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Study on Marble Powder as Partial Replacement of Cement in Normal Compacting Concrete

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Abstract: *Along the rapid growth of human needs in many sectors, a significant decrease in the availability and viability of the natural resources was always faced. Neither the less, the high volume production is always associated with considerable amount of waste materials, which may adversely impacts the surrounding environment. Efforts on bypassing such dilemma were recently intensified in many countries and international establishments looking for new regulations and legislations to minimize and reuse the generated waste. One of the major waste generating industries is the marble quarry and production industry by 70% of this precious mineral resource is wasted in the mining processing and polishing procedures.40% of marble waste is generated worldwide during quarrying operations in the form of rock fragments and 30% waste generated during processing. It is being dumped either in nearby empty pits, roads, riverbeds, pasturelands, agricultural fields or landfill leading to wide spreading environmental pollution. Marble powder contains high calcium oxide content of more than 50%. The potential use of marble dust can be an ideal choice for substituting in a cementitious binder as the reactivity efficiency increases due to the presence of lime. A total of five concrete mixes, containing 0%, 5%, 10%, 15% and 20% partial replacement of cement with marble powder are investigated in the laboratory. These mixes were tested to determine compressive strength, split tensile strength and flexural strength for 7, 28 and 56days.*

Keywords: *concrete, fine aggregate, marble powder, strength, workability*

I. Introduction

Environmentally, when industrial wastes are recycled not only the CO_2 emissions are reduced but residual products from other industries are reused and therefore less material is dumped as landfill and more natural resources are saved. Fly ash, blast furnace slag and silica fume are most widely used industrial wastes in place of cement for concrete production attributed to their reactivity nature called pozzolanic behavior. In addition to pozzolanas, other inert by-products and waste materials have been used in concrete and mortar production as inert filler for similar reasons. Among these, marble waste powder which using marble waste powder in cement and concrete production is a by-product of marble processing factory was studied by many researchers for its use in concrete and mortar production as sand replacing or cement replacing material. 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. Chemically, marbles are crystalline rocks composed predominantly of calcite, dolomite or serpentine minerals. Marble powder can be used as filler in concrete and paving materials and helps to reduce total void content in concrete. Marble powder can be used as an admixture in concrete, so that strength of the concrete can be increased. Marble dust is mixed with concrete, cement or synthetic resins to make counters, building stones, sculptures, floors and many other objects. Marble powder is not available in all the places. Despite this fact, concrete production is one of the concerns worldwide that impact the environment with major impact being global warming due to CO_2 emission during production of cement. In addition to this, due to fineness of the marble powder, it will easily mix with aggregates so that perfect bonding is possible. Marble powder will fill the voids present in concrete and will give sufficient compressive strength when compared with the ordinary concrete.

Fig.1 Marble powder

II. Literaturereview

Veena G. Pathan1, Md. GulfamPathan: Their investigation revealed that replacing of cement with marble waste powder up to 20% reduces the slump of concrete mixes, whereas replacement of sand by marble waste powder up to 20% enhances the slump of the concrete mixes. In concrete production replacement of 5% cement by marble waste powder gives comparable compressive and flexural strength as of marble waste free concrete specimens but increasing the replacement range beyond 5% results in strength reduction. In concrete production, replacing of sand up to 20% by marble waste powder gives similar strength as of concrete mixes with 100% sand both at early and latter ages.

III. Experimental Details

It was proposed to investigate the properties of concrete, cast with partial replacement of cement with 0%, 5%, 10%, 15% proportions of marble powder and cured in water for 7, 28and 56days. In this experimental work, physical properties of materials used in the experimental work were determined. M30 grade of reference concrete was mixed and cured in potable water.

Properties of the materials:

Cement: Ordinary Portland Cement (OPC) of 53 Grade (Deccan cement) from a single lot was used throughout the course of the investigation. It was fresh and without any lumps. The specific gravity of cement obtained is 3.12.

Fine Aggregate: The fine aggregate used is natural sand obtained from the river Godavari conforming to grading zone-II of IS: 10262-2009. The specific gravity and fineness modulus are 2.58 and 3.46 respectively.

Coarse Aggregate: Crushed granite angular aggregate of size 20mm are used and the aggregates are free from dust before used in the concrete. The specific gravity and fineness modulus are 2.70 and 8.62 respectively.

Water: This is the least expensive but most important ingredient of concrete. A good thumb rule to follow is that if water is pure enough for drinking it is suitable for mixing concrete. Locally available portable water was used for mixing and curing.

Marble powder: It is collected from marble processing industry, Kakinada, Andhra Pradesh. Specific gravity and fineness tests were conducted for marble powder and the results obtained are 2.44 and 6.0.

Details of mix proportion: Grade of concrete is M30, the design is based on IS 10262-2009 and Water/cement ratio = 0.46

Table: 1 Details of mix proportion

S. No	%of Replacement	Cement (Kg/m^3)	Marble Powder (Kg/m^3)	Fine Aggregate (Kg/m^3)	Coarse Aggregates (Kg/m^3)	Water (lit/m^3)
1.	0	400	0	644.58	1199	184
2.	5	380	20	644.58	1199	184
3.	10	360	40	644.58	1199	184
4.	15	340	60	644.58	1199	184
5.	20	320	80	644.58	1199	184

IV. Specimen Details

Cube specimens of 150 mmx150mmx150mm size for compressive strength, Cylinder specimens of size 150 mm diameter x 300 mm height and prisms of size 100mm x 100mm x 500mm were cast to study the mechanical strength properties such as compressive strength, split tensile strength and flexural strength according to Indian standards.

Casting and curing:

The moulds were tightly fitted and all the joints were sealed by plaster of Paris in order to prevent leakage of cement slurry through the joints. The inner side of the moulds was thoroughly oiled before going for concreting. The mix proportions were put in miller and thoroughly mixed. The prepared concrete was placed in the moulds and is compacted using needle& plate vibrators. The same process is adopted for all specimens. After specimens were compacted the top surface is leveled with a trowel. The operation of curing is designed to overcome the problems of loss of hydration. The prepared specimens are cured in curing tank for a period of 7, 28 and 56days.

V. Test Results And Discussions

Table: 2 Fresh properties of concrete

S.No	Mix Id.	% replacement of cement with marble powder	Slump (mm)
1.	NM	0	55
2.	MP1	5	60
3.	MP2	10	65
4.	MP3	15	70
5.	MP4	20	75

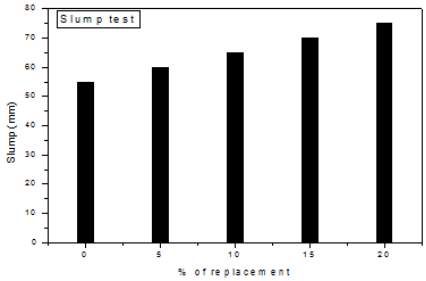

Fig.2 Slump Vs. % of replacement

From the above table and graphs we can observe that slump values gradually increased from mix 1 to mix 5. This indicates that with increase in the percentage of marble powder in concrete there is increase in the slump value.

Table:3 Hardened properties of concrete

S.No	Mix Id.	% of replacement	Compressive strength (MPa)			Split tensile strength (MPa)			Flexural strength (MPa)		
			7d	28d	56d	7d	28d	56d	7d	28d	56d
1.	NM	0.0	35.11	46.22	50.0	2.32	2.83	3.28	4.9	5	5.4
2.	MP1	5	35.55	46.50	51.40	2.26	3.0	3.328	5.0	5.33	5.6
3.	MP2	10	36.10	47.55	52.29	2.33	3.16	3.466	5.45	6	6.2
4.	MP3	15	34.66	46.30	50.10	1.96	3.11	3.18	5.2	5.4	5.42
5.	MP4	20	33.33	45.77	48.5	1.75	2.2	2.83	5.33	5.46	5.5

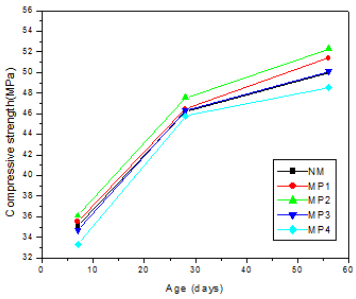

Fig: 3 Compressive strength Vs. % of replacement

The graph is drawn between the compressive strength Vs. % of replacement of marble powder at 7days, for the 5% replacement of marble powder the compressive strength increased by1.25% in the similar way, the gradual increase of replacement by 5% i.e at 10% the compressive strength is increased by 2.53%. The compressive strength decreased by 1.28% and 5.069 % by 15% and 20% replacement of marble powder respectively, at 10% replacement of marble powder maximum strength is arrived. At 28 days, initially at 5% of replacement, the compressive strength increased by 0.6%.At 10% replacement the compressive strength is maximum i.e it increased by 2.877% . At 15% and 20% of replacement, it was observed a gradual decrease of 0.17%, 0.97% respectively. At 20% of replacement the strength is least at the age of 28 days.At 56 days, initially with the 5% replacement of the marble powder the compressive strength increased by 2.8%. It is observed that the compressive strength increased by 4.58% with the gradual increase in the replacement of the marble powder.It is maximum at 10% replacement of the marble powder. The compressive strength is least at 20% replacement of the marble powder i.e decreased by 3% at 56 days.

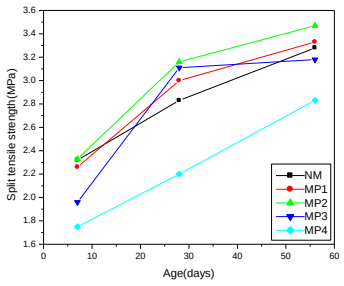

Fig. 4 Spilt tensile strength Vs. % of replacement

At 7 days, initially with replacement of the marble powder the split tensile strength decreased by 2.586%, at 10% replacement of the marble powder, we observed increased in strength but it is almost equal to normal mix, with 15% and 20% of replacement of the marble powder we can observe the decrease in the spilt tensile strength by 15.51% and 24.56% respectively. The split tensile strength is maximum at 10% of replacement. At 28 days initially with the 5% replacement of the marble powder the split tensile strength increased by 6.0% and with the gradual increase in the replacement of the marble powder, the split tensile strength also increased. The split tensile strength is maximum at 10% of replacement of the marble powder i.e 11.66%, with 15% and 20% of replacement of the marble powder, we can observe the increased in the spilt tensile strength by 9.89% and decreased by 22.26% respectively. At 56 days, it is observed that the slight increased in the split tensile strength with the replacement of the marble powder. It is maximum at 10% replacement of the marble powder i.e 5.6% increased, with 15% and 20% of replacement of the marble powder we can observe the decreased in the spilt tensile strength by 3.125% and 13.71% respectively.

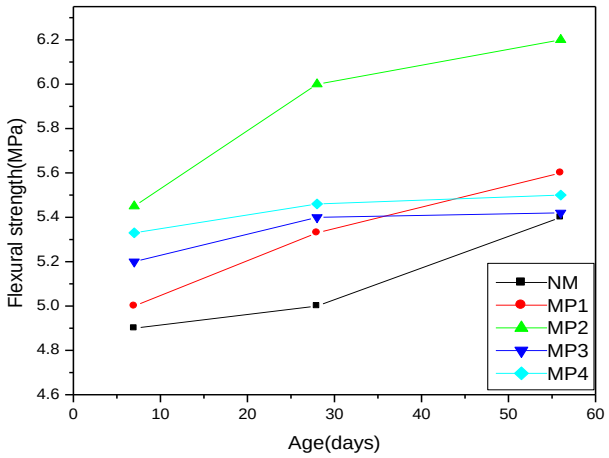

Fig. 5 Flexural strength Vs. % of relacement

At 5.0% replacement of the marble powder, it is observed that the change in the fluxural strength is very less i.e 2.04% increased, at the 10% replacement of the marble powder the strength is increased by 11.22%. In the same way with continous replacement of the marble powder the strength got increased by 6.12% and 8.77% as compared to normal mix. But these are less when compared with the strength at 10% replacement. At the 10% replacement of the marble powder the strength is maximum at 7 days of curing. At 28 days the strength got increased comparativly at 5% replacement of the marble powder by 6.6%, at 10% replacement of the marble powder, there is incresed in strength by 20% which is very high. In the same way with continous replacement of the marble powder the strength got increased by 8.0% and 9.2% as compared to normal mix. But these are less when compared with the strength at 10% replacement got optimum result at the 10% replacement of the marble powder. At 56 days of curing,with the 5% replacement of the marble powder and with out replacement of the marble powder, the change in strength is observed i.e 3.7% increase. The strength is maximum at the 10% replacement of the marble powder which is 14.8% increased. In the same way with continous replacement of the marble powder the strength got increased by 0.37 % and 1.85% as compared to normal mix.

VI. Conclusions

It can be seen from the results of this study that use of marble dust replacement of cement in the production of concrete for the construction industry should be encouraged where there comparitive cost advantage, the following conclusions can be made from this study.

- The workability increased with increase of marble powder.
- The mechanical propertis increased with increasing of curing days.
- The compressive strength increased with increase of marble powder up to 10% replacement
- It was observed that 2.81%,2.92% and 4.58% of strengtrh increased compared to normal mix with 10% replacement of marble powder at 7, 28 and 56days respectively.
- It was observed that 0.43%,11.6% and 5.6% of spilt tensile strength incresed at 10% of marble powder compared to normal mixat 7, 28 and 56days respectively.
- It was noticed that 11.22%,20% and 14.8% of flexural strength increased at 10% replacement of marble powder compared to normal mix at 7, 28 and 56days respectively.
- Considerable reduction in strength was observed at 15% and 20% replacement of marble powder.

- For compressive strength, spilt tensile strength and flexural strength 10% replacement with marble powder is found to be a best alternative for replacement as increase in percentage of strength is high compared to other variations in the mix.

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