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Sustainable Concrete Production through Use of Marble Powder as Partial Replacement of Cement in Concrete Mix

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Abstract:
Sustainability in Concrete Production can be achieved by innovating substitutions for cement and natural aggregates both coarse and fine with the increase in production of marbles it increases the waste that obtained from it. As marble powder is the waste product, obtained during the process of sawing and shaping of marble by parent marble rock, contains heavy metals which makes the water unfit for use. Marble powder creates environmental problems. Due to environmental problems, it has a great impact on human health as well as on nature. To control its effects we have to use this waste. In this paper I will review the waste marble powder obtained from the industry and investigate its effects on the concrete mix and also compare the compressive, flexure and split tensile strength, workability and durability of concrete mix. In this research feasibility of substitution of marble waste powder for cement has been investigated. Use of marble waste powder in concrete will result in economy in concrete production and environmental benefit. Fresh and hardened properties of different cement composites are investigated. Replacement levels up to 22,5% for cement and upto 45 % for fine aggregates has been tried. This paper provides a scope for more research which is required to design economical and durable concrete with this solid waste (marble powder) and find out the effect of marble powder on the properties of concrete by partial replacement of cement with marble powder in a concrete mix. The effect on concrete mix can be determined by the help workability test of concrete, compressive strength of concrete and flexural strength of concrete.

Key words: Waste Marble Powder, Cement, Concrete, Workability, Compressive Strength, Flexural Strength.

I. INTRODUCTION

Concrete is the important material in the construction other than steel and timber. Its main constituents are cement, sand, fine and coarse aggregates, and water. As there are several wastes coming from the industries we can use those wastes as the constituents of concrete by replacing or partially replacing the cement, sand or aggregates which makes it economical and also conserves the natural resources. Marbles are used in the construction purpose since the old times e.g. Monuments are mostly made up of marbles. The main purpose of marbles is to décor the building so marble industry is one of the leading industries.

The advancement of concrete technology can reduce the consumption of natural resources and energy sources and lessen the burden of pollutants on environment. Presently large amounts of marble dust are generated in natural stone processing plants with an important impact on environment and humans. This paper describes the feasibility of using the marble dust in concrete production as partial replacement of cement. In INDIA, the marble and granite stone processing is one of the most thriving industry the effects if varying marble dust contents on the physical and mechanical properties of fresh and hardened concrete have been investigated. Slump and air content of fresh concrete and absorption and compressive strength of hardened concrete were also investigated. The ingredients of Cement Concrete mix is Cement, fine aggregate and Coarse aggregate. Generally, we use sand (natural/crushed) as fine aggregate and cement as binding material in required quantity for different grades of Concrete mix to full fill the designed compressive strength. For manufacturing the cement, lot of environmental status deflecting due to originating the carbon dioxide, nitrogen oxide, sulfur dioxide, carbon monoxide gases in the environment. Therefore a lot of air pollution, soil pollution, etc. occurs during manufacturing of cement. To minimize these pollutant effects, we required the alternative of minimum consumption of Cement. In view of this, the study has been carried out by utilizing the marble powder up to the same extent at the place of cement. So that the environmental condition may not be disturbed as well as economy in construction material can achieve. 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% $CaCO_3$). Now a day, use of Marble stone in different building work & Engineering work is increasing day by day in the form of ornamental work of buildings and different construction practices. There by the waste of marble stone, i.e. pieces/chips create the waste disposal problem. Therefore, to utilize this marble stone piece/chips in the shape of powder seems to be a better alternative of cement, ecological balance as well as economy also. According to the study, marble has cementing properties like high fineness value and high oxide calcium content which imparts the cohesiveness in concrete. So by using marble powder as the constituent of concrete by partially replacing the cement and sand makes it economical and improves the environmental problem.

II. MATERIALS USED

Cement OPC (43 grade) cement is used throughout the course of project work. The properties of the cement used are shown in the Table 1 below

Aggregates
Aggregates are those chemically inert materials which when bonded by cement paste form concrete. Aggregates constitute the bulk of the total volume of concrete and hence they influence the strength of concrete to great extent.

1) Fine Aggregates:
The material which passed through I.S. Sieve No. 480 (4.75mm) is termed as fine aggregates. The source for fine aggregate used is from natural river bed. The fine aggregate used which have fineness modulus of 3.1, specific gravity of 2.6.

2) Coarse Aggregates:
The material whose particles are of such size as are retained on I.S. Sieve No. 480 (4.75mm) is used as coarse aggregates The aggregate used which have specific gravity of 2.73 and fineness modulus of 7.5.

Marble Powder
Marble dust which is used in this investigation was obtained during polishing and cutting of marble. Marble powder can be used as an admixture in concrete, so that strength of the concrete can be increased. We can reduce the environmental pollution by utilizing this marble powder

Quarry Dust
It is the residue material which is the extraction of rocks to form the fine particles less than 4.75mm through the IS sieve. Locally available quarry dust was used in the present study for replacement of fine aggregate.

CEMENT S.no.	Ingredients	Appr. proportion	Common Proportion
1	Lime(Cao)	60-67%	62%
2	Silica(SiO2)	17-25%	22%
3	Alumina(Al2O3)	3-8%	5%
4	Iron Oxide(Fe2O3)	3-4%	3%
5	Calcium Sulphate (CaSO4)	3-4%	4%
6	Magnesia(MgO)	0.1-3%	2%
7	Sulphur (S)	1-3%	1%
8	Alkalies	0.2-1%	1%

Table. 2. Characteristics properties of cement

S.no.	Test of cement	IS Requirements
1	Consistency of cement	---
2	Initial setting Time	Minimum 30 minutes As per IS 4031-1968
3	Final setting Time	maximum 600 minutes As per IS 4031-1968
4	Fineness	Max. 10% As per IS 269-1976
5	Soundness	Upto 10.00 mm As per IS :8112-1989

III. EXPERIMENTALINVESTIGATION

Blending Procedure:
Cube dimensions are 15cm×15cm×15cm. Cement, sand and aggregates are mixed in the ratio of 1:1.5:3. Water to cement ratio taken is 0.46. Fine and solid aggregates are taken in ratio of 1:2. Sand, cement, aggregate, water and marble powder was mixed in the amount as given below in Table 2. The blended concrete with different composition is allowed to set in moulds for one day. On the next day concrete blocks are taken out from the moulds. For initial setting blocks are allowed to remain in water for the duration of 7 days. For final setting blocks are allowed to remain in water for the duration of 28 days. A hydraulic cement produced by inter-grinding Portland cement clinker with other materials, or by blending Portland cement with other materials, or by a combination of inter-grinding and blending. The experimental investigation consisted of making M30 concrete with various proportions of marble powder as a replacement to cement. With the optimum results quarry dust is added to the mix as partial replacement for fine aggregate and polypropylene fiber is added as 0.5%,1%,and 1.5% and determining the Compressive strength of concrete.M30 mix was designed as per IS 10262:2009 and its mix ratio was found to be 1: 2.02:3.6:0.40

(i) COMPRESSIVE STRENGTH TEST:

The compressive strength of concrete for cubes, all mixes at 7 and 28 days of curing. Three cubes were casted for various percentage replacements of cement by MP. The result shows that the Compressive The required materials were weighed and mixing of concrete was carried out manually. Cube specimens of size 150 mm x150 mm x 150 mm is casted. The specimens are de moulded after 24 hours of casting and the specimens are cured in tank for 7 and 28 days. Cylinder specimens of size 150mm x 300 mm is also casted and cured in tank for 28 days. Strength increased with addition of waste marble powder up to 12% replace by weight of cement and further addition of marble powder, the compressive strength decreases. With the 12% replacement of cement with marble powder, different percentages (10%, 20%,30%) of quarry dust was replaced for fine aggregate. There is increase in compressive strength at 12% replacement of marble powder for cement with 30% replacement of quarry dust for fine aggregate. Polypropylene fiber was added as 0.5%,1%,1.5%.The compressive strength is increased at 0.5% of polypropylene fiber.

(ii) FLEXURAL STRENGTH TEST

Flexural strength of concrete beam is tested by two point loading machine. Standard concrete specimens of size 100mm×100 mm×500mm or 150mm ×150mm×700mm are tested over a span of 400mm and 600mm respectively on two point loading machine . The flexural strength of concrete beam is checked at the 7days, 14 days and 28 day curing period. The concrete specimens stored in water, should be tested immediately after they removed from the water and any surface water on concrete beams should be wiped out with the help of a cloth. After that the specimens must be placed accurately on two point loading machine to the determination of the Flexural strength of Concrete. The development of the relative strength of the blended cements in relation to the curing ages is observed to be different. Hence, it can be said that blended cement can achieve adequate early compressive strength**7**. Result shows that blended cement exhibits excellent compressive strength characteristics. Though blended cement has a high long-term strength for 7 and 28days curing period. It is well-known that for a given replacement level with mineral admixtures, properties of high-strength concrete are influenced by the reactivity of the mineral admixtures. From Fig. 2, we can see that the combination of marble dust and other ingredients has a modulus/compressive strength higher than alone for 7 and 28 days curing respectively. Therefore, the hydration rate of cementations materials in admixture is faster than that in alone, which will give rise to higher strength. It can also be seen from the SEM images that there are numerous un-hydrated marble dust particles in blended cement at the 7 and 24 days curing respectively (Fig. 1). The poor compressive strength of ordinary cement is due to the presence of large pores and free few minerals in the concrete (see Fig. 3). The use of high proportions of marble dust increases the strength of the cement paste. The blended cement seems to be the real challenge for the future of cement technology

IV. CONCLUSION-

According to past studies, it concludes that marble powder can be used as partial replacement of cement in a concrete mix. In a required quantity marble powder enhances the properties of concrete mix. It is a byproduct of the marble processing company and easily available in cheap rate as compare to cement. It may prove Eco friendly by controlling the production of cement which makes a cause of an unhealthy environment. This solid material is capable of improving the physical and chemical properties of concrete mix. The result of this present investigation indicates that the replacement of 12% of cement with waste marble powder attains maximum compressive and tensile strength. The optimum percentage for replacement of marble powder with cement and it is almost 12%cement for both cubes and cylinders and it also minimize the costs for construction with usage of marble powder which is freely or cheaply available more importantly. The Compressive strength of Cubes is increased with the addition of marble powder up to 12% replace by weight of cement. Optimum percentage replacement of cement with Marble powder and fine aggregate with quarry dust is12% and 30%.The compressive strength is increased about 8.5% and split tensile strength is increased about 8.57% when compared to conventional concrete. There is a decrease in workability as the replacement level increases, and hence the superplastizer is used. The compressive strength of concrete increased about 13.87% and split tensile strength is increased about 15.08% with the further addition of 0.5% polypropylene fibre by weight of cement to the concrete.

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