DURABILITY CHARACTERISTICS OF CONCRETE MADE WITH MARBLE POWDER AS PARTIAL REPLACEMENT OF CEMENT

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Abstract

This paper presents an experimental investigation on the durability characteristic of concrete made with marble powder as partial replacement of cement by various percentages like 0%, 5%, 10%, 15%, and 20% on the properties of M25-grade of concrete, when it is subjected to various weathering agencies. Concrete specimens of size 150 x 150 x 150 mm were casted and cured as per IS specification to find the durability of concrete. In order to find the durability characteristics of concrete we performed many tests, like water absorption test, water permeability test, hydrochloric acid attack (HCl), sulphate attack (MgSo4) and chloride attack (NaCl). For the acid attack tests the concrete specimens were kept immersed in 5% concentrated acid solution of, hydrochloric acid(HCl) with water, magnesium sulphate (MgSo4) with water, and sodium chloride(NaCl) with water for 90 days for observation. Before immersion of the specimens, they were weighed accurately and after required days of immersion and observation, the specimens were removed from acid solution. Then the specimens were weighed accurately and weight loss and hardness of concrete were studied. The various results which indicate the produce of replacement of cement by marble powder on concrete are presented in this paper to draw useful conclusions. The results were compared with the mix design of concrete of same grade(M-25). The test results indicate that use of replacement cement by marble powder has improved the durability of concrete at 20% of marble powder. But the test for water absorption and the water permeability of concrete also show the satisfactory results at 20 % marble powder.

Introduction

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 project describes the feasibility of using the marble sludge dust in concrete production as partial replacement of cement. Marble is one of the most important decorative materials used in buildings and monuments since ancient times. Starting from the quarry and marble industries to the utilisation places, by processing, it generate considerable amount of wastes (20-25%) and in fine powder form creates environmental problems polluting the soil, water and healthy atmosphere. As very fine in particle fraction and possessing pozzolanic characteristics by chemical composition like other waste materials such as flyash, rice husk ash, silicafume and slag, the marble powder has been recognized as a cement replacing material among the concrete researchers. In line with the reduction of the emission of carbon dioxide by avoiding the excess production and use of cement in concrete and aiming for green atmosphere, the utilisation of marble powder can promote waste management system if properly

understood and managed through proper research activities.

1. **Experimental Programme**. The main aim of this experimentation is to study the effect of partial replacement of cement by marble waste on the properties of concrete, when it is subjected to various weathering agencies such as chloride attacks, acid attacks etc.

2. Material Used

Cement:

Ordinary Portland cement of Ambuja Cement conforming to IS 269-1976 and IS 40311968 was adopted in this work. The cement used is of 53 grade.

Fine Aggregate:

Natural sand which is easily available and low in price was used in the work. It has cubical or rounded shape with smooth surface texture. Being cubical, rounded and smooth texture it give good workability. Sand which is used here is taken from stone crushing plant. Particles of this sand have smooth texture and are brownish colour. Sieve analysis was done to find out fineness modulus which comes out to be 3.29% which is under limit as per IS 383-1970.

Coarse Aggregates.

The aggregate used in this project mainly of basalt rock which comes under normal weight category. The aggregates are locally available. 50% of the aggregate used are of 10-12 mm size and remaining 50% are of 20mm size. The coarse aggregate was also tested for various properties like impact value test, crushing value test, elongation and flakiness index test to check their suitability for the experiment.

Marble powder.

Marble powder was collected from the dressing and processing unit in udaipur. It was initially in wet form (i.e. slurry); after that it is dried by exposing in the sun and finally sieved by IS-90 micron sieve before mixing in concrete.

3. Experimental Procedure.

In order to obtain the durability of concrete made with partial replacement of cement with marble powder the following tests have been conducted and test results were discussed.

1. Water absorption test
2. Water permeability test
3. Acid resistance tests
   Hydrochloric acid attack (HCl)
   Sulphate attack (MgSo4) Chloride attack (NaCl)

1.Water absorption test.

Water absorption (WA) test was carried out as per ASTM C 642-81 after 28 days of curing. The specimens were taken out from curing tank and dried in an oven at a temperature of 105°C for 24 hours, then cooled to ambient temperature and weighed accurately (dry weight). Dried specimens were then immersed in water. Weights of specimens at predetermined intervals of 12 hours were taken after wiping the surface with a dry cloth. This process was continued for at least 48 hours till a constant weight was obtained in two consecutive observations. Percentage of water absorption was determined.

Water Absorption test on concrete has also been carried out on 150 mm size cube specimens at the age of 28 days curing. The specimens were dried in oven, weighed and kept in the water for 60 days.

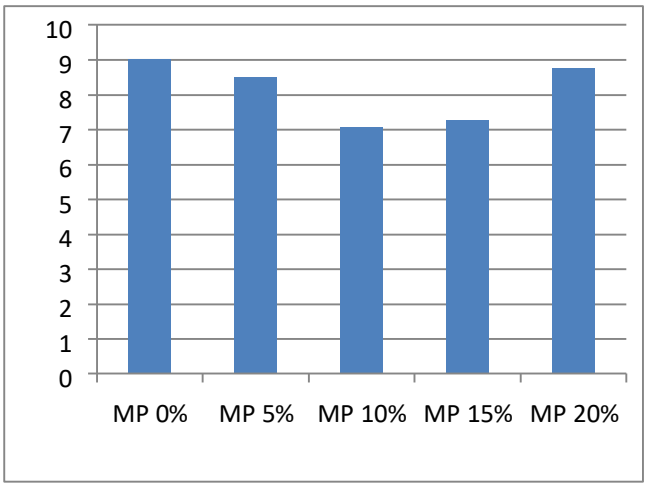
Graph-1. shows the water absorption of concrete with different percentage of marble powder.

Graph-1. shows the water absorption in concrete.

2.Water permeability test.

The water penetration test was conducted as per IS: 3085-1965. Concrete cubes after 28 days of curing were kept in the cube compartment of the test set up. Sides of cubes were sealed using a mixture of wax and rosin to achieve water tightness. Water at a constant pressure of 0.5MPa was maintained throughout the study period of 3 days. Quantity of water percolating over the entire period of test after the steady state was noted. The depth of penetration for OPC concrete and MP concrete were determined The results were compared for OPC concrete and MP concrete in Graph 2 . It is evident that there is considerable reduction in the permeability with the decrease of water binder ratio from 0.55 to 0.45. Lowest value of permeability was observed in case of MP concrete and 10% replacement of MP concrete of Mix M25.Marble Powder increases the cementitious compounds, minimizes water demand and reduced bleed channels, all of which increase concrete density. By the action of MP , a reduction of bleed channels, capillary channels and void spaces occurs. The small particles of MP will fill in the tiniest voids and increase the density of the concrete.

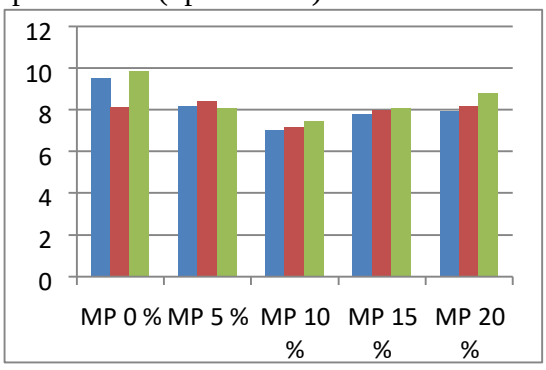
Graph-2 , Shows the permeability results of different samples.



4. Hydrochloric Acid Attack (HCL)

To conduct this test, 5% by volume of hydrochloric acid was mixed with ordinary potable water. The specimens were cured for 28 days in ordinary potable water and then immersed in the solution for a period of 60 days. The percentage of weight loss is found out after 60 days.For this test I have casted 15 cubes , 3 cubes for 0% of MP , 3 cubes for 5% of MP, 3 cubes for 10% of MP, 3 cubes for 15% of MP and 3 cubes for 20% of MP.

The weight loss is less when compared to conventional concrete in case of acid resistance test. It is decreased upto 10% replacement level and increased then upto 20%. However, the weight loss is always less when compared to conventional concrete. The weight loss is least for 10% replacement level. The strength loss is reduced for all levels of replacement (up to 20%).

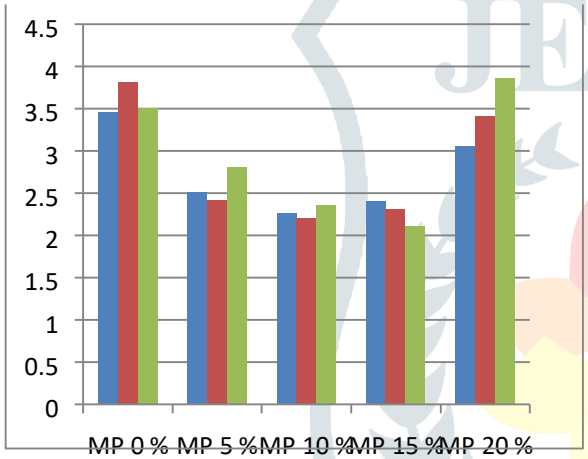


Graph -3 shows the weight loss of cubes with different percentage of marble powder(MP).

5. Magnesium Sulphate test(MgSO4)

A solution of magnesium sulphate (MgSO4) was prepared in which 5% by weight of magnesium sulphate was mixed with water.

The cubes which were cured for 28 days were then immersed in this solution. The cubes were taken from the solution after 60 days of exposure to the solution and were surface dried. The surfaces of cubes were cleaned, scrubbed and final surface dry weights were found. . The percentage of weight loss is found out after 60 days.For this test I have casted 15 cubes , 3 cubes for 0% of MP , 3 cubes for 5% of MP, 3 cubes for 10% of MP, 3 cubes for 15% of MP and 3 cubes for 20% of MP.



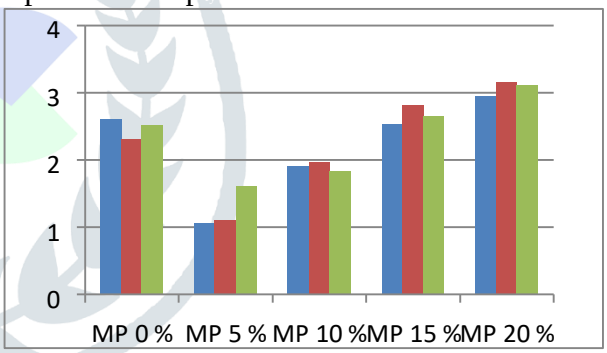
Graph-4 Shows the weight loss of cubes with different percentage of MP.

The weight loss is reduced up to 10% replacement and increased afterwards in case of sulphate resistance test. The weight loss is least for 10% replacement level and is 15% less when compared to conventional concrete. The strength loss is reduced upto 15% replacement level and thereafter increased. The least weight loss is observed for 15% replacement level as 23.5% less compared to conventional concrete.

6. Chloride Attack Test

A solution of sodium chloride (NaCl) was prepared in which 5% by weight of sodium chloride was mixed with ordinary potable water. The cubes which were cured for 28 days were then immersed in this solution. The cubes were then taken out from this solution after 60 days and were surface dried. The surface of cubes was cleaned, scrubbed and then final surface dry weights of the specimen were found.

The resistance of cement based materials to chemical attack is mainly due to permeability and alkalinity of concrete mass. The MP concrete used in the test shows very high resistance to the penetration of chloride ions in the tests performed according to ASTM C 1202 and higher resistance than conventional concrete. The weight loss is not significant when compared to conventional concrete in case of chloride resistance test. It is increased for 15% and 20% replacements and decreased for others. The weight loss is least for 5% replacement level and is 8.4% less when compared to conventional concrete. The strength loss is reduced for all levels of replacement up to 20%.



Graph-5, Shows the results of chloride attack's test.

4. Results & Conclusions

The following results & conclusions were drawn from the study and observations:

Water absorption is higher when compared with conventional concrete. It is not so encouraging for 5% replacement and it decreases up to 10% and increases further up to 20% replacement. The increase in water absorption for conventional to the 10% replacement of 28 days of cured specimen is 1.15%. The result of water absorption is not encouraging. It changes abruptly ,

sometimes it goes up and sometimes with small percentage of MP it goes down.

The weight loss is less when compared to conventional concrete in case of acid resistance test. It is decreased upto 10% replacement level and increased then upto 20%. However, the weight loss is always less when compared to conventional concrete. The weight loss is least for 10% replacement level. The strength loss is reduced for all levels of replacement (up to 20%) .

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The optimum level of replacement of cement with marble powder is 15% based on the strength requirements and is 10% based on the durability requirements. However further study is required for higher grades of concrete and compatibility with reinforcing material.

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References

1.IS:1199–1959 Methods of sampling and analysis of concrete.

2.IS:5513 –1996 Specification for vicat apparatus (second revision).

3.IS: 5514 – 1996 Specification for apparatus used in Le chatelier test (first revision).

4.IS: 5515 – 1983 Specification for compaction factor apparatus (first revision).

5.IS: 5816 – 1999 Method of test for splitting tensile strength of concrete cylinders.

6.IS:7320–1974(reaffirmed1999) Specification for concrete slump test apparatus.

7.IS: 9399 – 1979 Specification for apparatus for flexural testing of concrete

8.IS 4926-2003, Standard on Ready mixed concrete Code of Practice, BIS, New Delhi.

9.IS 383:1970, Indian Standard specification for coarse and fine aggregates from natural sources for concrete (Second Revision) 10.IS: 1130 1969(reaffirmed 2003) Specification for marble (blocks, slabs and tiles)

11.IS: 455 -1989 (reaffirmed 1995) Portland slag cement specification (fourth revision)

12.IS: 10082-1982(reaffirmed 1999) Specification for moulds for use in tests of cement and concrete (Second Reprint dec 1995).

List of Reference text books:

[1] “Design of Concrete Mixes”,by N.Krishna Raju,CBS Publishers & Distributors,Delhi, 1993.

[2] "Concrete Technology- theory and practice", by M S Shetty, S. Chand Company Ltd,

Delhi, First multicolour illustrative revised edition, reprint 2015.

[3]. "Concrete Technology"by A R Santhakumar, Oxford university press, Delhi, first published 2007.

Website

[1]https://en.wikipedia.org/wiki/Marble

[2]http://www.tunisianindustry.nat.tn/en/

[4]https://nptel.ac.in/course

[5]https://www.nbmcw.com/tech-articles