

AGRO-WASTES AS SUBSTITUENT OF FINE AGGREGATES IN CONCRETE

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Abstract- The mining of construction grade sand, which is used as fine aggregates in concrete, is the most disastrous activity that threatens the very existence of the river ecosystems. The aim of this research is to partially replace fine aggregates in concrete by various agricultural wastes. In this study, corncob ash, groundnut shell and sugarcane bagasse ash are used as the replacing fillers. These agro wastes are utilized as 0%, 5%, 10%, 15% and 20% as fine aggregates in concrete. Different properties of fresh concrete are investigated for these agro-waste fillers and various tests such as slump, shrinkage and density are carried out. In the hardened state of agro – waste concrete, various tests such as compressive strength, flexural strength, ultrasonic pulse velocity tests were determined at the age of 7 days, 28 days, 56 days and 90 days. With increasing percentage of replacement of rice husk ash, groundnut shell and sugarcane bagasse ash with fine aggregate, the slump value decreased while slump value increased with increase in corncob ash as a replacement material. Till optimal replacement of 20% of fine aggregate with sugarcane bagasse, the minimum compressive strength was achieved while maximum compressive strength was achieved for 5% replacement of groundnut shell with fine aggregate. Corncob ash as a replacement of 10% with fine aggregate showed maximum strength and ultrasonic pulse velocity showed decreased strength with increase in corncob content in concrete. Thus the utilization of agro – wastes proves to be very sustainable and eco – friendly in construction.

Keywords: Agro-waste concrete, Corncob ash, Groundnut shell, Sugarcane bagasse.

1. INTRODUCTION

Sand – used as fine aggregates in concrete plays a major role as fillers which contribute strength to the concrete. Over extraction of sand from river bed is not only depleting the natural resources but are also responsible for detrimental environmental changes. In order to provide a optimal and sustainable solution, the study focuses on the partial replacement of fine aggregates with agro – wastes in concrete. In this research, agro – wastes such as Corncob ash, Groundnutshell and Sugarcane bagasse are used as the partial replacement of fine aggregates.

Corncob ash utilization as a partial replacement of fine aggregates in concrete provides eco- friendly solution of ash disposal problem, which may otherwise create air pollution and may adversely affect human health [1]. The utilization of sugarcane bagasse as filler material in self compacting concrete and revealed that it exhibit improved durability to concrete [2]. Groundnut shell used as partial replacement of fine aggregates possesses maximum compressive strength at 5% replacement while sugarcane bagasse possesses minimum strength at 20% replacement [3]. The mechanical properties of concrete using clay brick as fine aggregate substitution and concluded that between 15-25% fine aggregate replacements the compressive strength of 45 – 58 MPa was achieved [4].

1.1 Sugarcane Bagasse used as replacement of fine aggregates in concrete

After crushing and extraction of Juice from sugarcane, the fibrous residue left over is known as ‘bagasse’. These bagasses are burnt and are converted into bagasse ash which is then used as fine aggregate replacement in concrete to minimize the use of natural aggregates. The bagasse samples to determine the crystalline characteristics by X – ray diffractometry and particle morphology by SEM analysis. In X-ray diffractometry test results, Quartz appeared as the principle element of sugarcane bagasse ash. SEM analysis revealed that samples of sugarcane bagasse ash were made up of grains with varied shapes and sizes up to 150µm [5]. Authors suggested that these findings reveal that sugarcane bagasse has binding properties and can be a suitable substitute of fine aggregates in concrete.



Fig. 1.1 Sugarcane Bagasse Ash

1.2 Groundnut Shell powder used as replacement of fine aggregates in concrete

Groundnut shell was first planted in South Africa mainly Brazil and later spread to other part of America, Asia and North-Western Argentina [5]. The problem of pollution is effectively solved by the utilization of groundnut shell in

the construction industry. The groundnut shell is used in the powder form as the replacement of fine aggregates. Groundnut shell is used for making roof sheet materials. For developing sandcrete blocks [7] and also as cement replacement [8] and as fine aggregate replacement [9], [10] and [6]).



Fig. 1.2 Groundnut shell Ash

1.3 Corncob Ash used as replacement of fine aggregates in concrete

Corncob is the agriculture waste obtained from maize crop. Corncob is discarded as waste in many developing countries. Burning of Corncob produces air pollution which results in serious repercussions on human health. The utilization of Corncob Ash as fine aggregate helps in conserving natural aggregate resources. Corncob used as substitution of blended cement [11. [12] determined the pozzolanic potential of Corncob Ash as replacement of cement in cement based composites.

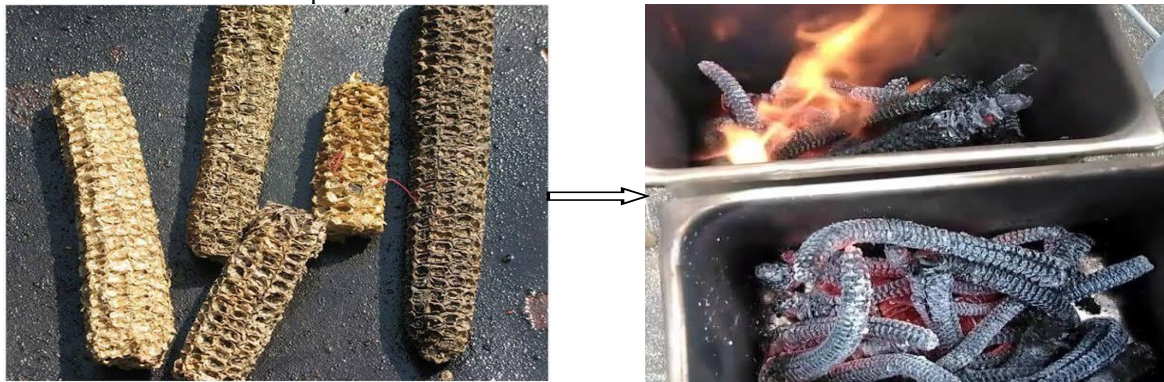


Fig. 1.3 Corncob Ash

2. METHODS

2.1 Experimental Investigation

The physical properties of various agro – wastes viz.sugarcane bagasse ash, groundnut shell, corncob ash along with sand are presented below.

Table-2.1 (a) Physical Properties of Sand and Agro Wastes

Properties	Sand [13],[10, [14]	Sugarcane Bagasse Ash [13,14]	Groundnut Shell [10]	Corncob Ash [1]
Specific Gravity	2.38-2.64	1.25 -2.54	-	1.15
Fineness Modulus	2.21 –3.44	1.42-2.12	-	2.35
Water Absorption (%)	0.74- 2.9	0.88	1.61	27.24

From Table 2.1 (a), it is observed that specific gravity and fineness modulus of agro – wastes are almost similar or less than the natural sand. Specific gravity and fineness modulus of Sugarcane Bagasse Ash satisfied the guidelines of IS 2386 Part -3 (Indian Standard, 1963) and Part – 1(Indian Standard, 1963b) [14]. According to [1], the fineness modulus of Corncob ash lie within the range specified by ASTM C 33 (2.3 -3.1). The specific gravity of Corncob Ash was found to be lower than sand and thus influence the density of concrete while water absorption percentage of Corncob ash is 15 times than that of natural sand. It is clear from the table that the Groundnut shell has water absorption percentage which lies within the range of natural river sand. The determination of physical properties of each agro-waste products and comparative study of each with that of sand makes them suitable candidate to be used as substitute of sand.

Table-2.1 (b) Chemical Properties of Agro Wastes

Properties	Sugarcane Bagasse Ash [13], [14]	Corncob Ash [1]
SiO ₂	64.23 – 90	63.73
Al ₂ O ₃	2.85 – 4.28	15.08
Fe ₂ O ₃	4.76 – 6.98	5.32
CaO	1 – 11.8	6.56
MgO	0.07 – 3.61	4.56
SO ₃	1.48	-
K ₂ O	3.19 – 3.53	2.05
P ₂ O ₅	0.23 – 2	2.5
Fe	2 – 4	-
N	0.2 – 0.3	-
Na ₂ O	-	0.1
TiO ₂	0.02	0.06
Mn ₂ O ₃	0.02	0.03
S ₂ O	0.09	-
K ₂ + Na ₂	5 – 10	-
Ash Content	1.86 – 4.73	2.3

Table 2.1 (b) shows the chemical properties of agro – wastes. It is suggested that for both sugarcane bagasse ash and corncob ash, the sum of SiO₂, Al₂O₃ and Fe₂O₃ is more than 70%, which is the required chemical composition of natural Pozzolana according to ASTM C618 (American Society for Testing and Materials, 2005). Thus, replacing fine aggregates with these agro – wastes in concrete or mortar could help in the process of hydration.

2.2 Selected Mix Proportion of Agro- waste Concrete

The mix proportions selected for various agro - waste based concrete were found out. Various researchers had followed different codes such as IS 10262:2009 (Indian Standards, 2009), ACI 211.1 (American Concrete Institute, 1991), KCI (Korea Concrete Institute, 1999) etc. for mix proportioning the agro – waste concrete.

3. TEST RESULTS AND DISCUSSIONS

3.1 Slump Test

Slump test is the most commonly used test for determining workability of all types of concrete. The measure of height of subsidence of concrete in a slump cone determines the workability of that particular concrete. The workability increases with higher w/c ratio. Table 4 shows the slump value of different agro-waste based concrete with different replacement levels. Researches on Sugarcane bagasse ash and Groundnut shells based concrete revealed that the slump value decreased with the increase in replacement percentage. Decrease in slump value of these agro-waste based concrete was due to high water absorption capacity which declined the flow ability of the mix at same w/c ratio. But in case of Corncob ash based concrete, slump value increased with increase in percentage of replacement.

Table-3.1 Slump Value

Percentage of Replacement	Bagasse Ash [13]	Ground nut shell [10]	Corncob Ash [1]
0	110 mm	52 mm	51 mm
2.5	-	-	-
5	-	38 mm	-
7.5	-	-	-
10	78 mm	-	-
12.5	-	-	-
15	-	20 mm	-
20	65 mm	-	165 mm
25	-	15 mm	-
30	32 mm	-	-
40	7 mm	-	-
50	-	5 mm	-
75	-	5 mm	-

3.2 Compressive Test

The compressive strength test for Sugarcane Bagasse was evaluated as per IS 516:1959 (Indian Standards, 1959). [13], [14] reported that Sugarcane Bagasse Ash with a replacement of 10% of fine aggregate in concrete showed an increasing compressive strength, but further increases of bagasse ash decreased the strength. Figure below represents the compressive strength of bagasse ash based concrete in different mix proportions and curing periods. In case of M30 grade concrete, [14] it is identified that at a replacement of 20% of bagasse ash with fine aggregates in concrete; the minimum compressive strength is achieved.

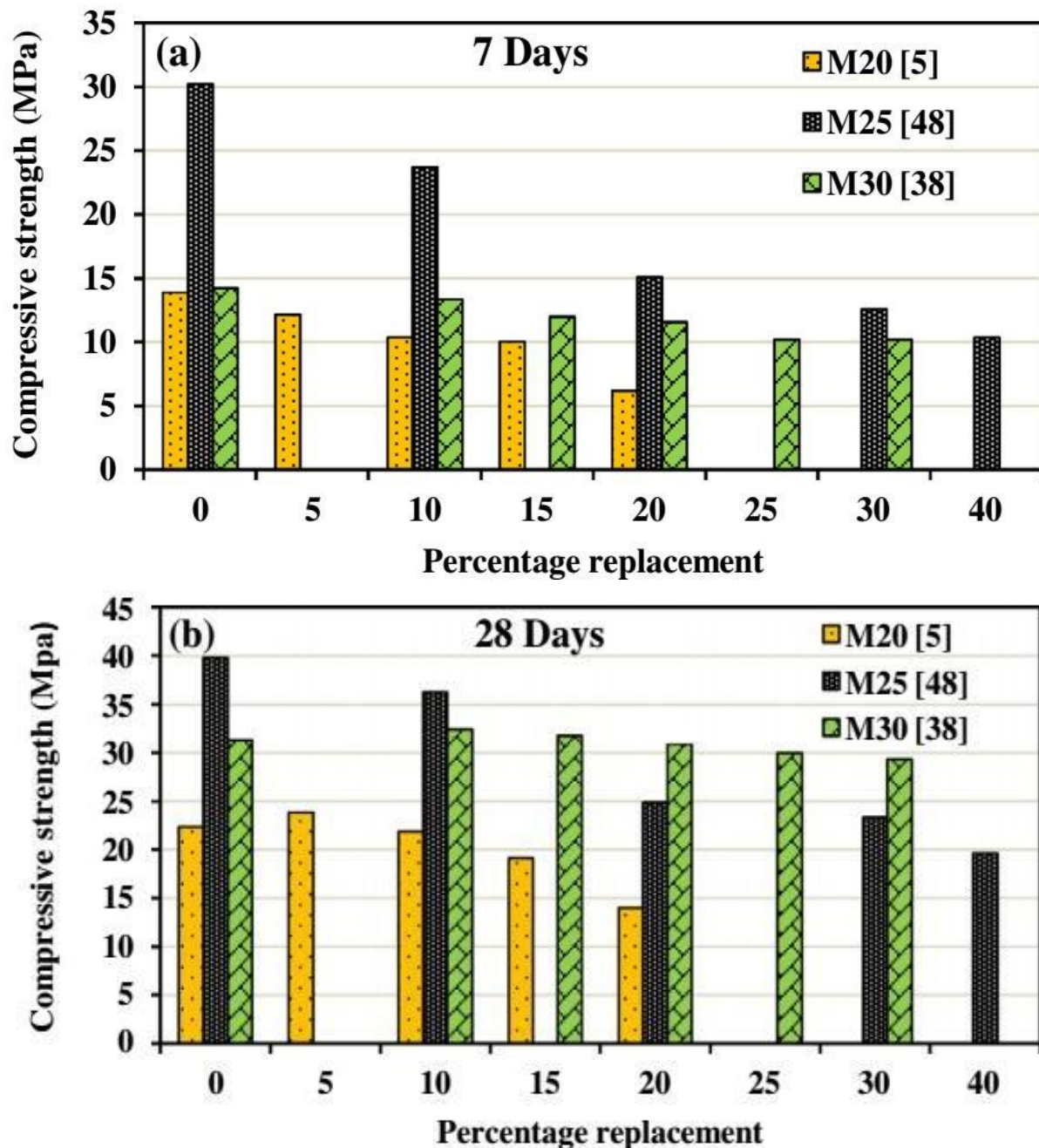


Fig. 4.1 Compressive strength of bagasse ash concrete at (a) 7 days and (b) 28 days

4. FUTURE RECOMMENDATIONS

The following future studies are recommended on the basis of the review made with agro-waste as partial replacement of fine aggregate in concrete.

- Limited research work had been carried out in the area of utilization of agro-waste as fine aggregate in concrete. Thus a comparative study of engineering properties on every agro-waste concrete with conventional concrete can be conducted.
- Limited studies are conducted on durability property of agro – waste based concrete. Therefore, durability property of every type of agro – waste can be carried out.
- Various mechanical properties such as tensile and flexural Strength, UPV, elastic modulus could be studied on all agro- waste based concrete.
- Thermal property and strength variation of all these agro-waste based concrete can be determined in the future research work.

CONCLUSION

The following conclusions were drawn from the study:

- For Sugarcane bagasse ash and Groundnut shells based concrete, the slump value decreased with the increase in replacement percentage while corncob ash based concrete, slump value increased with increase in percent age of replacement.
- Sugarcane Bagasse Ash with a replacement of 10% of fine aggregate in concrete showed an increasing compressive strength, but further increase of bagasse ash decreased the strength while compressive strength decreased with the increase in the percentage of corncob ash in the concrete mix. The compressive strength of concrete at 28 days was approximately 22 MPa.
- Sorptivity coefficient increases with increase in percentage of sugarcane bagasse ash and decrease with an increase in compressive strength while water absorption of control and corncob ash mixes decreased with age.

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