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EXPERIMENTAL INVESTIGATION OF MARBLE WASTE CONCRETE WITH SUGARCANE BAGASSE

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Abstract: Reusing marble debris as a fine aggregate and sugarcane bagasse ash as additional cementitious material is becoming more and more popular as a building ingredient. Byproducts from the cogeneration unit of the sugar industry and the marble processing unit, respectively, are sugarcane bagasse ash and marble waste. Environmental deterioration results from the common disposal of bagasse ash and marble waste in landfills near the production and processing facilities, respectively. The characteristics of ingredients such as sugarcane bagasse ash, cement, slag, marble waste, river sand, crusher sand, coarse aggregate and water used in concrete For the main research study, the mixtures (10%, 20 and 30% of bagasse ash with optimum percentage of marble waste) of concrete have been tested for its compressive strength, splitting tensile strength and abrasion resistance. The experiments were carried out to attain an optimum dosage of sieved bagasse ash and marble waste for concrete. Additionally, the effect of different curing methods on bagasse ash and marble waste blended concrete using river and crusher sand was evaluated for compressive strength, abrasion resistance. The results displayed that the superior performance was attained up to a certain replacement level of sugarcane bagasse ash with optimum content of marble waste. The optimum dosage of bagasse ash was found as 20% concrete along with the optimum content of marble waste such as 25% and 10% in concrete. To promote the internal revenue generation at sugar industries, some techniques were explored for using bagasse ash in the production of bagasse ash blended cement like fly ash blended cement production.
Key words: SCBA, Compressive Strength, MW, Split tensile Strength, Flexural Strength

1. Introduction:

In earlier research studies, different materials were investigated for use as supplementary cementitious materials for the blended cement production. Significant increase in strength, reduction in permeability as well as heat of hydration were evidently observed for the blended cement concrete compared to the conventional cement concrete [10].

Many potential materials which are available in abundance are not used in the concrete due to lack of characterization, evaluation of pozzolanic reactivity and their performance in concrete [1].It is imperative to characterize locally available pozzolanic materials with a proper evaluation scheme to achieve effective utilization in concrete instead of disposal as a waste [9].

In general, aggregate in concrete is structural filler and occupies most of its volume. Throughout the years, the utilization of concrete globally has reached astounding scales. Reports had shown that 11.5 billion tons of concrete are consumed every year out of which aggregate is 9 million tons [5]. Globally, sand and gravel are the utmost extracted materials. The United Nations narrates that aggregate accounts for 85% of global mining activity, measured in weight [13]. River sand and crusher sand have been widely used as fine aggregate [12]. River sand is a naturally occurring material formed by the breakdown of earth‟s crust, the transport and deposition of the sediments. Crusher sand is produced by crushing hard granite stone. The rapid growth of infrastructure and construction industry requires huge extraction of aggregates which destroys the eco-system just to dredge up billions of tons annually [14].This even exceeds the extraction of fossil fuels and biomass. The exploiters of sand and the common resource compete to extract the maximum possible volume without considering the social or ecological consequences [16].

1.1 Sugarcane Bagasse

The sugar industry in India is being considered as backbone to economy for the nation and farmers. According to the information from the Indian Sugar Mill Association, more than 500 sugarcane factories are actively working throughout country [2]. In the recent times, a sugar industry in India has started generating energy and trades the surplus to the government through the power grid. Sugarcane is cultivated in a large scale in the country and India has become first in the sugarcane production. The average sugarcane production in India is about 35.5 crore tons. Bagasse ash in its wet state has a very high gross calorific value of 2250 kcal/kg and hence, it discovers maximum usage in electricity production [22]. For this purpose, the steam is generated using boilers which utilize the bagasse in the form of fuel at a temperature of 400oC - 600oC. Nonetheless, it caused partial combustion of bagasse and produces a low fuel value. As a result, in the years of 1980s the sugar industries with cogeneration plant had been started to encounter the power demand in India. Currently, this cogeneration plant is a promising alternative for power production owing to the rise in the use of fossil fuels.

1.2 Marble Waste

Marble has been used as a construction material since the antediluvian period. It is formed by the metamorphism of sedimentary carbonate rocks. Natural stones obtained from the earth"s crust were polished and used as building stones in ancient times. With the development of civilization, they are currently being used mainly for aesthetic purposes. The marble industry helps in improving the socio-economic status of any country [8].

Marble has withheld its importance because of its variety of appearances and its ability to survive for a long duration of time without being deprived of its look. Marble powder is the by-product produced during the sawing and polishing of marble blocks. Water used to prevent the rock saw from overheating mixes with the powder, producing sludge. This sludge when deposited in the nearby lands causes groundwater contamination and reduces soil productivity Marble powder can be produced from marble sludge by the process of drying and applying mechanical load and can be used in concrete. The fusion of marble powder into concrete and other cement-based products would make notable environmental and economic contributions. Also, concrete containing Marble Waste (MW) is relatively 15% economical than conventional concrete. Hence, an attempt has been made in this study for utilization of marble waste as a partial replacement of fine aggregate along with bagasse ash as pozzolanic material in concrete and construction products [15].

1.3 Objective of the Project

1. To investigate the combined use of sieved sugarcane bagasse ash and marble waste with optimum proportion in concrete.
2. To examine the possibilities for use of both bagasse ash and marble waste in alkali-activated binder.
3. To develop a sustainable methodology for the production of concrete using bagasse ash and marble waste.
4. To explore ways to increase the revenue generation using bagasse ash through production of bagasse ash blended cement in sugar industries.

2. Materials and Methodology

2.1 Sugarcane bagasse ash - Sugarcane bagasse is used as fuel in the cogeneration boilers of sugar plants. After burning the bagasse, the residual ash is collected as a by-product using a bag-house filter and is disposed to the nearest land. In this study, bagasse ash was collected from a sugar plant and then, the collected raw bagasse ash was further dried at 105-110ºC for 24 hours to remove the evaporable water content. The dried bagasse ash was further sieved through 300μm sieve to remove large un burnt fibrous fractions and obtain superior reactive materials. The sieved SCBA was adopted in the manufacture of blended concrete.

Fig. 1 Sugarcane bagasse ash

Table 1 Physical Properties of bagasse ash

Physical Properties	***Result***
Specific Gravity	2.16
Soundness (mm)	1.36
Consistency (%)	40
Initial Setting Time (mm)	145
Final Setting Time (mm)	445

2.2 **Ordinary Portland cement**

Table 2 Properties of cement

Properties	***Value***
Specific Gravity	3.13
Soundness (mm)	2.7
Fineness (m2/kg)	310
Consistency (%)	31
Initial Setting Time (minute)	65
Final Setting Time (minute)	442

2.3 Marble waste - The marble waste is used as a partial replacement for both river and crusher sand in this experimental investigation. Physical characteristics of marble waste were found as per the procedures laid down in the Indian standards IS 383-2016. Sieve analysis was carried out for the river sand and marble waste. Marble waste samples had 90% of particles finer than 2 mm, 70% of particles passing through 600 µm sieve and 35% of particles passing through 300 µm sieve. It is imperative to note that, 65% of marble waste particles were retained on 300 µm sieve. Only 5% of particles were finer than 75 µm. Specific gravity, water absorption and unit weight of marble waste are 2.58, 0.8% and 1.58 g/cc respectively.

Fig. 2 Waste marble grains

2.4 Fine aggregates

Table 3 Physical Properties of River Sand and Crusher sand used

Characteristic	***River Sand***	***Crusher Sand***
Specific Gravity	2.64	2.78
Water Absorption (%)	0.95	1.9
Bulk Density (g/cc)	1.62	1.562
Fineness Modulus	2.85	3.11

2.5 Coarse aggregates

Table 4 Properties of Coarse Aggregates

Sl. No	***Properties***	***Value***
1	Specific Gravity	2.82
2	Water Absorption (%)	0.65
3	Bulk Density (g/cc)	1.40
4	Fineness Modulus	6.80

Table 5 Mix details of concrete specimens

Mix ID	**OPC**	**SCBA (S) %**	**Marble Waste (M) %**	**River Sand (R) %**
S_0R	100	0	0	100
$S_0 M_{25}R$	100	0	25	75
$S_{10} M_{25}R$	90	10	25	75
$S_{20} M_{25}R$	80	20	25	75
$S_{30} M_{25}R$	70	30	25	75

Table 6 Mix details of concrete specimens

Mix ID	**OPC**	**SCBA (S) %**	**Marble Waste (M) %**	**Crusher Sand (R) %**
S_0R	100	0	0	100
$S_0 M_{25}R$	100	0	25	75
$S_{10} M_{25}R$	90	10	25	75
$S_{20} M_{25}R$	80	20	25	75
$S_{30} M_{25}R$	70	30	25	75

3. Result and Discussion

In this study the workability is increased on initial replace of SCBA and after that workability starts decreasing constantly by increasing replacement of SCBA on 20%.

3.1 Compressive Strength

In order to determine the optimum percentage of marble waste, five mixes were cast with marble waste as replacement of fine aggregate with different levels (0%, 25%, 50%, 75% and 100%). In addition, a mix was cast with 100% crusher sand (known as manufacturing sand because it is obtained by crushing rock to the similar size of river sand) for comparison with marble waste. Six concrete cube specimens of size 150 mm each were cast and compressive strength was determined after 7 days and 28 days of curing. Moreover, 20% level of replacement of cement with bagasse ash was reported.

3.1.2 Effect of Sugarcane Bagase and Marble waste on compressive strength

Compressive strength of control concrete specimens as well as specimens with different levels of replacement of sugarcane (10%, 20% and 30 %) were determined to find the optimum level for the replacement of natural River sand and crusher sand with marble waste. As per IS 516-2004, three concrete specimens were tested for each replacement level and its average taken as compressive strength. Compressive strength of concrete specimens with 25% level of replacement marble waste was found to be increased 2.75% compared to the control concrete after 7 days and 28 days respectively. Five mixes were cast namely S0M0R (Control), S0M25R (only 25% MW), S10M25R (25% MW and 10% SCBA), S20M25R (25% MW and 20% SCBA) and S30M25R (25% MW and 30% SCBA).

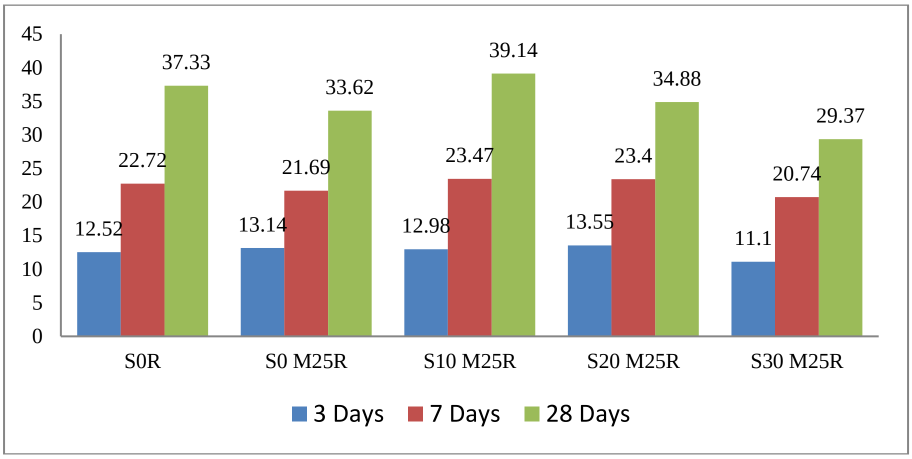

Fig.3. Compressive Strength of SCBA and MW concrete with River Sand

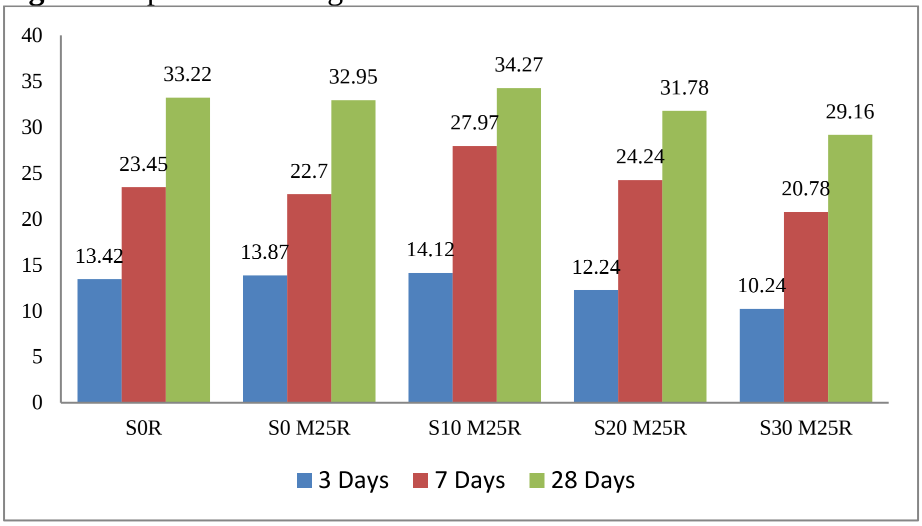

Fig.4. Compressive Strength of SCBA and MW concrete with River Sand

It is interesting to note that the sieved bagasse ash can be used up to 20% level of replacement along with 25% of marble waste on the substitution of river sand in concrete without compromising the compressive strength.

In case of crusher sand the optimum percentage of sugarcane bagasse 10% and marble waste is 25%.

3.1.3 Flexural Strength

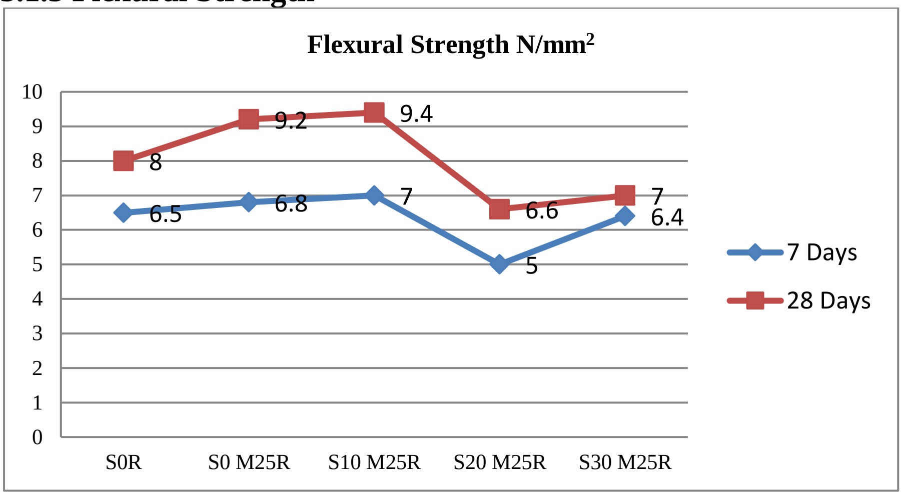

Fig.5. Flexural Strength of SCBA and MW concrete with River Sand

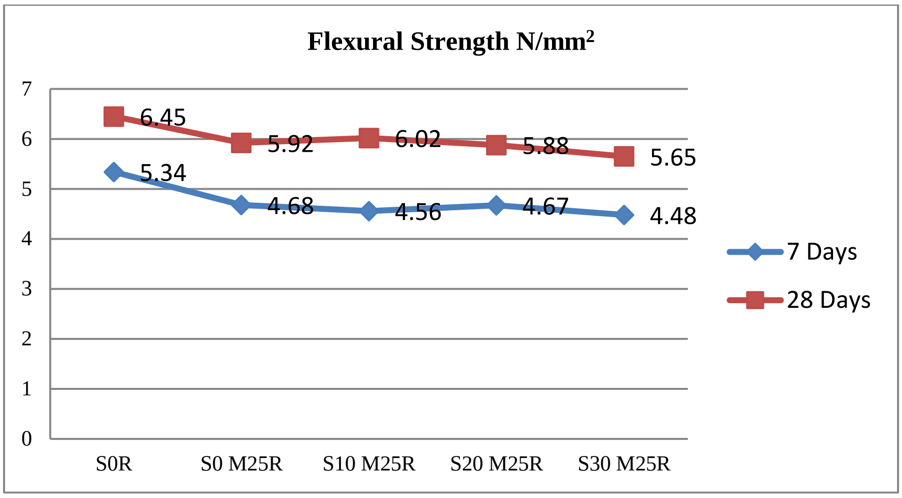

Fig.6. Flexural Strength of SCBA and MW concrete with Crusher Sand

3.1.4 Split Tensile Strength

The splitting tensile test was carried out on concrete cylinder specimens as per procedure laid down in IS 5816 (1999) after 7 and 28 days of curing. Figure 7 20% replacement level of SCBA with optimum MW based (S20M25R) specimens had shown the highest strength of 4.40 MPa and 4.60 MPa after 7 and 28 days of curing respectively. Moreover, it is 5.77% and 8.50% higher than the control (S0M0R) specimen and 3.85% and 5.0 % higher than S0M25R specimen after 7 days and 28 days of curing respectively. A significant improvement in the strength of S0M25R (3.85% and 3.3%) and S10M25R (4.33% and 6.13%) specimens were found to be higher than the control (S0M0R) specimen after earlier and later stage of curing respectively. The lowest tensile strength of 3.90 MPa was observed in S30M25R specimens after 28 days of curing.

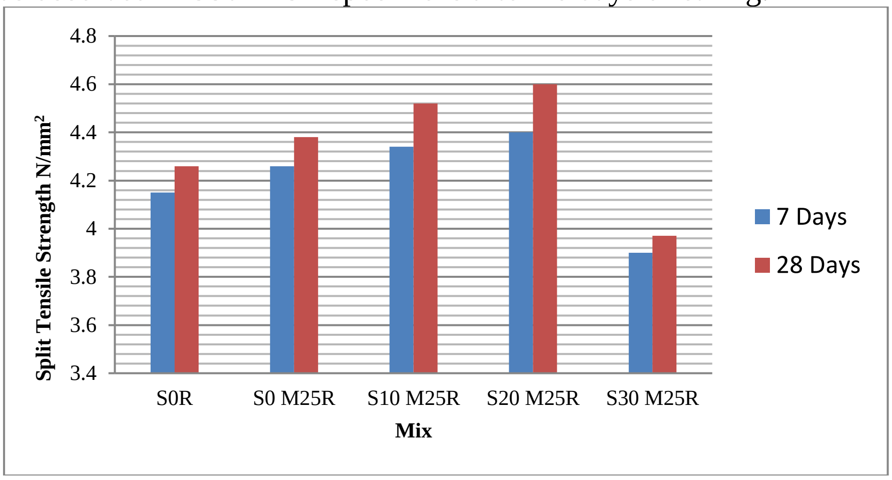

Fig.7. Split Tensile Strength of SCBA and MW concrete with River Sand

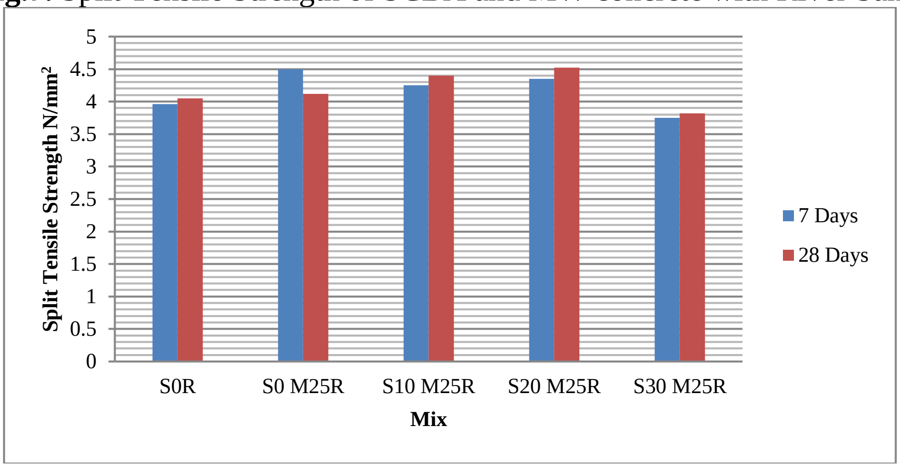

Fig.8. Split Tensile Strength of SCBA and MW concrete with River Sand

Figure 8 the substantial enhancement in tensile strength of 4.05 MPa was found in only marble waste blended concrete (S0M25C) specimen and it is 2.3% higher than the control specimen after 28 days of curing. A significant improvement (10% and 13%) was noticed in the tensile strength of SCBA-MW blended (S10M25C and S20M25C) specimens compared with control (S0M0C) specimen and S20M25C specimen had exhibited the highest strength of 4.52 MPa after 28 days of curing. 30% of SCBA with an optimum percentage of MW (S30M25C) had revealed the lowest strength of 3.75 MPa after 7 days of curing.

3.1.5 Rebound Hammer Test

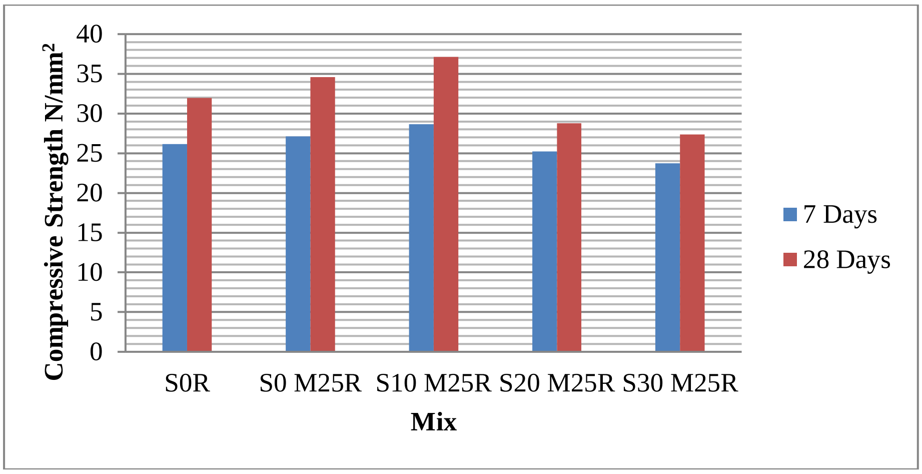

Fig.9. Rebound Hammer Test of SCBA and MW concrete with River Sand

4. Conclusion

1. It has been determined that the ideal replacement levels for marble waste and sugarcane bagasse are 25% and 20%, respectively, with river sand.
2. It has been determined that 10% and 25% of the waste from sugarcane bagasse and marble should be replaced with crusher sand, respectively.
3. Studies on the effects of bagasse ash in crusher sand, river sand, and marble waste-based concrete have shown that the greatest percentage of SCBA substitution for cement without sacrificing compressive strength is between 10% and 20%.
4. Compared to control specimens made of crusher sand, the concrete based on SCBA and MW exhibits significantly greater compressive strength and flexural capacity.
5. Three suggested procedures can result in three possible products: SCBA blended cement, highly reactive bagasse ash produced by a combined sieving-grinding process, and moderate reactive bagasse ash. There has been a noticeable decrease in carbon dioxide emissions as a result of the SCBA blended cement manufacture.

3.3 Future Scope

Field investigations are advised to comprehend the performance of the SCBA marble waste-based construction items under site settings, as this study was primarily carried out in a laboratory. Furthermore, other building goods like hollow blocks, roof tiles, manhole covers, etc. can also benefit from the combined usage of SCBA and marble waste. The impact of other SCBA processing techniques, including as burning and grinding, on the performance of SCBA and marble waste-based construction materials needs to be investigated because the current study only looks at a basic sieving procedure. To comprehend their impact on performance, it is advised to utilise other viable substitute materials in concert, such as fly ash and slag in the SCBA and marble waste-based building goods. A key factor in acceptance is not only performance evaluation but also the cost of construction materials. Consequently, research must be done on the financial advantages of SCBA-based marble waste-based construction materials over traditional ones.

Therefore, it is advised to conduct a thorough investigation into the cost analysis of SCBA-marble waste-based construction goods. Reusing industrial wastes (SCBA and marble debris) as valuable building materials and then lowering the carbon-intensive conventional clinker production process are noteworthy examples of environmentally responsible practises. To comprehend the environmental advantages connected to their use in the construction goods, a thorough life cycle analysis for SCBA-marble waste utilisation is advised.

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