Experimental Study of Strength Properties of Concrte by Partial Replacement of Cement by Marble Powder

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Abstract- ***Each*** **year tons of waste materials are disposed on the valuable land which results and degradation of valuable land. Manufactured sand is an alternative for river sand. Another reason for the use of M-sand is its availability and transportation cost. Manufactured sand is produced from hard granite stone by crushing. The size of manufactured sand is less than 4.75mm. Marble is industrially processed by being cut, polished and used for decorative purposes. During the cutting process, 20-30% of a marble block becomes waste marble powder. In this project Marble powder had been used as replacement of cement by different percentage for making concrete. The percentage replacement of concrete will be 0%, 10%, 20% and 30%. For making concrete OPC-53 grade cement is used. Cubes, beams and cylinders will be casted and tested compressive strength, split tensile strength and flexural strength.**
Keywords: Waste, Partial replacement, Marble Powder, Coarse Aggregate, Cement.

I. INTRODUCTION

Concrete as a construction material has gained its popularity in past three decades. Hence, the ingredients for making concrete have reached the demand of hour. As the demand rises, the cost of each material reaches higher prices. Hence in this project a solution to make an economic concrete was obtained with a sustainable strength enhancing of concrete. As a solution to this prevailing condition, the cement have been replaced with the marble powder. Cement is one of the most produced materials around the world. Due to the importance of cement as a construction material, and the geographic abundance of the main raw material, limestone, cement is produced in virtually all countries. The widespread production is also due to the relatively low price and high density of cement. However, the production of Portland cement, an essential constituent of concrete, leads to the release of a significant amount of CO2 and other greenhouse gases (GHGs). The cement is partially replaced with marble powder at 0%, 10%, 20% and 30%.

II. LITERATURE REVIEW

Marble powder used as partial substitute for Portland cement on the mechanical properties and durability of high-performance concretes. On the basis of the experiments performed, it can be concluded that the marble powder is suitable for formulation of high-performance concretes (HPC) and their properties are significantly better compared to the reference concrete (RC).

The materials used in this project were Cement, Fine aggregate (River sand), Waste marble powder, Coarse aggregate, High range water reducer. The tests carried out in this project were compressive strength, resistance to chloride ion penetration, oxygenpermeability.

The prepared specimens were stored for one year in an environment containing 5% calcium chloride (media 1) and drinking water (media 2). In order to investigate the marble powder on the performance properties of concrete, two different concrete mixes were employed. The control mix contained only Portland cement as the binder. In the high-performance concrete with marble powder, Portland cement was partially replaced with 15% marble powder (by weight) obtained by optimization. All concretes were mixed in accordance with ASTM C192 standard in a power- driven revolving pan mixer. To ensure a concentration of chlorides constant throughout the tests, the solution in the tank was regularly checked once a week and changed if the difference between the concentration of the solution and the initial concentration exceeded 5Marble powder could be used as partial replacement of Portland cement up to 15% in composite cement. Additionally, to this, an improvement in durability characteristics is observed; without decreasing the compressive strength of the concrete. The durability test on the concrete containing marble powder consisted of immersion in running water, chloride solution, in all cases, structural changes to the samples were noted. In all cases the addition had improved the physical characteristics of concrete relatively to the reference concrete sample. The results show the positive influence of marble powder on the properties of concrete under hydrochloric mediums [1]. The seven variant concrete mixtures were made by partially replacing marble powder (up to 15%) in place of sand; cement and amalgam were evaluated for the mechanical strength, ultrasonic pulse velocity (UPV), carbonation and microstructure analysis. Marble powder exhibited no function in hydration process, moreover it acts as afiller.

The materials used in this project were Cement, Fine aggregate, Coarse aggregate, Marble powder and Super plasticizer. The test carried out in this project was Compressive strength, Split tensile test, Ultrasonic pulse velocity test and Accelerated carbonation test.

The investigation was carried for cement concrete, as partial replacement of cement, sand and combined form with marble powder at different ratios. Control concrete (without marble powder) was identified as M100. The present study includes the blended concrete with marble powder at ratios 0%, 10% and 15% by weight. For concrete mixture, cement and sand were replaced by marble powder. Substitution of sand by marble powder in ratio 0%, 10% and 15% by weight; substitution of cement and sand in combined form with marble powder in ratio 0%, 10% and 15% by weight. In control mixtures cement content is 432 kg/m^3; marble powder modified concrete; cement content depends upon substitution ratios of marble powder.

The optimal results of the study were investigated with 10% sand and 10% cement amalgam replaced by 20% marble powder. The mechanical and durability properties can be achieved using 20% marble powder. Moreover, reduction of cement decreases overheads as cement is an expensive component and replacement of cement as well as sand can lead to development of economical as well as sustainable concrete [2]. To investigate the possibility of using marble powder and limestone filler in the production of self-compacting concretes with or without fly ash. Two series of concrete mixtures containing binary and ternary blends of fine materials were designed and cast with a constant water-binder ratio of 0.35.

The materials used in this project were Cement, Fly ash, Fine aggregate, Coarse aggregate, Marble powder, Limestone filler, Superplasticizer. The tests carried out in this project are Compressive strength, Split tensile test.

Using filling materials and mineral admixtures as substituting additives in concrete has a great tendency to fulfill the expectations in providing greater sustainability in the construction industry. The issues regarding the cost, recycling the industrial wastes, rehabilitation in durability and mechanical performance of concrete will therefore put a pressure on the utilization of such materials. The current study aims at highlighting the fresh and hardened characteristics of self-compacting concretes produced with binary and ternary systems of Portland cement, marble powder, limestone filler and fly ash. For this purpose, two series of concrete mixtures were designed with respect to the inclusion of fine aggregate, whereas marble powder and limestone filler have partially replaced the total binder at the levels of 5%, 10% and 20% by weight. Fresh properties of self-compacting concretes were tested for flow and passing ability, viscosity, initial and final setting times, while compressive and split tensile strengths were measured for determination of the mechanical properties. Moreover, chloride ion penetration, water sorptivity and electrical resistivity were measured to evaluate the transport properties of self-compacting concretes produced in the study. 28- and 90-day compressive strength developments of the binary and ternary mixtures demonstrated a similar tendency. But, due to the relatively slowhydrationreactioncharacteristicsoffineaggregate,28-daycompressivestrengthsofternarymixeswerelower than that of binary mixtures. Addition of limestone filler provides greater compressive strength for the both series of the mixtures. Accordingly, it can be inferred that limestone filler affects the hydration kinetics of the cement paste as well as filling ability. Split tensile strengths of concretes showed relatively the same trend with compressive strength. The maximum split tensile strength values were achieved in concretes having 10% replacement level of limestone filler [3]. Investigation of mechanical properties carried out on the concrete specimens containing diatomite and waste marble powder as partial replacement of cement in concrete. The laboratory work essentially consists of characterization of the raw and waste materials, preparations of concrete specimens with diatomite and waste marble powder in different ratios by weight as replacement for cement and a super plasticizing admixture to reduce water demand and compression and flexure tests of thespecimens.

In this study, commercial Ordinary Portland Cement was used when preparing the concrete specimens. Four different types of limestone aggregates were used when casting each of the test specimens, namely: crushed stone III (12-22 mm), crushed stone II (6-12 mm), crushed sandstone (0-6 mm) and river sand (0-4 mm). A water reducing admixture was added to the mixtures at the ratio of 1% of binder materials by weight. It was constituted of polycarboxylates based polymer and high range water-reducing super plasticizer that was third generation super plasticizer for concrete and mortar. The diatomite samples were crushed, homogenized and mineralogical analyzed with the diffractometer. Quartz is also identified in very low concentration. The compressive strength of concretes containing cement replaced by the diatomite ranged 5% and 10% increased. It is known that microfossils in diatomite play an important role in the strength development of concrete specimens [4]. An overview of works reported regarding the use as partial replacement of sand and cement by marble powder in concrete is presented in the paper. Gaps in the studies to date have been pointed out. An environmental impact comparison of normal concrete with the use of marble powder as partial replacement of cement and sand is carried out using the UMBERTO NXT life cycle analysis software with Recipe midpoint and endpoint methods. Finally, a detailed cost analysis study has been performed to justify the use of marble powder in concrete which has exhibited encouraging results in terms of strength and quality. It has also been found that the use of marble slurry in concrete reduces its environmental impact and is economicallybeneficial.

The use of marble powder in concrete in the range of 10-15% increases the compressive strength and split tensile strength of concrete in the range of 15-20%. The use plasticizers enhance the strength due to the w/c reduction. The sand substitution with marble powder in the ratio of 35-50% shows favourable results for compressive and split tensile strengths. Durability properties like porosity, abrasion resistance, carbonation, sorptivity, sulphate resistance and water penetration have improved[5].

III. MATERIALS ANDTESTING

A.Cement

A cement is a binder, a substance used for construction that sets, hardens and adheres to other materials to bind them together. Cement mixed with fine aggregate produces mortar for masonry or with sand and gravel produces concrete. Ordinary Portland Cement is composed of calcium silicate sand, aluminate sand and alumina ferrite. It is obtained by blending predetermined proportions of limestone, clay and other materials in small quantities which is pulverized and heated at high temperature around 1500 ºC to produce clinker. The clinker is then ground with small quantities of gypsum to produce a fine powder called Ordinary Portland Cement [OPC]. When mixed with water, sand and stone it combines slowly with the water to form a hard mass called concrete. Cement is hygroscopic material meaning it absorbs moisture, in the presence of moisture it undergoes chemical reaction termed hydration. Therefore, cement remains in good condition as long as it does not come in contact with moisture. Ordinary Portland Cement confirming to IS 8112-1989 [43 grade] is used for experimental work. Laboratory test were conducted on cement to determine specific gravity, consistency, initial and final setting time andfineness. The properties of cement is shown in table 1.

TABLE 1. RESULT OF TESTING CEMENT

SL. No	Characteristics	Value
1	Fineness modulus	2.85%
2	Specific gravity	3.15
3	Standard consistency	26%
4	Initial and Final setting time	35minutes

B.Marblepowder

One of the major wastes produced in the stone industry during cutting, shaping and polishing of marbles is the MDP (Marble Dust Powder). During this process, about 20-25% of the marble is turn into powder form. India being the third (about 10%) topmost exporter of marble in the world, every year million tons of marble waste form processing plants are released. Due to the availability of large quantity of waste produced in the marble factory, this project has been planned and preceded. Marble powder is obtained by crushing and grinding of the marble chips or marble stone. It can be also obtained from marble slurry. Marble is metamorphic rock resulting from the transformation of the pure limestone. The purity of marble depends upon its colour and appearance. It is white if the limestone is composed of solely of calcite (100%$CaCO_3$). Table 2 shows the properties of marble powder.

TABLE 2.PROPERTIES OF MARBLE POWDER

SL. No	Characteristics	Value
1	Fineness modulus	2.85%
2	Specific gravity	2.5

C. Fineaggregate

Aggregate which is passing through 4.75 IS sieve is termed as fine aggregate. Fine aggregate is added to concrete to assist workability. For this project M-sand is used as fine aggregate. Fine aggregate should be free from coagulated lumps. Manufactured sand is an alternative for river sand. Due to fast growing construction industry, the demand for sand has increased tremendously, causing deficiency of suitable river sand for the use of construction, the use of manufactured has been increased. Another reason for the use of M-sand is its availability and transportation cost. Since manufactured sand can be crushed from hard granite rocks, it can be readily available at the nearby places, reducing the cost of transportation from far-off river sand bed. Thus, the cost of construction can be controlled by the due of manufactured sand as an alternative material for construction. The other advantage of using M-sand is, it can be dust free, the sizes of M-sand can be controlled easily so that it meets the required grading for the givenconstruction.Locally available good quality M-sand was used. Laboratory test were conducted on fine aggregate to determine the different physical properties as IS 383 (Part 3)-1970. Table 3shows the properties of fine aggregate.

TABLE 3.PROPERTIES OF FINE AGGREGATE

SL. No	Characteristics	Value
1	Fineness modulus	2.25%
2	Specific gravity	2.53

C. Coarseaggregate

The size of aggregate bigger than 4.75mm is considered as coarse aggregate, crushed stone obtained by crushing of granite that could pass through 20mm sieve and retained on 4.75mm IS sieve and contained only so much fine materials as it is permitted by specification along were produced. Coarse aggregate is used mainly for providing bulk to the concrete to the strength of concrete depends also on the strength of the coarse aggregate and hence selection suitable aggregate is very essential. It should be hard, strong, dense, durable, rough and free from salt and organic matters. Well graded aggregate provides denser concrete with lessvoids. Table 4 shows the properties of coarse aggregate.

TABLE 4.PROPERTIESOF COARSE AGGREGATE

SL. No	Characteristics	Value
1	Fineness modulus	2.3
2	Water absorption	2.25%
3	Impact test	9.45

D. Water

Water is an important ingredient of concrete as it actively participates in the chemical reaction with cement. The quantity and quality of water is required to be watched into carefully so that it can form the strength giving cement gel. Portable water is used for making mortar. The pH value of mortar lies between 6 and 8 that indicates the water is free from organic matters. Water is needed to chemically react with the cement (hydration) and to provide workability with the concrete. The amount of water in the mix in pound compared with the amount of cement is called water/cement ratio. The lower the w/c ratio, the stronger the concrete (higher strength, lesspermeability).

IV. EXPERIMENTALANALYSIS

A.Compressive StrengthTest

Table 5 shows the variation of compressive strength. For compressive strength test, cube specimens of dimensions 150 × 150 × 150 mm were cast for M30 grade of concrete. The moulds were filled with different proportions of cement, marble powder, fine aggregate and coarse aggregate. Compaction was given to the mix using compacting rod. The top surface of the specimen was levelled and finished. After 24 hours the specimens were demoulded and were transferred to curing tank where they are allowed to cool for 7, 14 and 28 days. After 7, 14- and 28-days curing, these cubes were tested on compression testing machine as per IS 516-1959 [14]. The failure load was noted. In each category, two cubes were tested, and their average value is reported. The compressive strength was calculated asfollows**:**

$$\text{Compressivestrength} \quad \frac{\text{Failure load}}{\text{Cross sectional area}}$$

TABLE. 5 COMPRESSIVE STRENGTH TEST RESULT

SL. No	Percentage of replacement of marble powder	7 days	14 days	28 days
1	0%	26.6+65	27	30.85
2	10%	18.44	19.109	21.33
3	20%	26.44	26.99	27.99
4	30%	26.507	27.219	28.88

B.Split Tensile Strength Test

Table 6 shows the variation of split tensile strength. For split tensile strength test, cylinder specimens of dimension 150 mm diameter and 300 mm height were cast. The moulds were filled with different proportions of cement, marble powder, fine aggregate and coarse aggregate. Compaction was given to the mix using compacting rod. The top surface of the specimen was levelledandfinished.After24hoursthespecimensweredemouldedandweretransferredtocuringtankwherethey are allowed to cool for 7, 14 and 28 days. After 7, 14- and 28-days curing, these cubes were tested on compression testing machine. The failure load was noted. In each category, one cylinder is tested, and value is reported.The split tensile strength was calculated as follows:

$$\text{Split tensilestrength} = \frac{2P}{\pi d L}$$

Where P = failure load
D = diameter of cylinder
L= length ofcylinder.

TABLE. 6 VARIATION OF SPLIT TENSILE STRENGTH

SL. No	Percentage of replacement of marble powder	7 days	14 days	28 days
1	0%	4.102	4.527	4.980
2	10%	3.04	3.667	3.980
3	20%	3.42	3.687	4.01
4	30%	3.414	3.848	4.405

C.Flexuralstrength:

Table 7 shows the variation of Fleural strength. For flexural strength test, beam specimens of dimension 500 mm length, 100 mm depth and 100 mm width were cast. The moulds were filled with different proportions of cement, marble powder, fine aggregate and coarse aggregate. Compaction was given to the mix using compacting rod. The top surface of the specimen was levelled and finished. After 24 hours the specimens were demoulded and were transferred to curing tank where they are allowed to cool for 7, 14 and 28 days. After 7, 14- and 28-days curing, these cubes were tested on compression testing machine. The failure load was noted. In each category, one cylinder is tested, and value is reported.The flexural strength was calculated as follows:

Flexure strength of concrete= $\frac{Pl}{bd^2}$

Where P = failure load, l = length of prism, b = width of prism, d = depth of prism.

TABLE. 7 VARIATION OF FLEXURALSTRENGTH

Sl.No	Percentage of replacement of marble powder	7 7 days	14 days	28 days
1	0%	4.12	4.34	4.58
2	10%	2.32	2.689	3.12
3	20%	3	3.564	3.980
4	30%	3.6	3.9	4.35

V. CONCLUSION

The paper presents the necessity of sustainable construction in present world and the possibility partial replacement of cement by marble powder and using it into concrete production. The study focuses about the application of marble powder to reduce the construction cost and to be ecofriendly. It may open a new path of economic and pollution free concrete construction and the desired strength can be achieved. In this experimental investigation, a study on conventional concrete with concrete by replacement of marble powder 0%, 2.5%, 5%, 7.5%, 10%, 12.5% and 15% by cement have been studied and the results were presented. Marble powder is a byproduct that can be used in concrete to obtain durability, cost, and environmental benefits. The compressive strength and split tensile strength of concrete is increased with addition of marble powder. Increase the marble powder content by more than 12.5% improves the workability but affects the compressive and split tensile strength of concrete. The flexural strength of beams is gradually increased up to 10%. Thus, it concluded that the partial replacement of cement with waste marble powder is possible and economical when compared with conventional concrete.

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