Experimental Studies of Marble Concrete Prepared with Micro Silica and Rice Straw Ash

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Abstract. This experimental study is about the investigation of the concrete prepared with marble waste, micro silica and Rice Straw. Investigation is done by determining and comparing the mechanical strength properties and cost of Proposed concrete with the Normal conventional concrete. The different test on the marble concrete shows that the increment in marble powder content increases the mechanical strength of concrete. Marble is costlier than the Coarse aggregate, so it also increases the cost of the concrete. Micro silica fills the voids in the concrete and helps in the increment of the strength. After the replacement of recycled aggregates and addition of the silica fume, Rice Straw ash can replace cement by 15% without any decrement in the strength of the concrete. Total water absorption of the concrete Decreases due to use of marble because it does not absorb any water.

**Keywords:** Micro Silica, Marble Concrete, Rice Straw Ash, Mechanical Properties, Nondestructive Test

1. Introduction

Indeed concrete is being used, as a construction material, worldwide since ancient time because shelter has always been a fundamental requirement of human being. Although now it has been developed and is being used totally in a different way. Now it has a large consumption in construction of residential building, high rise building, bridges, tunnels, and dam etc. Concrete has long history and it has been advanced with the time with different techniques and innovations [1–3].

The main reason for these improvements and advancement was to make concrete efficient for construction and to make it durable, light weighted, stronger, and sometimes to enhance the other properties of concrete as per need and requirement. Out of these listed and unlisted factors, strength and durability are two important factors which plays an important role in the business of concrete. With the time, many researchers have focused on the strength improving techniques and elements and on the techniques which can share hand in the durability of concrete. Because strength of concrete make it cost effective and possible to withstand the heavy loads [4–6].

2. Practical Application

1. Using the Marble Stone in place of Coarse Aggregate can be used for foundation purpose.
2. Silicious and marble concrete can be used in the concrete where the high strength of concrete is desirable.
3. Micro Silica

Micro silica is a ferrous mineral combination made out of extremely better shiny silica (SiO2) circles. A large portion of the silica particles are not more noteworthy than 1 micron in breadth and are normally 50 to multiple times less than customary concrete or fly debris particles. The twisting (rigidity) of substantial increments with the compressive strength, and the elasticity is generally just about 10% of the compressive strength. Contrasted and standard concrete, the rigidity proportion of silica smolder concrete is regularly marginally lower [7–9].

As the Strength of compression of silica fume concrete increases, the tensile strength also increases, but the speed gradually decreases. Researchers report that the Strength of Split tensile of 10% silica fume concrete (w / c = 0.35) is 8.5% to 8.9% in the age range of 28 to 182 days, while the range of Similar concrete without silica fume is 9.4% to 10.7% [10–12].

Micro silica is a tiny and fine material, with a mean measurement multiple times less than molecule of concrete. In light of 8% of the heaviness of concrete, around 100,000 particles for each concrete will make up for the shortcomings and water hole in newly pre-arranged cement. This dispenses with the drain and feeble change zone among total and grout that happens in conventional concrete. Due to the pozzolanic and miniature filling impacts of micro silica, it has a wide scope of utilizations, including consumption obstruction, sulfate opposition, heat decrease, scraped spot obstruction, and compound obstruction [13–15].

It can be used as silica fume impervious concrete, such as high-strength concrete. And as spray concrete. Silica fume can increase concrete Strength by more than 25%. Silica fume is much cheaper than cement, so it is very important from an economic point of view. Silica fume is a substance that may cause air pollution; it is a by-product of certain industries. The use of micro-silica in concrete can reduce air pollution up to a good limit. Silica fume can also reduce voids in concrete. Reduction of phenomenon of capillary action is seen after the addition of the silica fume. Absorption and porosity also decreases because fine particles of silica fume react with lime present in cement [16–18].

4. Marble Waste Concrete

For centuries, marble Stone is been using as an very important building material, especially for aesthetics and decorative purposes. In marble processing, such as cutting, finishing and polishing to size and uniformity, for decorative purposes, marble dust and small marble aggregates are produced as by-products. During the sawing, shaping and polishing process, approximately 25-30% of the processed marble becomes powdered form. The treatment and reuse of marble industrial waste is one of the environmental problems worldwide. Marble is the world’s largest production of natural stone, accounting for 50% of the world’s natural stone production. About 85% of India’s production comes from Rajasthan. Natural aggregates are crushed stone (limestone) from the Makrana quarry also known as Sang-E-Marmar nigari in Rajasthan [19–21].

The recycled Marble aggregate is gravel and sand from waste from the Fil-Fila white marble quarry. In fact, the results of the characterization show that the scale index and the sand equivalent value of the recycled aggregate obtained are consistent with Indian standards. Marble powder is also rich in calcium which contributes in the increment of the mix of the concrete. Due to its non absorbent behavior with water it also increases the workability of the concrete when used with concrete without disturbing the main mix of the concrete. This indicates that the sand is very fine and can improve the workability of the concrete at the expense of strength.
The modulus of fineness of the recovered sand is 3.2, it is a coarser sand that assists with getting a decent strength esteem, yet it may not be a decent serviceable mix. The Los Angeles coefficients for normal total and reused total are 25.14 and 37.09, individually, and these qualities are steady and more proper with standard determinations. In view of Miniature Deval test results, regular totals are more harder than reused totals. The carbonate content of the reused total is higher than that of the reused total. A characteristic material that works on the grip of the additional concrete paste.

5. **Rice Straw Ash**

Straw is a large quantity of agricultural residue available in rice-producing countries. Use locally available straw. RS consists of leaves, stems and roots, and is composed of fibrous cellulose with a high content of silica. Straw (RS) is the residue that is produced in the rice production process, with an annual global production of 67 million tons. Such wastes are difficult to manage, especially in natural environments, such as wetlands that often produce wetlands.

The straw is properly burned in the clay stove used by the villagers to cook until it is completely ashes. The ash is then sieved to 300 µm. The sieved ashes are used in cement mixtures as a partial substitute for cement to make mortar. Through chemical analysis, it was found that the silicon oxide content in RSA was 62%. According to (IS: 4031 (Part 11) 1988), the specific gravity of the RSA used is 2.0.

RSA increased compressive strength by 12.5% and replaced 10 points with RSA in the mortar. Initial set time and final set time increase with increasing RSA replacement rate. Since RSA is an agricultural residue and can be obtained naturally, construction costs can be reduced. The results of this work analysis show that the effect of the addition of RSA on the performance of the mortar is satisfactory. The use of RSA significantly improves the strength of the mortar and can be used as a pozzolan material in cement mortars. However, fine grinding and controlled temperature combustion may be required to obtain high-quality RSA.

6. **Methodology**

For the experimental study of marble concrete with micro silica and Rice straw ash the concrete grade of M35 is taken for consideration with the ratio of 1:1.6:2.9 and water cement ratio as .45. the properties of the constituents material shown in figure 1 and table – 1.

| Table 1 Mechanical Characteristics and properties of constituent Materials |
|---------------------------------|-------------------|------------------|
| Cement                         | Specific gravity  | 3.2              |
| Grade                          | OPC43             |                  |
| Setting time                   | 33 min and 559 min|                  |
| Fineness Modulus               | 97%               |                  |
| Finer aggregate                | Specific gravity  | 2.59             |
| Density                        | 1680 Kg/m³        |                  |
| Coarser aggregate              | Specific Gravity  | 2.675            |
| Marble Waste                   | Specific Gravity  | 22.41            |
| Rice Straw ash                 | Specific gravity  | 2.14             |
|                                | Fineness Modulus (90µ) | 100%          |
|                                | Fineness Modulus (90 µ) | 93%          |

This study is done by preparing 11 mixes of different ratios of material and analysis them in terms of mechanical properties and cost analysis further the NDT rebound hammer test is being used for the strength determination. The Micro silica is added by 10% for the increment of the strength of
concrete. The coarse aggregate is replaced by the Marble powder by 50% and 100% with the differential replacement of cement by 5%, 10%, 15%, and 25% respectively. For the compressive strength test 150X150X150mm mould are prepared. For flexure and split tensile the mould dimensions are 150X300mm and 100X100X100mm. For cost analysis the current rates of market and SOR is used, see table 2.

| Table 2 Cost of constituent particles |
|---------------------------------------|
| Material     | Cement | Fine Aggregate | Coarse aggregate | Micro Silica | Rice Straw ash | Marble Waste |
| Cost         | 8 Rs/Kg | 2.5 Rs/Kg      | 1.5 Rs/Kg        | 12 Rs/Kg     | 0 Rs/Kg        | 2.7 Rs/Kg    |

The various quantities of the constituent materials are calculated for all the ratios as follows:

7. Results and Discussion

| Table 3 Results for the experimental Study |
|--------------------------------------------|
| Mix Ratio | Strength Of Compression | Strength of split tension | Strength Of Flexure | Water Absorption | Cost Comparison | Rebound Hammer. |
| In N/mm² | In N/mm² | In N/mm² | In N/mm² | In % | In Rs | % Increment | 28 Days |
| HAR0 | 22.428 | 35.6 | 2.294 | 3.642 | 3.315 | 4.177 | 8.000 | 6466.500 | 0.000 | 36.440 |
| HAR1 | 23.877 | 37.9 | 2.443 | 3.877 | 3.42 | 4.309 | 7.852 | 6624.500 | 2.444 | 38.794 |
| HAR2 | 25.074 | 39.8 | 2.8 | 4.072 | 3.505 | 4.416 | 5.848 | 7312.100 | 13.079 | 40.739 |
| HAR3 | 24.507 | 38.9 | 2.507 | 3.979 | 3.2 | 4.366 | 5.915 | 7312.100 | 13.079 | 39.818 |
| HAR4 | 23.814 | 37.8 | 2.436 | 3.867 | 3.3 | 4.304 | 5.981 | 7312.100 | 13.079 | 38.692 |
| HAR5 | 23.373 | 37.1 | 2.1 | 3.795 | 3.4 | 4.264 | 6.048 | 7312.100 | 13.079 | 37.976 |
| HAR6 | 25.03 | 34.3 | 2.211 | 3.509 | 3.1 | 4.1 | 6.115 | 7312.100 | 13.079 | 35.109 |
| HAR7 | 28.539 | 45.3 | 2.92 | 4.634 | 3.74 | 4.711 | 3.844 | 7999.700 | 23.714 | 46.369 |
| HAR8 | 26.655 | 42.31 | 2.727 | 4.328 | 3.614 | 4.553 | 3.911 | 7999.700 | 23.714 | 43.309 |
| HAR9 | 24.896 | 39.518 | 2.547 | 4.043 | 3.493 | 4.4 | 3.978 | 7999.700 | 23.714 | 40.450 |
| HAR10 | 23.253 | 36.91 | 2.379 | 3.776 | 3.375 | 4.253 | 4.045 | 7999.700 | 23.714 | 37.781 |
| HAR11 | 21.718 | 34.474 | 2.222 | 3.527 | 3.262 | 4.11 | 4.111 | 7999.700 | 23.714 | 35.287 |

Concrete prepared by marble waste has higher strength than normal concrete because marble has calcium in abundance which increase the strength of concrete up to a great strength. Coarse aggregate can be replaced easily and fully by marble waste but marble waste is costlier than the CA so it also increases the cost of concrete, see table 3.

As finer than the cement with size of 150nm Micro Silica fill the voids of the concrete and contribute in the strength of the concrete. Silica also contributes chemically to the concrete it reduces the setting time of concrete and make concrete anti corrosion resistant.
Rice straw ash contributes in the strengthening of the concrete but for MWC (Proposed Marble Waste Concrete) already silica has replaced 10% of cement and after replacing 15% more cement can reduce the binding capacity of concrete which reduces the strength of concrete but due to presence of marble waste which is a source of calcium and micro silica which is added for the increment in silicious action in the concrete adjust the strength of concrete. Addition of rice straw ash can increase the absorption of water in the concrete. Which can be not good for the later stage, see figure 1, 2 and 3.

Rebound hammer test on the concrete is done by taking 10 values and the average is being taken for the analysis. The NDT results and conventional compression testing process are nearly the same for the Marble Waste concrete.
Figure 3 Results for the Flexural test of the proposed concrete
8. Conclusions and Future Scope
The present analysis has been concluded with following outcomes;

1. Marble waste can be fully replaced Coarse aggregate with giving the increment in the strength up to 25%.
2. Marble waste reduces the water absorption of the concrete because marble does not absorb water. But it increases the cost of concrete.
3. Micro silica fills the voids in the concrete and increases the strength of concrete.
4. Water in the Proposed concrete is not absorbed by Marble waste but the absorption is increased by the Rice straw ash.
5. Cost of proposed concrete is increased by Silica and marble but adjusted by the use of RCA
6. NDT gives average results when compared with normal methods of testing of concrete.

8.1. Future Scope
1. Marbleconcrete can be used for the High Strength Concrete.
2. Micro silica can be further be used after chemical treatment

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