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Periodic Research

The Significance of Partial Replacement of Cement With Waste Marble Powder

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Abstract

In this thesis the effect of using marble powder as constituents of fines in mortar or concrete by partially reducing quantities of cement has been studied in terms of the relative compressive, tensile as well as flexural strengths. Partial replacement of cement by varying percentage of marble powder reveals that increased waste marble powder (WMP) ratio result in increased strengths of the mortar and concrete .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 [1], 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. 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 40% of the final product from stone industry. This is relevant because the stone industry presents an annual output of 68 million tones of processed products. Therefore the scientific and industrial community must commit towards more sustainable practices[2]. There are several reuse and recycling solutions f or 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: Marble Powder, Building material ,.Fineness, Concrete

Introduction

Marble as a building material especially in palaces and monuments has been in use for ages. The marble has been commonly used as a building material since ancient times. Marble is a metamorphic rock resulting from the transformation of a pure limestone. Marble is a metamorphic rock produced from limestone by pressure and heat in the earth crust due to geological process .Chemically, marble are crystalline rocks composed predominantly of calcite, dolomite or serpentine materials. The other mineral constituents vary from origin to origin. Physically, marble are re-crystallized hard, compact, fine to very fine grained metamorphosed rocks capable of taking shining polish. Marble dust is an industrial waste produced from cutting of marble stone. Marble is used for construction and decoration; marble is durable, has a noble appearance, and is consequently in great demand. 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 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. Leaving these waste materials to the environment directly can cause environmental problem. The disposal of these materials constitutes an environmental problem because more of these materials are being generated yearly. This put pressure on the limited number of landfill and suggests more sustainable use of such in construction development and in production of new products like concrete. . A major component of concrete is cement, which similarly exerts environmental and social effects. The cement industry is one of the three primary producers of carbon dioxides, a major greenhouse gas 5-10%. The other two are the energy production and transportation industries. The use of marble dust as filler material in cement reduces the amount of natural resources required. This displaces some cement production, an energetically expensive and

environmentally problematic process, while reducing both the need for land area for extracting resources and amount of industrial waste that must bedisposed of. 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.

The advancement of concrete technology can reduce the consumption of natural resources and energy sources which in turn further lessen the burden of pollutants on the environment. Presently, large amount of marble dust are generated in natural stone processing plants with an important impact on the environment and humans. In India, marble dust is settled by sedimentation and then dumped away which results n environmental pollution, in addition to forming dust in summer and threatening both agriculture and public health. Thus the utilization of the marble dust in various industrial sectors especially the construction, agriculture, glass and paper industries would help to protect the environment. 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.Test results show that this industrial bi product is capable of improving hardened concrete performance up to 10%, Enhancing fresh concrete behaviour. 30 cubes, 15 Beam and 15 cylinders have been casted. The compressive strength, Flexural strength and tensile strength of cubes and cylinders was measured for 7 and 28 days. There are several reuse and recycling solutions for this industrial by-product, both at an experimental phase and in practical applications. On the other hand, recycling waste without properly based scientific research and development can result in environmental problems greater than the waste itself. One of the logical means for reduction of the waste marble masses calls for utilizing them in building industry itself. Some attempts have been made to find and assess the possibilities of using waste marble powder in mortars and concretes and results about strength and workability were compared with control samples of conventional cements and mortar/concrete . 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 CO2 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. India is among the top world exporters of marble stone. The Indian marble industry has been growing steadily at an annual rate of around 10% per year. Cutting of stones produces heat, slurry, rock fragments and dust. 20 to 30% of marble blocks are converted in to powder. 3,172 thousand tons of marble dust was produced in year 2009-10. Waste Marble dust (WMD) can be used to improve the mechanical and physical properties of the conventional concrete. The possibility of utilizing WMD as an alternative very fine aggregate in the production of concrete will also induce a relief on waste disposal issues. Now-a-days the cost of material is increasing so if we use the waste material in the production of the concrete so we decrease the price. In India, million tons of wastes from marble industries are being released from marble cutting, polishing, processing and grinding. If the waste is disposed on soils, the porosity and permeability of topsoil will be reduced, the fine marble dust reduces the fertility of the soil by increasing its alkalinity. When the waste is dumped and dried out, the fine marble dust suspends in the air and slowly spread out through wind to the nearby area. When dumped along a catchment area of natural rainwater, it results in contamination of over ground water reservoir and also cause drainage problem. Exposing the waste material to the environment directly can cause environmental problems. Therefore, many countries have still been working on how to re-use the waste materials.

The other benefits to cement industry include lower cost of cement production and lower green house gas emission per tonne of cement production. This may also enable cement industries to take benefits of carbon trading. The present scenario should deal with utilization of industrial wastes such as fly ash (from thermal power plants), marble sludge (from marble industry), blast furnace slag and steel slag (from iron & steel industries), phosphor gypsum (from fertilizer plants), red mud (from aluminum industries), lime sludge's (from sugar, paper, calcium carbide industries), lead-zinc slag (from zinc industries) and kimberlitic (from mining) for manufacture of cement and related building materials. From the results it is observed that all of the major components of ordinary Portland cement clinkers are present in the produced clinkers. Waste can be used to produce nee products or can be used as admixtures so that natural sources are used more efficiently and the environment is protected from waste deposits. The ordinary stone dust obtained from crushers does not comply with IS: 383-1979. The presence of flaky, badly graded and rough textured particles result in hash concrete for given design parameters. Use of marble dust as a fine aggregate in concrete draws serious attention of researchers and investigators. Marble powder has a very high Blaine fineness value of about 1.5 m^2/g with 90% of particles passing 50 µm sieves and 50% under 7 µm. The maximum compressive and flexural strengths were observed for specimens containing 6% waste sludge when compared with control and it was also found that waste sludge up to 9% could effectively be used as an additive material in cement. To avoid the pollution and reuse the waste material, the present study has been carried out. As the Properties of marble powder are as good as the sand, the marble sludge powder and quarry dust has been used as fine aggregate in the cement concrete.

Now strength and durability properties of concrete play an important role in concrete structures. In the past, only strength of concrete was considered in the concrete mix design procedure assuming strength of concrete is an all pervading factor for all other desirable properties of concrete including durability. Although compressive strength is a measure of durability to a great extent it is not true that the strong concrete is always durable concrete. It is now recognized that the strength of concrete alone is not sufficient, the degree of harshness of the environmental condition to which concrete is exposed over its entire life is equally important. Therefore, both strength and durability have to be considered explicitly at the design stage.

Fig: Marble Powder

Effects of Marble Dust as Partial Replacement of Cement in Concrete

The advancement of concrete technology can reduce the consumption of natural resources and energy sources and lessen the burden of pollutants on the environment. The cost of natural resources is also increased. They have forced to focus on recovery, reuse of natural resources and find other alternatives. Presently large amounts of Stone waste are generated in natural stone processing plants with an important impact on environment and humans. The use of the replacement materials offer cost reduction, energy savings, arguably superior products, and fewer hazards in the environment. Stone blocks are cut into smaller blocks in order to give them the desired shape and size. During the process of cutting, in that original Stone mass is lost by 25% in the form of dust. Every year 250-400 tons of Stone wastes are generated on site. The Stone cutting plants are dumping the powder in any nearby pit or vacant spaces, near their unit although notified areas have been marked for dumping. This leads to serious environmental and dust pollution and occupation of a vast area of land, especially after the powder dries up so it is necessary to dispose the Stone waste quickly and use in the construction industry. 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 This project describes the feasibility of using the marble sludge dust in concrete production as partial replacement of cement The compressive strength of concrete was measured f or 7 and 28 days. In order to evaluate the effects of marble dust on mechanical behavior, many different mortar mixes were tested.

Research Significance

The main purpose of this research is to investigate the possibility of utilizing waste marble dust generated during cutting and polishing process in marble factories in order to reuse it in cement and concrete production. Physical and mechanical properties of paste, hardened mortar and hardened concrete made of marble dust modified cement were investigated. The effect of marble dust addition on the internal microstructure and hydration products of paste samples were also investigated. Testing specimens were prepared by blending marble dust with cement and sand in 0.0%, 5.0%, 7.5%, 12.5%, 17.5 and 22.5% replacement ratios by weight.

There are two types of natural stone processing waste: solid and semi-liquid or slurry. In fact during the marble cutting process by gang saws, water is used as a coolant and the powder flows along with it as waste marble slurry. Depending on the kind of process involved, the sludge generated is equal to between 20-30% of the weighof the stone worked. Deposition in landfill is the most current destiny for these residues. Marble dust has various industrial uses, in fact thanks to the high percentage of fines and the low percentage of metallic oxides, the ultra-fine calcareous particles could well be recovered and marketed for a number of industrial applications that employ micronized calcium carbonate. It is also used as filler in concrete and paving materials. The recycled sludge can be also used as whitewash, in paint, as filler for electric insulators or industrial filters. It can be safely estimated that 1 ton of marble stone processed in gang-saw or a vertical/horizontal cutter produces almost 1 ton of slurry (70% water). In addition to loss, disposal of this waste material will cause the following environmental problems:

1. If the waste is disposed on soils, the porosity and permeability of topsoil will be reduced, the fine marble dust reduces the fertility of the soil by increasing its alkalinity.
2. When the waste is dumped and dried out, the fine marble dust suspends in the air and slowly spread out through wind to the nearby area.
3. When dumped along a catchment area of natural rainwater, it results in contamination of over ground water reservoir and also cause drainage problem.

Therefore, this is to study the use of marble waste powder in construction industry to address environmental problem due to the waste and to seek alternative cement and sand based material and for efficient use of natural resources.

Methodology

In order to achieve the objectives of the research and for the development of concepts, which are fundamental for the formation of the whole research work, a comprehensive literature review is made to understand the previous efforts which include the review of text books, periodicals and academic journals, seminars and research papers. The method

followed to achieve the objectives of the research determines the required data, which intern is a ground to decide on type and method of data collection and their analysis. Different alternative data collection methods such as experiments, observations and archival records are examined and used when proved suitable. Both primary data (collected personally) from the source itself and secondary data from different sources is collected and used for the analysis.

The test results were presented in tabular and graphical forms and the analysis and discussions were also made on the research findings both qualitatively and quantitatively. Finally based on the findings, conclusions and recommendations were forwarded

Marble Based Concrete

The use of marble powder for making concrete leads to the following beneficial aspects.

1. Better microstructure and homogeneity.
2. Higher content of ultra fine material.
3. Increased dispersion of cement and filler.
4. Lower water sorptivity and oxygen permeability.
5. Higher resistance against chloride penetration than conventional concrete.
6. Higher internal frost resistance.

Consistency Test

Normal consistency tests, for the blended cements, were conducted, by Vicat apparatus, to observe the changes in water requirement of pastes due to the marble waste powder filler.

Mix Design

The design of concrete mixes involves determination of the proportions of the given constituents namely cement , water, coarse aggregate and fine aggregates and admixtures , if any, which would produce concrete possessing specified properties both in the fresh and hardened states with the maximum overall economy. Workability is specified as the important property of concrete in fresh state; for hardened state compressive strength and durability are important. The mix design is therefore, generally carried out for a particular compressive strength of concrete with adequate workability so that fresh concrete can be properly placed and compacted, and achieves the required durability.

Volumes

Volume of cube = 15 x 15 x 15 =3375cm3
Volume of cylinder = $\pi \times 7.5^2 \times 30$ =5301.44 cm3
Volume of Beam Mould=15 x15 x70=15750 cm3
Total volume = 24426.44
Add 10% extra volume = 26869.084 cm3
Volume of concrete = (1 / 2.52) + (1.53 / 2.71) + (2.75 / 2.85) + (0.43 / 1) = 2.31
Weight of cement = (1 / V) x volume = (1 / 2.31) x 26869.084) = 11.63kg
Weight of f ine aggregate = 1.53 x 11631.63 = 17.79 kg
Weight of coarse aggregate = 2.75 x 11631.63 = 31.98 kg
Required amount of water = 0.43 x 11631.64 = 5001.60 litre= 5.001kg

For Three Specimen

Weight of cement = 34.89 kg
Weight of Fine aggregate = 53.37 kg
Weight of coarse aggregate = 95.94 kg
Requiredwater=15kg

Mix designation	Percentageof WMP	Water (kg)	Cement (kg)	Coarse Aggregates(kg)	Fine aggregate(kg)	Marble Powder(kg)
MX0	0	15	34.89	95.94	53.37	0
MX1	5	15	33.146	95.94	53.37	1.744
MX2	7.5	15	32.274	95.94	53.37	2.616
MX3	12.5	15	30.529	95.94	53.37	4.361
MX4	17.5	15	28.785	95.94	53.37	6.105
MX5	22.5	15	27.04	95.94	53.37	7.850

Table :Marble Dust Based Concrete Mix
Mix proportion
The comparison of various mixes containing WMP in different percentages
Compressive Strength after 7 Days(P/225*10)

Mix Designation	Percentage of marble	Load (kN)	Compressive Strength(N/mm^2)	Average Compressive strength(N/mm^2)
MX0	0	580 620 610	25.77 27.55 27.11	26.81
MX1	5	650 590 665	28.88 26.22 29.55	28.21
MX2	7.5	670 655 690	29.77 29.11 30.66	29.84
MX3	12.5	680 700 660	30.22 31.11 29.33	30.22
MX4	17.5	580	25.77	

		600 550	26.66 24.44	25.62
MX5	22.5	570 545 530	25.33 24.22 23.55	24.36

Compressive Strength after 28 Days

Mix Designation	Percentage of Marble	Load (kN)	Compressive Strength(N/mm^2)	Average Compressive strength(N/mm^2)
MX0	0	820 850 810	36.44 37.77 36.00	36.73
MX1	5	880 900 860	39.11 40.00 38.22	39.11
MX2	7.5	950 890 920	42.22 39.55 40.88	40.88
MX3	12.5	900 930 950	40.00 41.33 42.22	41.18
MX4	17.5	820 760 800	36.44 33.77 35.55	35.25
MX5	22.5	730 790 755	32.44 35.11 33.55	33.70

The present investigation was undertaken to study the effect of WMP on strength characteristic strength of concrete. To achieve the objectives of the present study, the cement were replaced 5%, 7.5%, 12.5%, 17.5% and 22.5% respectively. The compressive strength, tensile strength and the flexural strength test were determined for the mixes at the curing age of 7 days and 28 days. Due to its quite high fineness, marble powder proved to be very effective in assuring very good cohesiveness of mortar and concrete. The results obtained for the above mixes were compared to investigate the effects of partial replacement of sand by WMP on the above strength parameters of concrete. The conclusion drawn from this study is presented in this chapter.

Conclusions

Based on the experimental results obtained from this study, the following conclusions can be drawn:

1. A 10% WMD can be used as an additive material in production of cement.
2. Use of WMD in production of WMDCs does not affect the setting time.
3. The ratio of WMD in the cements increases the values of specific gravity and specific surface decrease.
4. There is a linear relationship between WMD and quantities of cement retained on sieve.
5. it proved to be very effective in assuring very good cohesiveness of mortar and Concrete.
6. The compressive strength of WMD MX4 is higher than those of OPC.
7. The study indicates that the marble waste can be incorporated in Portland limestone production.
8. Cost of cement production can be decreased by use of 10% WMD.
9. The Compressive strength of Cubes are increased with addition of waste marble Powder up to 12.5 % replace by weight of cement and further any addition of wasteMarble powder the compressive strength decreases.The Tensile strength of Cylinders are increased with addition of waste marblepowder up to 12.5 % replace by weight of cement and further any addition of waste marble powder the Tensile strength decreases.Thus we found out the optimum percentage for replacement of marble powder with cement and it is almost 12.5 % cement for both cubes and cylinders.
10. We have put a simple step to minimize the costs for construction with usage of
11. Marble powder which is freely or cheaply available more importantly.
12. We have also stepped into a realm of s the environmental pollution by cement production being our main objective as Civil Engineers.

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