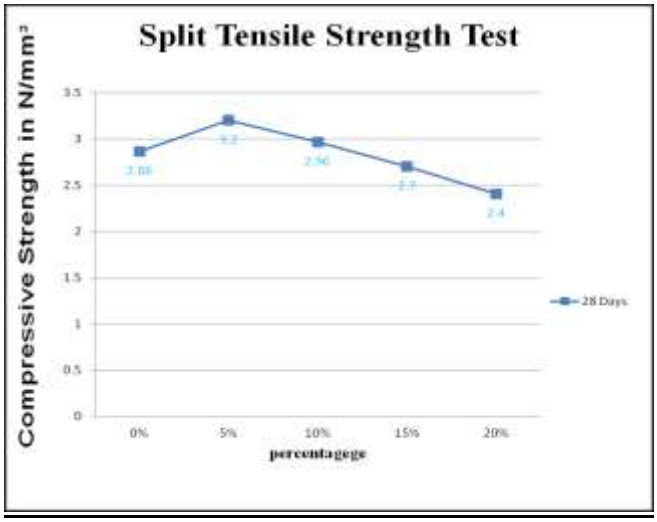

Figure 8: Split Tensile Strength

XIII. CONCLUSIONS

As the fineness of marble dust is high, it proves to be a good substitute in assuring good and better cohesiveness of cement concrete in the presence of a super-plasticizer admixtures, water to cement ratio was just adequate.

The following conclusions are drawn from the present study:

- Compressive strength of concrete decreased with the increase in paper sludge replacement. However, at each replacement level of sludge, an increased and decrease in strength was observed. Compressive strength however of 28 days is higher than at 7 days. Compressive strength is increased with addition of 4%-8% Marble Dust.
- It has been seen from the above study that compressive strength increases with age. This is true for all cases of replacement. As we replaced cement with crumb rubber, the strength has increased with age.
- Slump is decreased with addition crumb Marble dust to concrete thus decreases to workability requirements of concrete. Whereas slight addition of crumb rubber i.e. only 8% replacement of fine aggregate can still give satisfactory results
- Split tensile strength is increased with addition of 8% Marble dust. After that It was observed that as the replacement percentage of Marble dust increased, the spit tensile decreased.
- So Marble dust can be used in replacement of fine aggregate thus reducing environmental hazards. But high quantities of replacements are not recommended as it leads to decrease in strength properties.

XIV. FUTURE SCOPE

In the present experimental study, the fine aggregates in concrete will be replaced by certain percentages of Marble Dust (0%,4%,8%,1.2%,1.6%). Main objectives

- To study the mechanical properties of concrete i.e compressive strength, split tensile strength, and flexural strength.
- To protect the environment from pollution
- To find out the optimum replacement percentage of marble dust with hooked end steel fibres.
- To develop eco- friendly buildings

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest

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