Pooja J.Chavhan et al Int. Journal of Engineering Research and Applications www.ijera.com
ISSN : 2248-9622, Vol. 4, Issue 4(Version 1), April 2014, pp.377-381

RESEARCH ARTICLE OPEN ACCESS

To Study the Behaviour of Marble Powder as Supplementry Cementitious Material in Concrete

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ABSTRACT
Concrete is the most widely used construction material in civil engineering industry because of its high structural strength and stability. Leaving the waste materials to the environment directly can cause environmental problem. Hence the reuse of waste material has been emphasized. 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. Marble stone industry generates both solid waste and stone slurry. The concrete industry is constantly looking for supplementary material with the objective of reducing the solid waste disposal problem. In that paper marble powder is replace by sand the research is carried out by using M25 grade concrete with replacement of 0%, 5%,10%,15%,20%,25%,30%,35%,40%,45%,50% marble powder by sand and is carried out to determine the optimum percentage of replacement at which maximum compressive strength and also split tensile strength is achieved There are several reuse and recycling solutions for this industrial by-product, both at an experimental phase and in practical applications. These industrial wastes are dumped in the nearby land and the natural fertility of the soil is spoiled. The physical, chemical and mechanical properties of the waste are analyzed.
Keywords- Cement, Compressive Strength, Marble Powder, Sand, split tensile strength

I. INTRODUCTION

Leaving these waste materials to the environment directly can cause environmental problem. Hence the reuse of waste material has been emphasized. 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.. This is relevant because the stone industry presents an annual output of 68 million tonnes of processed products. Therefore the scientific and industrial community must commit towards more sustainable practices. There are several reuse and recycling solutions for this industrial by-product, both at an experimental phase and in practical applications.

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. A large quantity of powder 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. This huge unattended mass of marble waste consisting of very fine particles is today one of the environmental problems around the world Concrete is a heterogeneous mix of cement, aggregates and water. The global consumption of natural sand is too high due to its extensive use in concrete. The demand for natural sand is quite high in developing countries owing to rapid infrastructural growth which results supply scarcity. To overcome from this crisis, partial replacement of natural sand with marble powder sand is economic alternative. The concrete industry is constantly looking for supplementary material with the objective of reducing the solid waste disposal problem .marble powder are among the solid wastes generated by industry. In this research we prepared three specimen for each sample of cubes for compressive strength test, cylinder for split tensile strength test,The test on hardened concrete are destructive test while the destructive test includes compressive strength test as per IS: 516-1959, split tensile strength test as per IS: 5816-1999

The objectives and scope of present study are: –

1. To find the optimum percentage of replacement of natural sand with marble powder at which maximum strength is obtained.
2. To find the optimum mix design with regards to the amount of water, Marble powder and cement ratio.

3. To conduct compression test on and control concrete on standard IS specimen size (150x150x150) mm.
4. To study in detail about the presence marble powder in concrete.
5. To conduct compressive strength test, split tensile strength test
6. To provide economical construction material.
7. Provide safeguard to the environment by utilizing waste properly.

II. NECESSITY FOR THE USE OF MARBLE POWDER

Marble stone industry generates both solid waste and stone slurry. Whereas solid waste results from the rejects at the mine sites or at the processing units, stone slurry is a semi liquid substance consisting of particles originating from the sawing and the polishing processes and water used to cool and lubricate the sawing and polishing machines. Stone slurry generated during processing corresponds to around 20% of the final product from stone industry. Therefore the scientific and industrial community must commit towards more sustainable practices. There are several reuse and recycling solutions for this industrial by-product, both at an experimental phase and in practical applications.

2.1 APPLICATION OF MARBLE POWDER

An additive for thermoplastic and as a hardening agent for rubber industry are as follows:-

1. power coating, paints and ceramic industry
2. reinforced polyester glass fiber
3. leather cloth and flooring applications
4. detergent applications
5. glass industry (in manufacturing sheet & optical glasses)

2.2 ADVANTAGES OF MARBLE POWDER

1. Marble powder can be used as a filler in concrete and paving materials and helps to reduce total void content in concrete.
2. Marble powder can be used as an admixture in concrete ,so that strength of the concrete can be increased.
3. We can reduce the environmental pollution by utilizing this marble powder for producing the other products.
4. Marble dust is mixed with concrete, cement or synthetic resins to make counters, building stones, sculptures, floors and many other objects.
5. Marble dust gives an iridescent feel to the object because of the crystallized particles present in the dust from the marble. These cultured marble objects are often seen in luxury settings. Synthetic marble objects made with marble dust are more commonly used than 100 percent solid marble objects.
6. Marble dust is also used to make paint primer for canvas paintings, and as a paint filler.
7. Used as a component for manufacture of white cement.
8. The marble powder is also used to create carbonic acid gases which is used in the bottling of beverages.

2.3 DISADVANTAGES

1. Only 20% of the final product is obtained from stone industry.
2. Marble powder is not available in all the places.

III. CHEMISTRY OF CONCRETE

The three basic ingredients of concrete are aggregate, cement and water. Aggregates are chemically inert and are bound together by the cement. They are there to give bulk to the concrete and are not involved in the chemical processes.

Cement is made by mixing crushed clay and limestone together and roasting it in a kiln. The resulting powder is a mixture of five chemicals. About 50% is Tricalcium silicate, 25% is dicalcium silicate, 10% Tricalcium aluminates, 10% tetra calcium aluminoferrite and 5% gypsum or hydrated calcium sulphate.

When cement is mixed with water, its constituents are hydrated. The calcium silicates form calcium silicate hydrate, calcium hydroxide and heat. These products contribute to the strength of the concrete.

Tricalcium silicate reacts quickly producing a lot of heat.

$$2(CaO)_3(SiO_2) + 7H_2O \rightarrow (CaO)_3(SiO_2)_2.4(H_2O) + Ca(OH)_2 \quad (1)$$

Dicalcium silicate reacts more slowly and produces less heat.

$$2(CaO)_2(SiO_2) + 5H_2O \rightarrow (CaO)_3(SiO_2)_2.4(H_2O) + Ca(OH)_2 \quad (2)$$

The chemistry of these reactions is complex. When the calcium silicates first come into contact with water, a reaction occurs in which calcium ions are formed and the water molecules are broken down to form hydroxide ions. It is this bond breaking that produces heat. Calcium hydroxide is not very soluble so it is soon saturated and forms a solid. At the same time, calcium silicate hydrate is formed which is also a solid. As long as water is in contact with the cement, these reactions continue but they get slower and slower, and can take several years to reach full strength.

Zooming out a level, the aggregate is not involved in the reaction, but forms a surface for the solids to form on. This will be easy at first, as there are large areas of water and cement mixed together. As the solid is formed, however, there is less and less space between the grains of aggregate and silicate hydrate for the water to move around and reach un-reacted cement. This means that the reaction will slow down as the pores between the aggregate get smaller.

IV. MATERIALS AND METHODS

The materials used in experimental investigation include:

4.1 CEMENT

Ordinary Portland cement of 43-grade was used in this study Conforming to IS:8112-1989 which has Specific gravity 3.15, Normal consistency 32%.

4.2 MARBLE POWDER (MP)

In that project the collection of marble powder from ghat road Nagpur The specific gravity of Marble powder is 2.842gmm/cc, Fineness by sieving 24.4%, Specific surface area(cm2/gm) $11.4*10^3$ Marble is a metamorphic rock resulting from the transformation of a pure limestone. The purity of the marble is responsible for its color 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. A large quantity of powder 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. This huge unattended mass of marble waste consisting of very fine particles is today one of the environmental problems around the world.

Fig.1: Sample of Marble powder

4.3 AGGREGATE

Good quality river sand was used as a fine aggregate conforming to Zone- II of IS: 383- 1970 have fineness modulus of 2.735, specific gravity of 2.5 and water absorption 0.98%. The coarse aggregate passing through 20 mm and retained on 10 mm sieve was used in research. Its specific gravity of 2.85 and water absorption 0.8%.

4.4 WATER

In this research potable water free from organic substance was used for mixing as well as curing of concrete.

4.5 CHEMICAL PROPERTIES OF MARBEL POWDER

Table1:Following are the chemical property of Marble powder

Material	LOI	SiO2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	**K_2O**	**Na_2O**
Marble powder	40.63	4.99	1.09%	1.09%	32.23%	18.94	0.02	0.91	0.63

V. EXPERIMENTAL PROGRAMME

5.1 MIXTURE PROPORTIONING

The M25 mix proportioning is designed as per guidelines, according to the Indian Standard Recommended Method IS 10262- 2009. The total binder content was 422.77 kg/m³, fine aggregate is taken 632.95 kg/m³ , coarse aggregate is taken 1198.525 kg/m³. This research is carried out in two phase, in first phase mix of M25 grade concrete with replacement of 0%,10%,15%,20%,25%, 30%, 35%,40%,45%,50% of natural sand with Marble powder is carried out to determine the optimum percentage of replacement at which maximum compressive strength is achieved. In second phase, cylinder moulds were used for casting. The total mixing time was 5 minutes; Compaction of concrete in three layers with 25 strokes of 16mm rod was carried out for each layer is done. The concrete was left in the mould and allowed to set for 24 hrs before the cubes were demoulded and placed in curing tank until the day of testing.The three specimens of each mix was prepared and left for curing in the curing tank for 7,14 and 28 days.

Table 2: Mix proportion for every mix marble powder by sand

Sr. No	Grade of concrete	Mix proportion	w/c
1	M25- (5% MP)	1 : (1.09/0.0575) : 2.814	0.45
2	M25- (10% MP)	1: (1.035/0.115) : 2.814	0.45
3	M25- (15% MP)	1 : (0.97/0.173) : 2.814	0.45
4	M25- (20% MP)	1 : (0.92/0.23) : 2.814	0.45
5	M25- (25% MP)	1 : (0.863/0.288) : 2.814	0.45
6	M25- (30% MP)	1 : (0.805/0.345) : 2.814	0.45
7	M25- (35% MP)	1 : (0.748/0.403) : 2.814	0.45
8	M25- (40% MP)	1 : (0.69/0.46) : 2.814	0.45
9	M25- (45% MP)	1 : (0.632/0.518) : 2.814	0.45
10	M25- (50% MP)	1 : (0.575/0.575) : 2.814	0.45

Table 3: Details Of Replacement Of Marble Powder By Fine Aggregate

Sr No	Cement	Sand	Marble Powder	Aggregate
1	100%	100%	0%	100%
2	100%	95%	5%	100%
3	100%	90%	10%	100%
4	100%	85%	15%	100%
5	100%	80%	20%	100%
6	100%	75%	25%	100%
7	100%	70%	30%	100%
8	100%	65%	35%	100%
9	100%	60%	40%	100%
10	100%	55%	45%	100%
11	100%	50%	50%	100%

5.2 TESTING METHOD

Testing is done as per following IS code. The testing is carried out for compressive strength on cubes as per IS : 516 – 1959, split tensile strength on cylinder as per IS : 5816 – 1999, flexural strength on beam of as per IS: 516 – 1959. Permeable voids tests is carried out as per ASTM C642-97.

Table No. 4: Compressive strength, Flexural strength, Split tensile strength

Sr. No	% Replacement	7 Days Strength N/Mm2	14 Days Strength N/Mm2	28 Days Strength N/Mm2	Split Tensile Strength 28 Days N/Mm2
1	0%	26.51	30.14	28.26	4.65
2	5%	21.07	24.48	26.22	4.36
3	10%	28.82	32.55	30.25	4.89
4	15%	22.23	24.53	27.22	3.93
5	20%	19.24	21.92	23.12	2.53
6	25%	23.63	25.56	26.96	2.81
7	30%	26.81	30.22	28.99	4.20
8	35%	21.58	24.19	26.20	4.62
9	40%	21.72	27.1	30.44	3.51
10	45%	28.99	32.17	34.08	5.86
11	50%	27.1	33.13	35.67	5.72

From testing results graph for compressive strength of marble powder with replacement of fine aggregate is shown are as follows :-

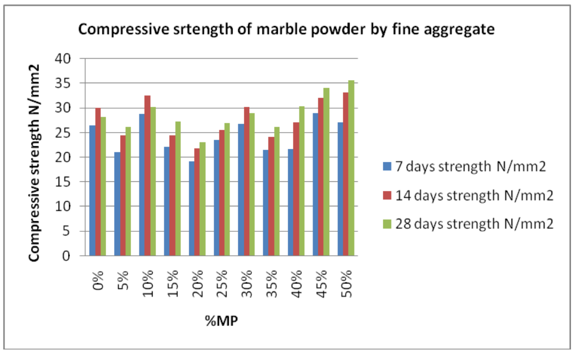

Fig.2: Compressive strength of marble powder with replacement of fine aggregate

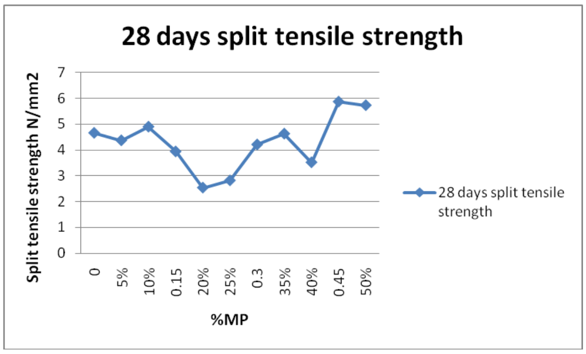

Fig.3: Split tensile strength of replacement of marble powder by fine aggregate

VI. CONCLUSION

Based on the results presented above, the following conclusion can be drawn:

1. Compressive strength increases with increase of marble powder
2. Compressive strength increases with 30% replacement and also 45%,50% replacement by sand
3. The maximum 28 days split tensile strength was obtained with 45%marble powder replaced with fine aggregate.
4. We have put forth a simple step to minimize the costs for construction with usage of marble powder which is freely or cheaply available; more importantly.
5. We have also stepped into a realm of saving the environmental pollution by cement production; being our main objective as Civil Engineers.
6 Marble slurry utilization in black cotton soil is one of the best ways to improve soil properties and to protect the environment up to some extent from the harmful effects of disposal of marble slurry in land and water.

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