Experimental Research on the Strength Parameters of Concrete using Sugarcane Bagasse Ash, Marble Waste Powder and Recycled Concrete Aggregate

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Abstract: ***The demand of utilization of the waste product from the industries is at its peak therefore, several experimental investigations have been carried out to examine their physical and chemical properties when they are used as a replacement material in concrete. This lead to the revolutionary techniques which achieved high strength parameters. The crushed concrete is the most impeccable technique to produce the recycled aggregate. It can also be derived from any kind of concrete debris. The main advantage of recycled concrete aggregate (RCA) is that it resembles the same properties as that of concrete. Sugar bagasse ash (SBA) is the burnt by product of sugarcane's bagasse. It is very fine and it becomes the main advantage of bagasse ash. Another type of replacement material is marble waste powder and it is derived by cutting and polishing the marble. In the present experimental study, which was conducted in an attempt to utilize these waste product, design mix of concrete was designed by partially replacing cement with bagasse ash, fine aggregate with marble powder and coarse aggregate with recycled concrete aggregateat varying proportions. Different tests were conducted in order to evaluate and determine its strength parameters. In the gist, the conclusion which was made for the present study is that the compressive strength and flexural strength tends to increase at the beginning and gives maximum value for the design mix containing 20% SBA, 20% Marble Powder and 25% RCA and after this the strength starts to fall.The maximum split tensile strength was achieved with the design mix which entails 20% SBA, 40% Marble Powder and 25% RCAwhereas,other mixes gives satisfactory results.***

Keywords: Sugarcane Bagasse Ash, Marble Waste Powder, Recycled Concrete Aggregate.

I. INTRODUCTION

Since the beginning, concrete material plays an impeccable role in the construction industry as it imparts maximum compressive strength and stiffness to the structure. It comprises of different material such as cement aggregate, water etc.

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When all these raw ingredients mix together, a slurry paste forms after the chemical reaction. But the availability of the raw material is posing a great threat to the natural resources as they are being used lavishly for construction purposes. In order to avoid this issue, utilization of by-products of industrial production as it is the only answer to the problem. Various materials like fly ash, bottom ash, metakaolin, iron and copper slag, rice husk ash, marble powder etc are the most common type of material which are being used for replacement of the raw ingredients.Various material has different properties which effect the concrete in their own way. Some material enhances strength parameters, some are used for increasing workability and others are used for targeting other properties of concrete.

II. RECYCLED CONCRETE AGGREGATE

One of the most impeccable alternative to raw material is concrete aggregate (RCA) which is obtained from construction and demolition (C&D) wastes, which results inprotectingthe natural resources and land; avoid environmental pollution; and reduce the overall charges of construction. The utilization of recycled concrete aggregate in structural construction is practiced in many countries. Various techniques of processing the wastes, effects on the properties of concrete are to be explored. The properties of recycled concrete aggregates are mentioned in table 2.

Table 1: Properties of RCA

Details	Values
Shape	Irregular
Size	10 mm, 20mm
Specific Gravity	2.40
Water Absorption	4.04

Figure 1: Concrete Debris

Figure 2: Recycled Concrete Aggregate

SUGARCANE BAGASSE ASH

Sugarcane industry is one of the leading industry as the demand of sugar is huge in the country. The end product of extracting the sugar from sugarcane is bagasse. The bagasse is a very useful waste as it is used in the boilers in burning process. The ash which is left behind after the burning is called Sugarcane Bagasse Ash. SBA has high utilization in concrete as it can be used for replacing cement due to its fineness. The properties of SBA can vary with its source as it depends on how the bagasse is burned. The properties of bagasse are mentioned below in the table 3.

Table 2: Properties of Bagasse Ash

Details	Values
Specific Gravity	1.8
Fineness Passing (45µm)	95
Mean grain size	5.1

Figure 3: Bagasse Ash

MARBLE WASTE POWDER

Marble waste powder is yet another waste product of marble industry which has been proved useful in replacing the fine aggregates in concrete making. Marble waste powder (MWP) is derived as the result of polishing and cutting process of marble. This by-product is cannot be used further in marble industry and is useless to them. Therefore, researchers have found a way to utilize this waste product in concrete as an alternative to fine aggregate in order to reduce the cost of concrete and environmental pollution. The properties of marble waste powder have been represented in table 4.

Table 3: Properties of Marble Powder

Details	Values
Specific gravity	2.51
Water absorption (%)	0.82
Specific surface area(m2/kg)	535
Partial retain of 75 micron IS sieve	1.23

Figure 4: Marble Waste Powder

ADMIXTURE

Super plasticizer type retarding admixture confirming to IS 9103-1999 was adopted for making the concrete samples at fixed proportion. The properties of admixture which was used in the present study is mentioned in table 4.

Table 4: Properties of Admixture

Details	Value	Requirement as per IS: 9103-1999
Dry Material content (%)	29.72	Within ±3% as stated by the manufacturer
pH	6.59	Minimum 6.0
Relative density	1.08	Within ±0.02% as stated by the manufacturer
Appearance	Light Brown	Light brown

III. DESIGN MIX PROPORTION

Total 7 design mix as per Indian Standard was prepared with varying proportion of bagasse ash, marble waste powder and recycled aggregate along with the control mix in order to examine their effect on concrete. The partially replacement of cement with bagasse ash is done from 10 % to 30% with the increment of 10%. Marble waste powder was used in a proportion of 20% and 40%. Coarse aggregated was partially replaced with the fixed proportion of 25% with recycled concrete aggregate. Different proportion of various material is shown in table 5.

Table 4: Different Proportions of BA, MWP and RCA for Concrete Mix

Design Mix	Baggage Ash (%)	Marble Powder (%)	RCA (%)
Control Mix	0	0	0
M1	10	20	25
M2	10	40	25
M3	20	20	25
M4	20	40	25
M5	30	20	25
M6	30	40	25

For compressive strength, a moulding cubes of 150mm x 150mm x150mm were prepared and then it was tested under the compression testing machine as per IS: 516-1959. For split tensile strength, cylindrical moulds of size 150mm diameter and 300mm height were casted and test was performed as per IS: 5816-1999.And for testing the flexural strength, the samples of beam (size 100mm x 100mm x 500mm) were casted under the provisions of IS: 516-1959.These concrete samples were tested at 7 days and 28 days for their respective strength parameters.
Along with these tests, ultrasonic pulse velocity test as per IS: 13311.1-1992 and rebound hammer test were executed at 28 days.

IV. RESULTS AND CONCLUSION

Figure 5 shows the variation of compressive strength at 7 days and 28 days. It can be clearly seen that the compressive strength of concrete mix is increased from control mix to M3 almost linearly and mix M3 shows maximum compressive strength of 24.09 MPa at 7 days and 36.45 MPa at 28 Days. Then the compressive strength decreases from 36.45 Mpa for M3 to 32.15 Mpa for M6. But all the mixes give satisfactory results.

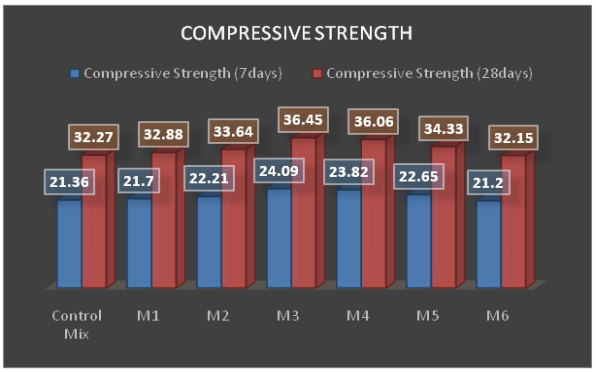

Figure 5: Compressive Strength Outcomes

It was concluded from figure 6 that the M3 mix shows higher flexural strength of 5.61 Mpaat 28 days than other design mixes and M6 mix has minimum flexural strength of 5.23 Mpa at 28 days. The variation in flexural strength is slight for all the mixes at both the curing period i.e. 7 days and 28 days.

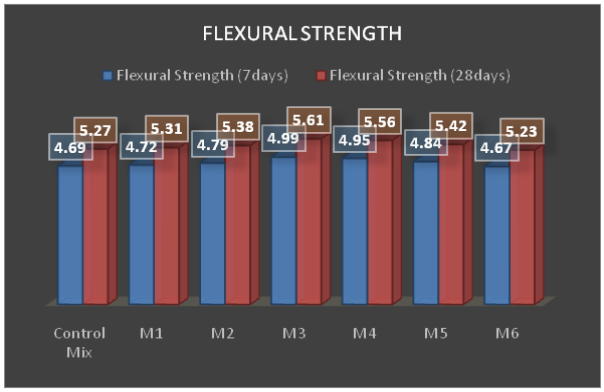

Figure 6: Flexural Strength Outcomes

The variation in results of split tensile strength at 7 days and 28 days is represented in fig 7.Maximum split tensile strength of 3.12 MPa at 7 days and 4.46 at 28 Days can be seen for mix M4. Whereas, the control mix shows the minimum strength at both the curing period.

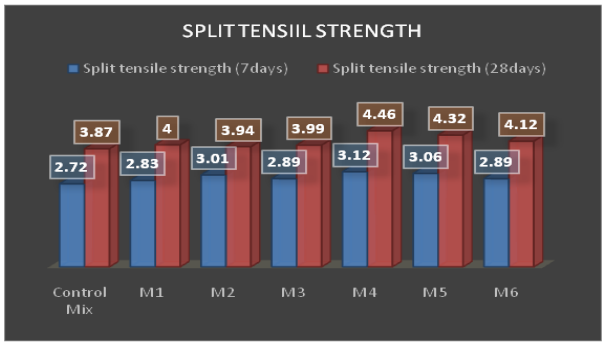

Figure 7: Split Tensile Strength Outcomes

Figure 8 and 9 show the variation in the results of ultrasonic pulse velocity and rebound hammer test respectively. In both the test, M3 shows the maximum value.

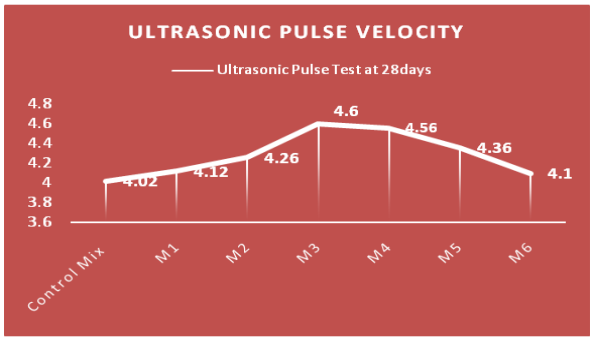

Figure 8: Ultrasonic Pulse Velocity Outcomes

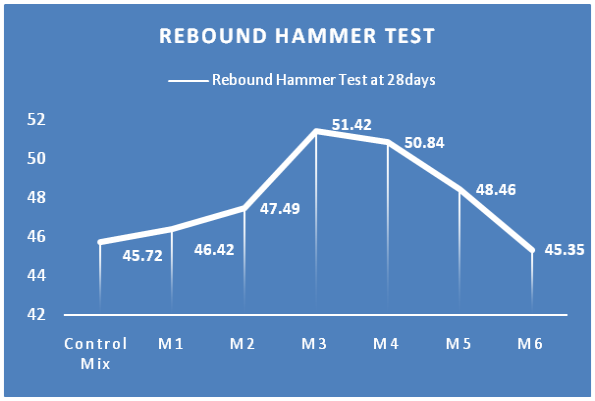

Figure 9: Rebound Hammer Test Outcomes

For the present experimental examination, final conclusions were made for strength parameters, UPV and rebound hammer test.

- The compressive strength and flexural strength of concrete is maximum for the concrete mix containing 20% bagasse ash, 20% marble waste powder and 25% RCA.
- Whereas, the split tensile strength was found to be maximum for concrete mix M4 which entails 20% bagasse ash, 40% marble waste powder and 25% RCA.
- Test results of ultrasonic pulse velocity and rebound hammer indicated that concrete mix M3 shows the higher values than any other concrete mix.

In the gist, the optimum proportion of various replacement material is 20% bagasse ash, 20% marble waste powder and 25% RCA as it gives higher values for the present study.

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