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UITILIZING BIOMATERIAL AND GLASS WASTE FOR PARTIALLY REPLACEMENT OF CEMENT AND SAND IN CONCRETE

DARSI KAVYA AND PUSULURI SAI SRAVANI
Department of Structural Engineering, Amrita Sai Science and technology, Paritala, Krishna (Dt).521180, Andhra Pradesh, India.
Pusuluri Sai Sravani, Mtech (CTM) Assistant professor Amrita Sai Institute of Science and technology

ABSTRACT

The purpose of this study was to determine the optimal replacement percentage for sand with glass powder waste, which has excellent pozzolanic properties, and the effect of replacing Pozzolonic Portland cement (PPC) with Rice Husk Ash (RHA), a local biomaterial additive. The primary motivation for this study was to find solutions to the problems that arise while trying to properly dispose of agricultural waste like rice husk ash. The project was also designed to address the increasing problem of glass waste's low breakdown characteristics. Because of the growing demand for construction materials and the subsequent increased exploitation of raw materials and generation of hazardous gases (such as SO2 and NOX) during cement manufacturing, the ultimate goal was to lessen the reliance on cement, which is extensively used in construction. Compressive strength values at 7, 14, 21, and 28 days were measured as 20.27, 28.34, 33.67, and 37.60 N/mm2 in previous investigations where the replacement fraction was set at 20%.

1. INTRODUCTION

1.1 GENERAL

Recently, there has been a lot of interest in investigating whether or not biomaterials and glass waste may be used as partial cement and sand substitutes in concrete. This new area of study is focused on reducing the amount of waste produced by building projects and increasing the use of eco-friendly, renewable resources. Rice husk ash, fly ash, and groundnut shell ash are only some of the biomaterials that have showed promise as cement substitutes in concrete mixes. Large amounts of silica and alumina, both of which are required for cement manufacturing, can be found in these biomaterials. Many beneficial enhancements can be accomplished by putting them into concrete. Concrete's compressive strength, water resistance, and resistance to chemical deterioration are all improved by the use of these biomaterials.

Like sand, glass shards have recently been recognised as a potential alternative in the production of concrete. Recycled glass can be effectively used as a sand replacement after being crushed and processed, lowering the demand for natural sand and reducing the trash produced by glass recycling processes. Adding glass aggregate to concrete has additional advantages, such as making the material better at insulating against heat loss. Therefore, buildings made of concrete combined with glass trash can be more efficient in their use of energy. The industry's dedication to sustainable practises is on display in the investigation of biomaterials and glass waste as partial cement and sand replacements in concrete. Construction projects can help create a more sustainable and greener future by adopting these cutting-edge methods of waste reduction and material usage.

1.2 Why Bagasse ash

More than 300 million tonnes of trash are created annually from sugarcane production. About 10 million tonnes of waste material, sugarcane bagasse ash (SCBA) [1,2], is produced as a result of this process. SCBA contains a lot of ash and oxides of silicon, aluminium, and calcium. This research set out to examine the viability of using SCBA as a partial replacement for fine aggregate in cement concrete, as this resource is becoming increasingly scarce due to environmental and biological constraints. The slump, compaction factor, compressive strength at 7 and 28 days, tensile strength at 28 days, and sorptivity coefficients of fresh concrete were the primary focus of the study. Bagasse ash was tested as a fine aggregate replacement at concentrations ranging from 10% to 40%.

This research intends to solve the problem of scarce natural sand and provide sugarcane bagasse (SCBA) a useful end use by investigating its potential as an additive to concrete. The study's findings will aid in the creation of ecologically friendly building practises by shedding light on how SCBA affects the performance and features of concrete.

1.3 Why Rice Husk Ash

Significant developments in concrete technology have occurred in recent years, all with the goal of improving concrete's performance in a variety of contexts. Self-compacting concrete (SCC), high-strength concrete (HSC), and ultra-high-strength concrete (UHSC) are all examples of these developments. In particular, HSCs are lauded for their excellent qualities due to their lower water-to-binder ratio and higher cementitious material concentration. The quantity of powdered additives used in the concrete-making process is a critical aspect in determining the final product's characteristics. Powder additives, which can be added in any quantity, greatly enhance the mechanical and chemical workability of concrete. When the right additives are used in the right amounts, a noticeable difference in the quality of the finished concrete is seen.

The options for improving the strength, durability, and general performance of concrete structures have expanded thanks to these developments in concrete technology. Engineers and researchers can improve the performance of concrete to build stronger, more efficient structures by optimising the mixture design and integrating suitable powder additions. The construction industry stands to benefit greatly from further investigation into these cutting-edge materials and methods, which could lead to the creation of more durable and environmentally friendly buildings.

1.4 Glass Powder

Glass garbage, which amounts to millions of tonnes annually, is a major environmental problem. Glass does not biodegrade and hence usually ends up in landfills. This wasteful disposal strategy adds to the mountain of trash plaguing our planet. Glass' primary ingredient, silica, makes it a material worth exploring for possible recycling and reuse. Researchers have tested the impacts of using ground glass as a partial replacement in mortar and concrete to address this problem. The ratio of water to binder was held constant while varying the amount of ground glass (0-25%) added. Flow rates and compressive strengths were evaluated. It was found that the use of glass somewhat altered the flow of mortar, although it had a negligible effect on the workability of concrete.

Additional tests were run with the same mixture details, but with the addition of a superplasticizing additive at the rate of 1% by weight of concrete, in order to assess the packing and pozzolanic effects. The results showed that the admixture improved the compressive strength of the mortars. In a similar vein, concrete cube tests were made and put through a year of strength testing. Compressive strength testing revealed that mortars and concrete with recycled glass were more durable than their control counterparts. These results suggest that using 20% recycled glass in concrete can reduce both costs and environmental impact. This study presents an attractive strategy for recycling glass waste, which has environmental and financial advantages. The use of recycled glass in building materials helps with environmental preservation and lessens trash sent to landfills.

2. LITERATURE SURVEY

2.1 GENERAL

The results of replacing cement with biomaterials were the subject of a meta-analysis of more than a hundred academic studies. According to the results, such substitutions can boost the compressive strength of concrete cubes by as much as 30%. Numerous literature sources were reviewed, and in Section 2.2, we describe the important observations from these investigations. This is a well-studied issue with many potential applications.

2.2 LITERATURE SURVEY

Rice husk ash (RHA) is a locally available ingredient that has been found to have positive effects on environmental pollution, concrete quality, and production costs in civil construction projects (Hana et al., 1984). Incorporating RHA also provides a practical approach to dealing with agro-waste.

Rashad (2003) observed that when concrete was mixed with 100% glass sand, its residual compressive strength was improved even after being heated to 700°C. Glass sand was added to the mix to increase the concrete's resilience to both salt and sulfuric acid. While the carbonation resistance was enhanced at longer times (56 and 91 days), it was decreased at 7 and 28 days due to the addition of glass sand (5-20%). The poor absorption capacity and impermeable qualities of glass also explain why increasing the glass sand content reduced drying shrinkage.

Another study evaluated the usage of glass sand powder as a substitute for both natural sand and cement (Elsevier, 2003). Glass and cement were found to undergo a pozzolanic reaction, which aided in the development of concrete's compressive strength, according to the study's authors. The concrete mixes' resistance to chloride penetration was improved thanks to the increased compaction of the interior structure.

2.3 OBJCTIVE OF STUDY

Following an exhaustive analysis of the relevant literature, the following aims have been established for this study:

a) Examine the results of using other materials to sand and cement in concrete, such as rice husk ash, bagasse ash, and glass powder. The effects of these biomaterials and waste additives, which have showed promise in improving concrete characteristics, will be investigated in depth.

b) Determine how well these materials perform as partial replacements for sand and cement in compressive strength tests on concrete samples. The performance of the replaced concrete will be evaluated by measuring its compressive strength, a key characteristic that defines the concrete's structural integrity and durability.

3. EXPERMENTAL PROGRAM AND METHODOLOGY

3.1 GENERAL

Bagasse ash, rice husk ash, and glass powder were all used as components in the experimental setup. Mortar was modified by substituting the components for a portion of the sand and cement called for in the recipe. So that it would be easier to work with, water was also added.

3.2 MATERIALS

Bagasse Ash: The dry pulpy residue that is left over after sugarcane or sorghum stalks have had their juice extracted. It is a waste product of the sugar industry, with about 3 tonnes of wet bagasse produced for every 10 tonnes of sugarcane crushed. Bagasse ash has the potential to be used as a fuel source in the generation of power and in the building trade. It is a well-documented contributor to dust production, which has been linked to health problems for humans. However, cutting-edge studies have proven that bagasse ash can be recycled into useful building materials. Ash obtained from the uncontrolled combustion of rice husk for a period of 72 hours is known as rice husk ash (RHA). Burning causes temperatures of 400 to 600 degrees Celsius. The resulting grey ash is known as RHA after being sieved using a conventional sieve of 75 m. RHA, like bagasse ash, is a waste product from the processing of paddy. Rice mills frequently employ it as a fuel source. RHA's high pozzolanic content makes it an ideal choice for cutting-edge building practises. It also finds usage in the casting process for molten metals. It is commonly used in modern construction since its use increases concrete's strength qualities.

Glass powder is an amorphous, non-crystalline form of glass that has been finely ground into a powder. Window panes, dinnerware, and optoelectronics are just a few examples of the many everyday and cutting-edge applications of glass. In this research, glass powder was used in place of cement to cut down on the generation of greenhouse gases. Adding glass powder to concrete also improves its visual attractiveness. As a result, glass powder can successfully replace cement in many building projects. Pozzolonic Portland cement (PPC) 43 grade, meeting the requirements of the Indian Standard Organisation, was used in the experiment. PPC is frequently employed in the building sector due to its pozzolanic qualities. The interaction between cement, pozzolana, and aggregates can't begin until water is added, making water an essential ingredient in concrete formation. It speeds up the hydration process, guaranteeing the formation of a strong concrete matrix.

Aggregates were employed in the experiment, with coarse aggregates ranging in size from 6-10 mm and fine aggregates (glass powder) ranging in size from 2.75 mm to 4 mm.

The experimental mixtures employed the following material ratios:

Glue: 1 ounce
One portion coarse aggregate
Two-thirds fine aggregate
The optimal ratio of water to cement is 0.45 (1:2:0.45).
Rice husk ash and bagasse ash can replace up to 10% of cement by weight.
Substituting glass powder waste for sand at 5%, 10%, or 15% by weight
The bulk density and specific gravity of RHA, bagasse ash, PPC, and glass powder are listed in Table 3.1.

Table 3.1 Properties of Materials

Materials	Specific gravity	Bulk DensitY
Rice Husk Ash	2.14	0.781
Bagasse Ash	2.84	1.95
PPC	3.15	3.1
GP	2.62	0.53

Table 3.2 shows sieve analysis of fine aggeregate as per IS 383. Sand sieve analysis is show in the table.

Table 3.2 Sieve Analysis of Fine Aggregates as per IS383

Sieve analysis	Weight Retained	% Retained	% passing
6.3	0	0	100
5.0	0	0	100
2.36	5	0.33	99.67
1.18	130	8.7	90.7
600µ	429	28.6	62.37
425µ	345	23.0	39.37

300µ	338	22.5	16.87
212µ	126	8.4	8.47
150µ	80	5.3	3.17
63µ	43	2.9	0.27
PAN	4	0.27	0

3.3 MOULDS

1. The experiment employs a conventional cube size of 150 mm.
2. Concrete with aggregates larger than 20 millimetres in size is unsuitable for 100 millimetre cubes, and concrete with aggregates larger than 40 millimetres in size is unsuitable for 150 millimetre cubes.
3. Cast iron or cast steel should be used to make the moulds for the specimens, with the inside faces being machined flat. Moulds for concrete cubes are often made of two pieces to allow for simple disassembly and reuse. A separate metal plate, held in place using clamps or springs, serves as the foundation for each mould. All of the mold's interior angles must be right angles in order to meet design requirements.
4. The moulds must be within the required dimensions, squareness, and parallelism tolerances in order to meet CS 1:1990 specifications. Section 7 of CS 1 details these prerequisites in further detail.

3.4 Methodology

1. Rice husk ash, bagasse ash, and glass powder were employed as supplementary materials in the experiment. Different combinations of these ingredients are used.
2. In this study, pozzolonic Portland cement (PPC) serves as the main cement.
3. To get to an M25 strength level, bagasse ash is combined with water and cement.
4. Table 4.1 details the percentages by which the ingredients should be combined.
5. Each biomaterial serves as a partial cement replacement, while glass powder stands in for some of the sand.
6. Cast cubes are made using the required mix design of M25 and material ratios.
7. After that, the cubes are put through a compression test.
8. In order to perform a compression test, a compression testing machine is used to impart a load to the cubes.

3.5 TESTING

50 cubes are cast and tested with various mixtures of materials. The values of deflections are measured and recorded as loads are applied. These numbers are derived from the following analyses and procedures:

Universal testing machine:

The tensile stress and compressive strength of materials are typically evaluated using a universal testing machine. Various common stress and compression tests can be run on materials, components, and structures using this universal testing machine.

Types of test

Tensile Test: One single piece of material is secured at both ends and tugged until it snaps; this is called a tensile test. Strength, elongation, and tensile modulus are all evaluated in this way.

Compression Test: In a compression test, an object is squeezed between two parallel plates until either a predetermined weight or displacement is reached, or the product fails to pass the test. Maximum force before failure, load at displacement, and displacement at load are common examples of such metrics.

Slump test: The new concrete consistency can be evaluated with a technique called the "slump test." It's an indirect method of determining if the right amount of water was added. Procedures for testing new concrete are carried out in accordance with the standards set forth in BS EN 12350-2-2009. The addition of rice husk ash and bagasse ash raises the water content in the concrete, thus the slump test should return a result between 40 and 60 mm.

Table 3.3 Mix Proportion

Rice Husk Ash(%)	SCBA (%)	Cement (%)	GP (%)	Sand (%)	Rice Husk/Cement	SCBA/Cement	GP/Sand
0	0	100	0	100	0	0	0
0	0	100	30	70	0	0	0.428571
2.5	2.5	95	25	75	0.026315789	0.026315789	0.333333
5	5	90	20	80	0.055555556	0.055555556	0.25
7.5	7.5	85	15	85	0.088235294	0.088235294	0.176471
10	1.	80	10	90	0.125	0.125	0.111111
12.5	12.5	75	5	95	0.166666667	0.166666667	0.052632
15	15	70	0	100	0.214285714	0.214285714	0

Different mix ratios have been shown as a percentage of the standard M25 concrete mix. Each component contributes equally to the whole. If the cement, sand, and aggregate in M25 concrete were to be replaced in part by, say, 5% rice husk ash (RHA) and 5% bagasse ash (SCBA), the resulting mixture would have a 90% cement content. Thus, the percentages indicate how much of the M25 concrete mixture each material makes up.

Table 3.4 Dimensions of Slump cone

SNO	Discription	Dimension
1	Diameter of metallic mould	200mm
2	Top diameter of metallic mould	100mm
3	Height it cone frustum	300mm
4	Thickness of sheet	1.60mm

Table 3.4 details the experiment's slump cone apparatus's dimensions. All dimensions are given in mm (millimetres). The metallic mold's diameter, top diameter, height of the cone frustum, and sheet thickness are all in accordance with the standards laid down in Indian Standards. Slump tests used to evaluate the workability and consistency of concrete mixtures are made more reliable and consistent when standard dimensions are used.

RESULTS AND DISCUSSION

Around 50 cubes of concrete were cast and allowed to cure for either 7 or 28 days. Curing the concrete involves submerging the wet sections in a water tank. This section presents the testing findings that were received. The cubes were made with varying amounts of components, each determined by the mix proportions listed in Table 3.3. Table 4.1 provides the exact kilogramme amounts of each material utilised. The data for compressive strength after 7 days and after 28 days is tabulated and displayed.

Table 4.1 additionally displays the mix proportions utilised in addition to the associated compressive strength outcomes for the various mix proportions. It gives a thorough analysis of the range of compressive strengths attained. Figure 4.1 provides a graphical comparison of the data for easier comprehension. In order to compare samples with varying mix proportions, a graph depicting the variation in compressive strengths at 7 days and 28 days was created. In addition, the normal M25 concrete and the partially replaced M25 concrete can be contrasted with one another.

Using the tabular data and visual representations, we can better understand how the concrete samples performed with varying mix amounts. These findings and discussions help evaluate the performance of material substitutions and their effect on the concrete's compressive strength.

Table 4.1 Compressive strength results for mixed proportion of different materials.

S.no	Designation	Mix Ratio						
		Rise Husk (kg)	SCBA Kg)	Cement (Kg)	GP (Kg)	Sand (Kg)	7 Days (Mpa)	28 Days (Mpa)
1	Mix 1	0	0	5	0	5	17.8	27.8
2	Mix 2	0	0	5	1.5	3.5	15.31	27.11
3	Mix 3	0.125	0.125	4.75	1.25	3.75	19.90	29.56
4	Mix 4	0.25	0.25	4.5	1.25	3.75	20.48	33.40
5	Mix 5	0.35	0.35	4.25	0.5	4.5	21.35	36.01
6	Mix 6	0.5	0.5	4	0.5	4.5	23.28	36.47
7	Mix 7	0.625	0.625	3.75	0.25	4.75	21.08	34.01
8	Mix 8	0.75	0.75	3.5	0	5	19.70	32.62

Table 4.1 shows the percentages of each component in the final mix, together with the matching 7-day and 28-day compressive strengths. In column 2, the various mix ratios are shown, and in the columns that follow, the various amounts of RHA, SCBA, cement, glass powder (GP), and sand are listed. We also provide the compressive strength values we measured after various curing times.

Looking at the data, it's clear that 5 kg of cement and 5 kg of sand were used to make Mix 1. The cement-water ratio was kept constant at 0.45. Compressive strength was 17.8 MPa after 7 days, and 27.8 MPa after 28 days.

Now, we'll be mixing We used 2.5 kilogramme of cement, 3.5 kg of sand, and 1.5 kg of GP. After 7 days, the compressive strength was at 15.31 MPa, but by 28 days, it had increased to 27.11 MPa.

Cement, RHA, SCBA, sand, and GP were all scaled down to 4.75 kilogrammes, 1.25 kilogrammes, 3.75 kilogrammes, and 1.25 kilogrammes, respectively, for Mix 3. Both the 7-day and 28-day compressive strengths increased significantly, to 19.90 and 29.56 MPa, respectively.

Mix 4 includes revised proportions of 4.5 kilogrammes of cement, 0.25 kilogrammes of RHA, 0.25 kilogrammes of SCBA, 3.75 kilogrammes of sand, and 1.25 kilogrammes of GP. There was an increase in compressive strength from 7 MPa to 20 MPa after 7 days, and from 33 MPa to 33 MPa after 28 days.

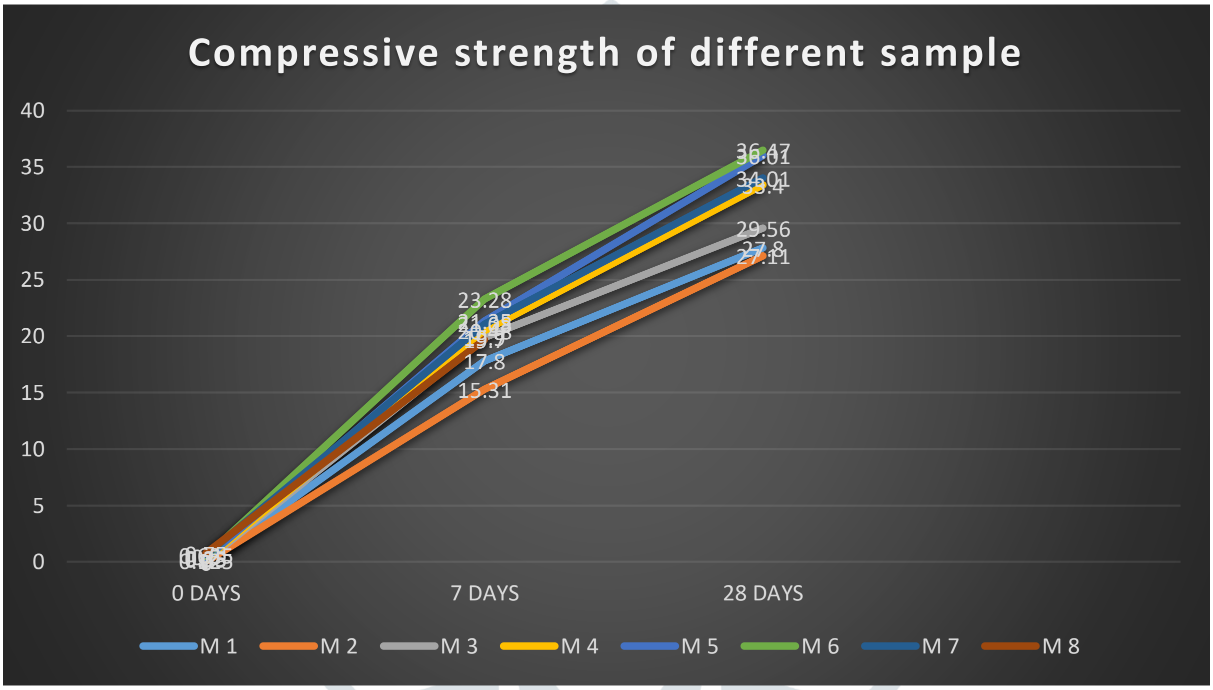
The fifth mixture had 4.25 kilogrammes of cement, 0.35 kilogrammes of RHA and SCBA, 4.5 kilogrammes of sand, and 0.5 kilogrammes of GP. Compressive strength increased from 21.35 MPa after 7 days to 36.01 MPa after 28 days.

Measurements for Mix 6 were modified to yield four kilogrammes of cement, half a kilogramme of RHA and SCBA, four and a half kilogrammes of sand, and half a kilogramme of GP. At 7 days, the compressive strength was at 23.28 MPa, and at 28 days, it had increased to 36.47 MPa, albeit slightly.

Additions of 3.75 kilogrammes of cement, 0.625 kilogrammes of RHA and SCBA, 4.75 kilogrammes of sand, and 0.25 kilogrammes of GP were made to the original proportions for Mix 7. At 7 days, the compressive strength was 21.08 MPa, and at 28 days, it had dropped to 34.01 MPa.

Without any sand replacement, Mix 8 consists of 3 kilogrammes of cement, 0.75 kilogrammes of RHA, and 0.75 kilogrammes of SCBA, together with 5 kilogrammes of sand. At 7 days, the compressive strength values dropped to 19.40 MPa, and at 28 days, they dropped to 32.62 MPa.

There was an increase in compressive strength across the board for the first set of mix proportions, and a drop for the last set. These findings shed light on how different mix proportions affected the performance and strength of the concrete samples.



Compressive strength of graphs

The results of the experiments show that the M25 mould can be used to produce concrete with adequate strength for construction when sand is replaced with glass powder and cement is replaced with biomaterials like bagasse ash or rice husk ash.

CONCLUSION

There was a steady increase in the concrete samples' compressive strength, which peaked at 20 MPa. The slope of the compressive strength graph gradually flattened out after this maximum was reached. Only Mix 5 had a strength greater than the standard M25 mix, whereas the other mixes all had strengths less than M25.

In particular, of all the tested quantities, the one with a blend of 0.35% rice husk ash and 0.35% bagasse ash showed the greatest strength. This demonstrates that these biomaterials work well as partial cement replacements to improve the concrete's strength qualities.

In sum, the results of this study show promise for the use of biomaterials and glass powder as environmentally friendly alternatives in concrete production. The construction industry can help with waste management and lessen its environmental impact by using these materials, all while keeping the strength requirements of their many projects met.

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