Effective Utilization of Sugarcane Bagasse Ash and Marble Waste in Construction Products

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Abstract: *The increasing scarcity of natural construction resources and the accumulation of industrial waste have encouraged the use of alternative materials in concrete. Several experimental studies have examined the physical and chemical behavior of waste materials when used as partial replacements, leading to improved strength characteristics. Recycled concrete aggregate (RCA), obtained from crushed concrete debris, closely resembles natural aggregate properties. Sugarcane bagasse ash (SBA), a finely divided by-product of burnt sugarcane bagasse, is suitable for partial cement replacement. Marble waste powder (MWP), generated during marble cutting and polishing, can be effectively used as a fine aggregate substitute. In this study, concrete mixes were prepared by partially replacing cement with SBA, fine aggregate with MWP, and coarse aggregate with RCA at different proportions. Strength and non-destructive tests were performed to assess performance. The results indicate that compressive and flexural strengths increase initially and reach maximum values at 20% SBA, 20% MWP, and 25% RCA, after which strength decreases. The highest split tensile strength was observed for the mix containing 20% SBA, 40% MWP, and 25% RCA, while all other mixes showed satisfactory behavior.*

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

I. INTRODUCTION

Concrete is one of the most widely used construction materials due to its high compressive strength and stiffness. It consists of cement, aggregates, water, and other constituents that react chemically to form a hardened mass. The excessive use of natural raw materials for concrete production has resulted in depletion of natural resources. To overcome this issue, the utilization of industrial by-products and waste materials has emerged as a sustainable alternative. Materials such as fly ash, rice husk ash, marble powder, and slag have been successfully incorporated into concrete, each contributing differently to strength, workability, and durability.

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 in protecting the 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 bagasse ash is produced from the combustion of bagasse, the fibrous residue remaining after sugar extraction. Due to its fine particle size and pozzolanic nature, SBA can be used as a partial replacement for cement. The properties of SBA depend largely on burning conditions and source. Properly processed SBA enhances particle packing and contributes to strength development in concrete..

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 generated during the cutting and polishing of marble stones. This waste material cannot be reused in the marble industry and often causes environmental problems. Researchers have identified its suitability as a partial replacement for fine aggregate in concrete, which helps reduce construction cost and environmental impact 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

hbdcv The experimental results show that the incorporation of SBA, MWP, and RCA significantly influences the strength characteristics of concrete. The maximum compressive and flexural strengths were obtained for the mix containing 20% SBA, 20% MWP, and 25% RCA. The split tensile strength was highest for the mix with 20% SBA, 40% MWP, and 25% RCA. Non-destructive test results further confirmed that the mix with 20% SBA, 20% MWP, and 25% RCA exhibited superior quality. The study concludes that these waste materials can be effectively utilized to produce sustainable and economical concrete without compromising performance.

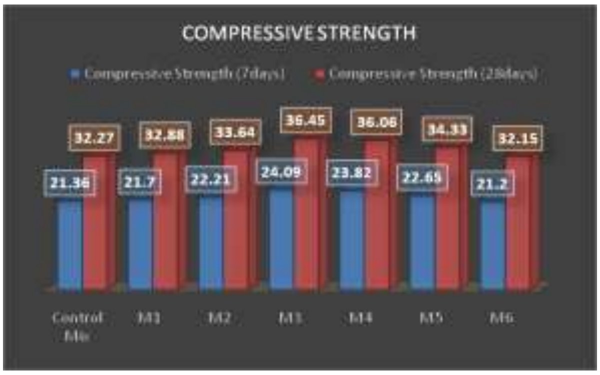

Figure 5: Compressive Strength Outcomes

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.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.

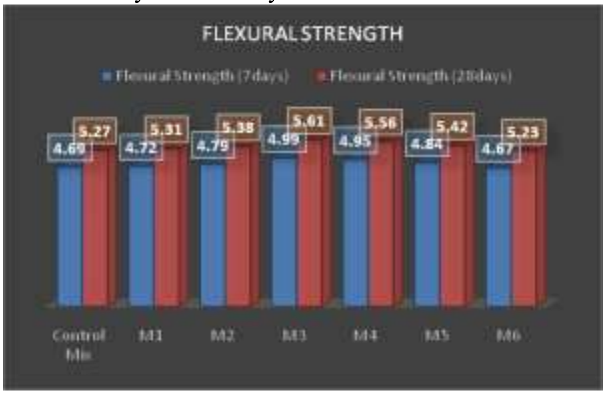

Figure 6: Flexural Strength Outcomes

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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