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EXPERIMENTAL STUDY ON CONCRETE USING MARBLE POWDER AS PARTIAL REPLACEMENT OF CEMENT

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ABSTRACT

The waste generated from the industries cause environmental problems. Hence the reuse of this waste material can be emphasized. Marble Dust Powder (MDP) is a developing composite material that will allow the concrete industry to optimise materiel use, generate economic benefits and build structures that will strong, durable and sensitive to environment. MDP is by-product obtained during the quarrying process from the parent marble rock; which contains high calcium oxide content of more than 50%. The potential use of MDP can be an ideal choice for substituting in a cementitious binder as the reactivity efficiency increases due tothe presence of lime. In this research work, the waste MDP passing through 90 microns, has used for investigating of hardened concrete properties. Furthermore, the effect of different percentage replacement of MDP on the compressive strength, splitting tensile strength (Indirect tensile strength) & flexural strength has been observed. In this experimental study, the effect of MDP in concrete onstrength is presented. Five concrete mixtures containing 0%, 10%, 15%, and 20% MDP as cement replacement by weight basis has been prepared. Compressive strength, split tensile strength & flexural strength of the concrete mixtures has beenobtained at 7, 14 and 28 days.

Key Words - Marble Powder, compressive strength, split strength, flexural strength, workability, concrete.

1. Introduction

It has been estimated that several million tons of MDP are produced during quarrying worldwide. Hence utilization of marble powder has become an importantalternative materials towards the efficient utilization in concrete for improvedharden properties of concrete. Marble is a metamorphic rock resulting from the transformation of a pure limestone. The purity of the marble is responsible for its colour and appearance it is white if the limestone is composed solely of calcite (100% $CaCO_3$). Marble is used for construction and decoration; marble is durable, has a noble appearance, and is consequently in great demand. Chemically, marbles are crystalline rocks composed predominantly of calcite, dolomite or serpentine minerals. The other mineral constituents vary from origin to origin.

The main impurities in raw limestone (for cement) which can affect the properties of finished cement are magnesia, phosphate, leads, zinc, alkalis and sulfides. A large quantity of MDP is generated during the cutting process. The result is that the mass of marble waste which is 20% of total marble quarried has reached as high as millions of tons. Leaving these waste materials to the environment directly can cause environmental problem.

Moreover, there is a limit on the availability of natural aggregate and minerals usedfor making cement, and it is necessary to reduce energy consumption and emission of carbon dioxide resulting from construction processes, solution to this problem are sought through usage of MDP as partial replacement of Portland slag cement.In India, MDP is settled by sedimentation and then dumped away which results an environmental pollution, in addition to forming dust in summer and threatening both agriculture and public health.

Therefore, utilization of the MDP in various industrial sectors especially the construction, agriculture, glass and paper industries would help to protect theenvironment. Waste can be used to produce new products or can be used as admixtures so that natural resources are used more efficiently and the environment is protected from waste deposits.

2. Literature Collection

Abdullah Anwar et al., 2014 studied on "Study of compressive Strength of concrete by partial replacement of cement with marble dust powder" and concluded that marble dust powder has a potential to provide an alternative to cement and helps in maintaining the surroundings every bit well as economical balance. The compressive strength properties of concrete containing marble dust powder at 0%, 5%, 10%, 15%, 20% and 25% of Portland cement. The investigation was primarily to determine a resolution to the disposal problem of marble dust by making usage of it in concrete production for sustainable construction development. The result obtained for 28 day compressive strength confirms that the optimal percentage for replacement of cement with marble dust powder is about 10%. This will post less on the production of carbon dioxide and solving the environmental pollution by cement production, thereby enhances the urban surroundings.

V.M. Sounthararajan et.al (2013) A Study has been conducted on Effect of the Lime Content in MDP for Producing High Strength Concrete. They found that the MDP up to 10% by weight of cement was investigated for hardened concrete properties. Furthermore, the effect of different percentage replacement of MDP on the compressive strength, splitting tensile strength and flexural strength was evaluated. It can be noted that the influence of fine to coarse aggregate ratio and cement-to-total aggregate ratio had a higher influence on the improvement instrength properties. A phenomenal increase in the compressive strength of 46.80 MPa at 7 days for 10% replacement of MDP in cement content was noted and also showed an improved mechanical property compared to controlled concrete

***Corinaldesi V et al.,* (2010)** Marble as a building material especially in palaces and monuments has been in use for ages. However the use is limited as stone bricks in wall or arches or as lining slabs in walls, roofs or floors, leaving its wastage at quarry or at the sizing industry generally unattended for use in the building industry itself as filler or plasticizer in mortar or concrete. The result isthat the mass which is 40% of total marble quarried has reached as high as millionsof tons. This huge unattended mass of marble waste consisting of very fine particles is today one of the environmental problems around the world.

Vaidevi C (2013): Found that the use of this waste was proposed in different percentages both as an addition to and instead of cement, for the production of concrete mixtures. The study showed the cost of these cementitious material decreases cost of construction when replaced by different percentages of MD. Compressive test and tensile tests were conducted.

Jashandeepsingh et al., 2015studied on "Partial replacement of cement with waste marble powder with M 25 grade" and concluded that up to 12% replacement of cement with waste marble there is an increase in all mechanical properties. The replacement of 12% of cement with waste marble powder attains maximu m compressive and tensile strength. The optimum percentage for replacement of marble powder with cement is almost 12% cement for both cubes and cylinders. To minimize the costs for construction with usage of marble powder that is freely or cheaply available. To realm of saving the environmental pollution by cement production being our main objective.

3. Experimental Investigation

3.1. Cement

Ordinary Portland cement of 53 grades conforming to IS: 12269-1987 was used for the present experimental investigation. The following experiments were conducted to identify the properties of cement as per IS code.

Table 1 Properties of cement

Properties of cement				
Standard consistency	**Specific gravity of cement**	**Fineness test**	**Initial setting time**	**Final setting time**
32%	3.16	7.11%	60 minutes	400min

3.2. Fine Aggregate

Fine aggregate is sand, which is usually obtained from rivers or lakes. In places where sand is not available or a large quantity of sand is required, crushed stone dust is used. The fine aggregate should be free from clay particles because it reduces strength and it takes more amount of water during the period of concrete mixing. Tests Performed on Fine Aggregates as per IS 383-1970.

Table 2 Properties of fine aggregate

Properties of fine aggregate				
Sieve analysis of river sand	**Sieve analysis of M-sand**	**Specific gravity of river sand**	**Specific gravity of M-sand**	**Water absorption test**
2.58	2.84	2.63	2.73	0.5%

3.3. Coarse Aggregate

Coarse aggregate shall consist of naturally occurring materials such as gravel or resulting from the crushing of parent rock, including natural rock, slags, expanded clays and shelves (lightweight aggregates) and other approved inert materials with similar characteristics, having hard, strong, durable particles, conforming to the specific requirements of this Section.

The coarse aggregate gives volume, stability, resistance to wear or erosion, and other desired physical properties to the finished product. Tests performed on coarse aggregates as per IS 2386-1963

Table 3 Properties of coarse aggregate

Properties of coarse aggregate				
Sieve analysis of coarse aggregate	**Specific gravity of Coarse aggregate**	**Water absorption test**	**Impact test**	**Abrasion test**
7.33	2.65	0.98	10.28	10.8

3.4. Marble Powder

Construction materials are more judged by their ecological characteristics because of the continual depletion of quarry aggregates. In India huge amount of marble waste is being generated because of lack of technology and also unscientific methods of quarrying marble.

Due to generation of marble waste there is a direct exposure of this material with the environment because of which serious environmental problems occur.

Marble is composed primarily of calcite, dolotimite, Typically, marble is composed of the following major constituents:38-42% Lime (CaO), 20-25% Silica (SiO_2), 2-4% Alumina(Al_2O_3), 1.5-2.5% various oxides (NaO and MgO), and 30- 32% various carbonates ($MgCO_3$ and others).

Table 4 Marble Powder

SI.NO	Particular	Result
1	Specific gravity	2.57
2	Fineness	5 micro
3	Colour	White
4	Particle shape	Powder form

3.5. Water

Fresh potable water, which is free from acid and organic substance, was used for mixing the concrete.

Fresh portable water free from organic matter and oil is used in mixing the concrete. Water in required quantities were measured by graduated jar and added to the concrete. The rest of the material for preparation of the concrete mix was taken by weigh batching. The pH value should not be less than 7.

4. Mix Proportioning

Concrete Mix Design In This Experiment Was Designed As Per The Guidelines In Is 10262-2009. All The Samples Were Prepared Using Design Mix. M30 Grade Of Concrete Was Used For The Present Investigation. Mix Design Was Done Based On Is 10262-2009. The Table 5 Shows Mix Proportion Of Concrete (Kg/M^3)

Table 5 Final Mix proportion: Conventional Mix

MIX PROPORTIONING	CEMENT (KG/M^3)	M-Sand (Kg/M^3)	FINE AGGREGATE (RIVER SAND) (Kg/M^3)	COARSE AGGREGATE (Kg/M^3)	WATER (litr)	MARBLE POWDER (Kg/M^3)
CCM	425.73	647.11	-	1110.21	191.58	-
CCR	425.73	-	647.11	1110.21	191.58	-
CC.MP5%	404.44	-	647.11	1110.21	191.58	21.28
CC.MP10%	383.15	-	647.11	1110.21	191.58	42.57

CC.MP15%	361.87	-	647.11	1110.21	191.58	63.85
CC.MP20%	340.58	-	647.11	1110.21	191.58	85.14
C.C= Conventional Concrete, C.CM = Conventional concrete with M-sand, C.C.R= Conventional Concrete with River Sand, CC.MP= Concrete With Marble Powder						

5. Fresh Concrete Properties

5.1. Slump cone Test

This test is performed to measure the workability of fresh concrete as per IS 1199-1959. Slump cone test is the most commonly used method of measuring consistency of concrete. It is used conveniently as a control test and gives an indication of the uniformity of concrete. Additional information on workability and quality of concrete can be obtained by observing the manner in which concrete slump. The apparatus for conducting the slump test essentially consist of a metallic mould in the form of frustum of the cone having the internal dimension of bottom diameter 20cm, top diameter 10cm, and a height of 30cm.

Fig 1 Slump cone Test

5.2. Compacting Factor test

Compaction factor test is the workability test for concrete conducted in laboratory. The compaction factor is the ratio of weights of partially compacted to fully compacted concrete. It was developed by Road Research Laboratory in United Kingdom and is used to determine the workability of concrete As per IS1199:1959 Compaction factor test apparatus consists of two conical hoppers and a bottom cylinder which is arranged as shown in Fig 3.7, steel rod of 1.6cm Diameter with a length of 61cm is used to tamp the concrete and a weight balance is used to weight the concrete.

Compaction factor = (W2-W1)/ (W3-W1)

Fig 2 Compacting Factor test

Table 6 Workability of fresh concrete

Workability	
Slump cone Test	**Compacting Factor test**
76	0.83

6. Hardened Concrete Properties

6.1. Compressive strength test

150 mm cube specimens were tested under compressive load in the respective to the age of curing. All the specimens were tested in saturated surface dry condition, after wiping out the surface moisture. For each mix combination, three identical specimens were tested at the ages of 7, 14, 28 days using compression testing machine of 2000 KN capacity under a uniform rate of loading of 140 kg/cm2/min. and the compressive strength will calculated as per IS: 516 – 1959. Fig. 3.8 shows the experimental set up of compressive testing machine.

Compressive Strength (f) = (P/A) N/mm2

Where,

P = Load at which specimen fails in Newton,

A = Area over which the load is applied

in mm^2f = Compressive Stress in N/mm^2

Fig 3 Experimental Set Up of Compressive Strength

6.2. Split tensile strength test

This is an indirect test to determine the tensile strength of cylindrical specimens. Split tensile strength tests were carried out on 100 mm dia.x200 mm high cylindrical specimen at the ages of 28 days of moist curing, using compression testing machine of 2000 N capacity as per IS 5816-1999.

Split tensile strength (ft) is estimated from the expression

$$T = 2P / \pi DL \ \ N/mm^2$$

Where,

T = Split tensile strength of concrete

P = Ultimate Load (Newton)

D = Diameter of cylinder (mm)

L= Length of cylinder (mm)

Fig 4 Experimental Set Up of Split Tensile Strength

6.3. Flexural strength test

In order to determine the flexural strength of concrete, prismatic specimens of a size 100 mm x 100 mmx 500 mm were cast with various proportions of all the concrete mixtures. After 28 days of moist curing the specimens were tested in flexural testing machine under a uniform rate of loading of 180 $kg/cm^2/min$. Flexural strength of specimens expressed as the modulus of rupture (fb) is then calculated using the formula and procedure given in IS: 516- 1959.

When the distance between the line of fracture and the nearer support, measured on centre line of the tension side of specimen (‘a’ in mm) is greater than133 mm for prism of size 100 mm x 100 mm x 500 mm, the modulus of rupture (fb) is then calculated from the Equations.

$$(fb) = Pl/ bd^2$$

For ‘a’ is less than 133 mm but greater than 110 mm for prism specimen, then modulus of rupture is calculated from the formula.

$$(fb) = 3Pa / bd$$

Fig 5 Beam testing machine

7. Experimental Procedure

The specimen of standard cube of (150mmx150mmx150mm) and standard cylinders of (200mmx100mm) and beam of (100mmx100mmx500mm) were used to determine the compressive strength, split tensile strength and flexural strength of concrete. Three specimens were tested for 7,14&28 days before crushing.

The following experiments are conducted on the specimen is the compressive strength test, split tensile strength test and flexural strength test.

8. RESULTS AND DISCUSSION:

The normal concrete are tested for their performance by determining their compressive strength, splitting tensile strength and flexure strength development at different ages of 7th, 14th and 28th days. The results obtained are discussed in detail in the following sections.

8.1. Compressive Strength Result

Compressive strength test is done as Per IS 516-1959. The test is conducted on Compression testing machine of capacity 2000 KN. Mechanical behaviour of concrete was studied for M30 grade of cubes were casted and cured for 7,14 and 28days.The compressivestrength is computed from following formula.

Table 7 compressive strength result

Mix Designation	Mix proportion				Compressive strength N/mm²		
	Cement	River sand	Marble powder	Coarse aggregate	7 days	14 Days	28 Days
CC	100%	100%	0%	100%	20.06	28.77	31.04
MP1	95%	100%	5%	100%	20.24	28.96	31.18
MP2	90%	100%	10%	100%	20.65	29.67	32.23
MP3	85%	100%	15%	100%	20.36	29.24	32.07
MP4	80%	100%	20%	100%	20.08	29.03	31.86

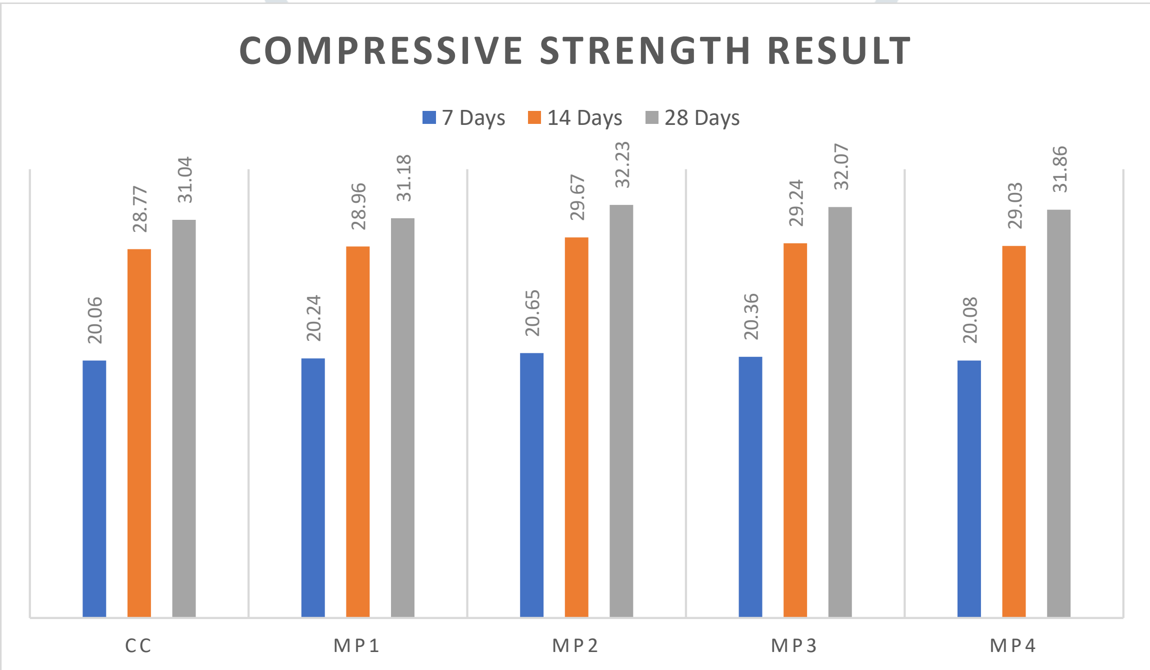

Fig 6 compressive strength result

8.2. SPLIT TENSILE STRENGTH TEST RESULT

The test is conducted on Compression testing machine of capacity 2000 KN. The cylinder is placed horizontally between the loading surfaces of compression testing machine and the load is applied till failure of the cylinder. The Split tensile strength is represented in the following table 8

Table 8 Split tensile strength result

Mix Designation	Mix proportion				Split Tensile strength N/mm^2
	Cement	River sand	Marble powder	Coarse aggregate	28 Days
CC	100%	100%	0%	100%	3.36
MP1	95%	100%	5%	100%	3.48
MP2	90%	100%	10%	100%	3.64
MP3	85%	100%	15%	100%	3.43
MP4	80%	100%	20%	100%	3.34

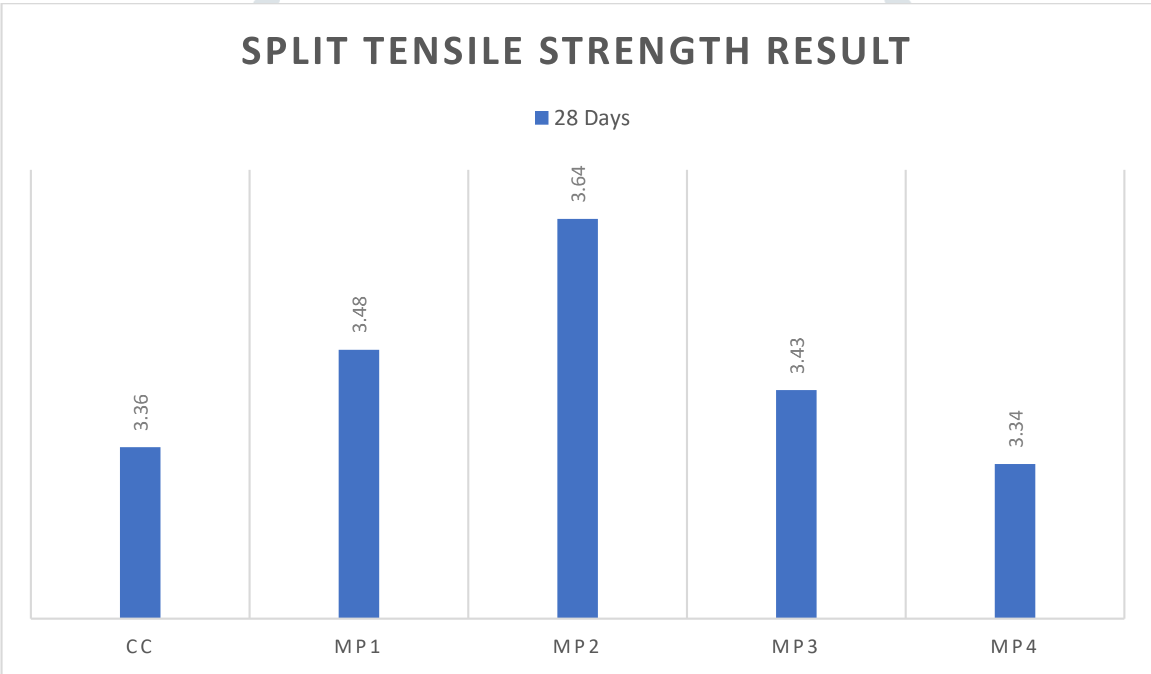

Fig 7 Split tensile strength result

8.3. FLEXURAL STRENGTH TEST RESULT

Flexural strength of the concrete was tested as per IS :516-1959 using the prism of size 100mmX100mmX500mm and the results were given in the Table 9

Table 9 flexural strength test result

Mix Designation	Mix proportion				Split Tensile strength N/mm^2
	Cement	River sand	Marble powder	Coarse aggregate	28 Days
CC	100%	100%	0%	100%	4.32
MP1	95%	100%	5%	100%	4.46
MP2	90%	100%	10%	100%	4.68
MP3	85%	100%	15%	100%	4.52
MP4	80%	100%	20%	100%	4.34

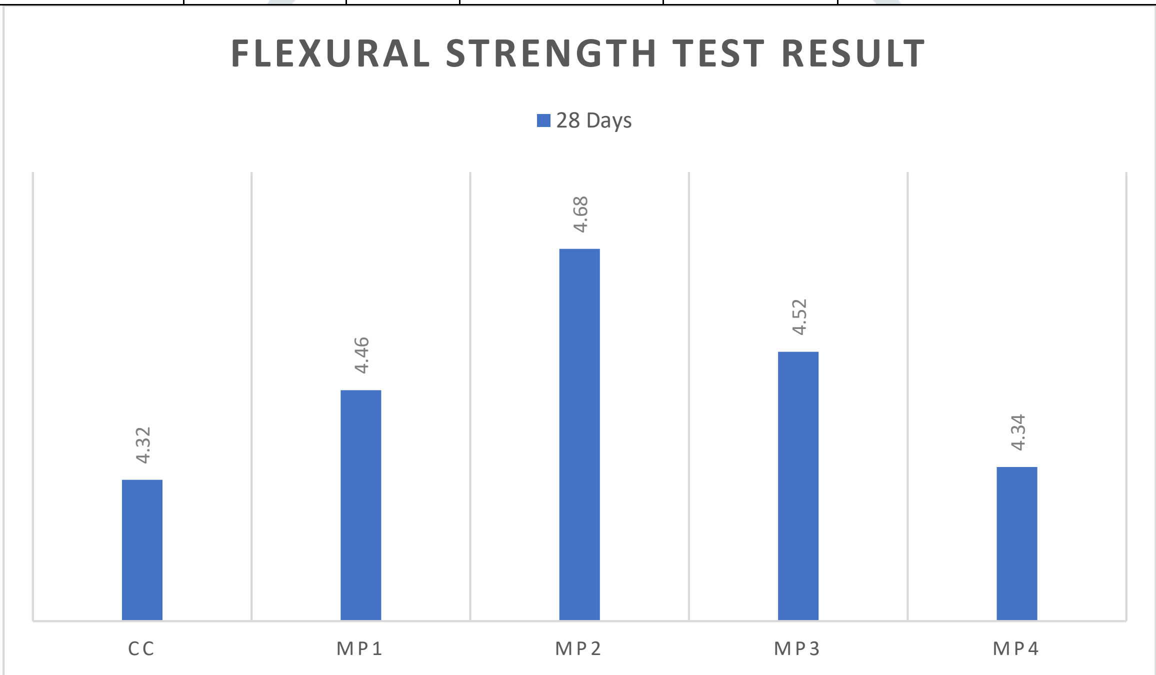

Fig 8 flexural strength test result

CONCLUSION

1. Compressive strength increases with increases of marble powder.
2. Upto to 10% replacement of cement there is increase in all mechanical properties
3. The optimum percentage for replacement of marble powder with cement and it is almost 10% cement for cubes
4. The replacement of 10% cement with waste marble powder attains maximum compressive strength
5. To minimize the cost of construction with usage of marble powder which is freely or cheaply available
6. More important to saving the environmental pollution by cement production. Being the main objective as civil engineering.

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