https://doi.org/10.36375/prepare_u.iei.a191

Comparative Study of Concrete made using Rice Husk Ash, Rice Straw Ash and Bamboo Leaf Ash

Rajiv Sharma Leihaothabam, Khwairakpam Sachidananda
Department of Civil Engineering
NIT Manipur
Langol, Imphal, Pin-795004
E-mail: rajivleihaothabam@gmail.com

Abstract – In order to negate the effect of cement production, many researchers are studying the use of different industrial and agricultural wastes to develop sustainable concrete. Among them, Rice husk ash (RSA), Rice straw ash (RSA) and Bamboo leaf ash (BLA) are used for partial cement replacement. This paper gives the comparative study of the specific gravity, chemical compositions, compressive strength, tensile strength and sorptivity of concrete made using RHA, RSA and BLA. A few papers have been referred where the cement contents in concrete have been replaced by 5%, 10%, 15% and 20% of its total weight by RHA, RSA and BLA. The values of compressive strength, tensile strength and sorptivity developed at 28 days of curing are used for this study. Highest value of compressive strength is observed when 15% of the total weight of cement is replaced by RHA, followed by 10% BLA concrete and then by 5% BLA concrete. Highest value of tensile strength is observed at 15% RHA concrete, followed by 15% RSA concrete and then by 10% BLA concrete. Lowest value of sorptivity is observed when 15% of the total weight of cement is replaced by BLA.

Keywords – Concrete: Rice husk: Rice straw: Bamboo leaf ashes.

INTRODUCTION

Cement production is one of the main contributors of environmental pollution. The process of cement production leads to the emission of greenhouse gases. It also requires a lot of energy for fuel consumption. Even by changing the typical process of fuel consumption, cost of production can be reduced significantly and it can also help in reducing the negative effects of cement production. Therefore, different industrial and agricultural waste materials should be adopted for fuel in cement production [1].

Rice husk ash, rice straw ash and bamboo leaf ash are the residues of burning rice husk, rice straw and bamboo leaf respectively. The energy produced while burning can also be used as fuels in cement production. The residues can also be used as partial replacement of cement in concrete. This will greatly help in the environment by saving energy and lowering the carbon footprint.

Rice husk, which is one of the most common agricultural wastes, is a by-product left during rice milling process. It is the outer, non-edible part removed from the rice grain. It is mostly produced in rural areas of developing countries like India. When rice husk is burned, the ash left behind is known as rice husk ash. RSA is around 20% of the total weight of rice husk. This RSA contains high amount of silica, which makes it a suitable pozzolanic material for cement replacement [2].

Rice straw is also one of the most abundantly available agricultural wastes. It is produced during the process of harvesting paddy. This waste is usually disposed and burnt. It gives negative impacts to the environment.

Rice straw is burnt to give rice straw ash. This residue is a pozzolanic material which is suitable for partial cement replacement. The energy produced from burning rice straw can also be used as a fuel for cement production [3].

Bamboo is one of the fastest-growing plants in the world. It is one of the best low-cost materials used for constructing houses especially in rural areas. Using bamboo leaf ash for partial cement replacement will be beneficial to the environment. BLA contains essential chemical compositions which makes it a suitable pozzolanic material [4].

Studies on RHA, RSA and BLA for using them as pozzolanic materials have been done by many researchers. These ashes are mixed at different percentage in concrete as partial replacement of cement. Their physical properties, chemical compositions, compressive and tensile strength developments have been studied. But, only

https://doi.org/10.36375/prepare_u.iei.a191

few studies are available where the comparison of chemical composition, compressive and tensile strengths of concrete made with RHA, RSA and BLA at different percentage of cement replacement is done.

In this review paper, a few papers have been referred where the cement contents in concrete have been replaced by 5%, 10%, 15% and 20% of its total weight by RHA, RSA and BLA. Then, their compressive strengths, tensile strengths and sorptivity values are compared. These comparisons are made easier by converting the values in terms of percentage change.

A. Specific Gravity

Specific gravity of RHA [5], RSA [6] and BLA [7] are given at TABLE 1.

TABLE 1
SPECIFIC GRAVITY OF RHA, RSA AND BLA

	RHA	RSA	BLA
Specific gravity	2.06	2.10	2.64

TABLE 2
CHEMICAL COMPOSITIONS OF RHA, RSA AND BLA

Chemical compositions	RHA	RSA	BLA
SiO_2	87.2%	76%	69.11%
Al_2O_3	0.15%	0.69%	2.52%
Fe_2O_3	0.16%	0.63%	1.74%
CaO	0.55%	4.96%	10.81%
MgO	0.35%	2.65%	1.73%
SO_3	0.24%	1.90%	3.31%
Na_2O	1.12%	1.36%	0.26%
K_2O	3.60%	9.89%	4.81%
P_2O_5	-	-	1.52%
Loss on ignition	6.55%	9.71%	8.15%

B. Chemical Compositions

Chemical compositions of RHA [5], RSA [3,6] and BLA [8,9] are given at TABLE 2.

C. Compressive Strength

The 28 days compressive strength of RHA concrete [10], RSA concrete [10] and BLA concrete [8] at different percentage of cement replacement is given at TABLE 3.

D. Tensile Strength

The 28 days tensile strength of RHA concrete [10], RSA concrete [10] and BLA concrete [8] at different percentage of cement replacement is given at TABLE 4.

E. Sorptivity

Sorptivity in concrete is its ability to absorb and transmit water through it via capillary action. It determines the permeability, durability and water resistance of concrete [9].

For RHA and RSA concrete, the test was done using a plastic container with steel bar of diameter 18 mm kept on the bottom of the container. After the concrete cubes were oven-dried at 105°C for 24 hours and wetted, the test was carried out. The sorptivity values given at 120 minutes were considered [10]. For BLA concrete, the sampled cubes were oven-dried for 24 hours at 110°C, tarried for 72 hours at 50°C and then kept airtight for 15 days. Five faces of each of the cubes were coated and the other side was kept open to the water. Then, the samples were submerged in water [8]. Sorptivity values were taken after 28 days of curing.

TABLE 3
COMPRESSIVE STRENGTH OF RHA, RSA AND BLA CONCRETE AT DIFFERENT % CONTENT FOR 28 DAYS OF CURING

% Content	Compressive strength (N/mm²)		
	RHA Concrete	RSA Concrete	BLA Concrete
0%	38.88	38.88	26.90
5%	36.36	31.42	27.60
10%	37.80	33.37	28.50
15%	42.80	38.63	25.50
20%	38.47	34.35	24.10

TABLE 4
TENSILE STRENGTH OF RHA, RSA AND BLA CONCRETE AT DIFFERENT % CONTENT FOR 28 DAYS OF CURING

% Content	Tensile strength (N/mm²)		
	RHA Concrete	RSA Concrete	BLA Concrete
0%	2.62	2.62	2.46
5%	2.24	2.32	2.67
10%	2.66	2.63	2.76
15%	2.90	2.85	2.41
20%	1.98	1.93	2.18

RESULTS AND DISCUSSION

Compressive Strength

To compare the compressive strengths of RHA concrete, RSA concrete and BLA concrete at different percentage of cement replacement, the percentage change in their compressive strengths are calculated and given at TABLE 5.

https://doi.org/10.36375/prepare_u.iei.a191

The comparison is done for 28 days of curing. Illustration of this change is also given at Fig. 1.
The compressive strength of RHA concrete decreases at 5% RHA content, then it increases when cement is replaced by 10% and 15% of its weight by RHA. Then, it again decreases at 20% RHA content. The compressive strength of the concrete at 15% RHA content is higher than the normal concrete i.e. when the RHA content is 0%.
The pattern of percentage change in compressive strength of RSA concrete for its different percentage is almost similar to that of RHA concrete. But, the compressive strengths of RSA concrete at different percentage content of cement replacement are lower than the normal concrete i.e. when the RSA content is 0%.
For BLA concrete, the compressive strength increases till 10% BLA content and then decreases. The compressive strength of the concrete at 10% and 5% BLA content is higher than the normal concrete i.e. when the BLA content is 0%.

TABLE 5
PERCENTAGE CHANGE IN COMPRESSIVE STRENGTH OF RHA, RSA AND BLA CONCRETE AT DIFFERENT % CONTENT

% Content	Percentage change in Compressive strength		
	RHA Concrete	RSA Concrete	BLA Concrete
0%	0	0	0
5%	-0.94672	-2.86344	0.1883
10%	-0.388	-2.10684	0.4304
15%	1.552	-0.06596	-0.3766
20%	-0.12804	-1.7266	-0.7532

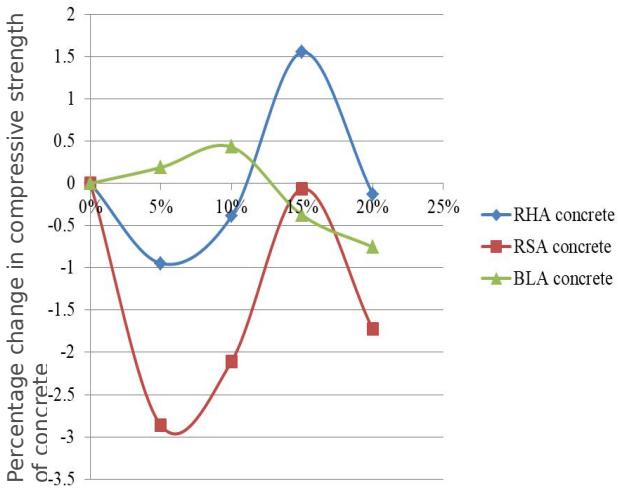

Fig. 1 Percentage change in compressive strength of RHA, RSA and BLA concrete at different % content

From Fig. 1, it is observed that the compressive strength of RHA concrete with 15% content is the highest. It is followed by 10% BLA concrete and then by 5% BLA concrete. Other mixes give the compressive strengths lower than that of the normal concrete mix.

Tensile Strength

To compare the tensile strengths of RHA concrete, RSA concrete and BLA concrete at different percentage of cement replacement, the percentage change in their tensile strengths are calculated and given at TABLE 6. The comparison is done for 28 days of curing. Illustration of this change is also given at Fig. 2.
The tensile strength of RHA concrete decreases at 5% RHA content, then it increases when cement is replaced by 10% and 15% of its weight by RHA. Then, it again decreases at 20% RHA content. The tensile strength of the concrete at 15% RHA content is higher than the normal concrete i.e. when the RHA content is 0%. The pattern of percentage change in tensile strength of RSA concrete for its different percentage content is also similar to that of RHA concrete.
Similarly, the tensile strength of RSA concrete decreases at 5% RSA content and then increases till 15% RSA content.

TABLE 6
PERCENTAGE CHANGE IN TENSILE STRENGTH OF RHA, RSA AND BLA CONCRETE AT DIFFERENT % CONTENT

% Content	Percentage change in Tensile strength		
	RHA Concrete	RSA Concrete	BLA Concrete
0%	0	0	0
5%	-0.14744	-0.1164	0.05649
10%	0.01552	0.00388	0.0807
15%	0.10864	0.08924	-0.01345
20%	-0.24832	-0.26772	-0.07532

https://doi.org/10.36375/prepare_u.iei.a191

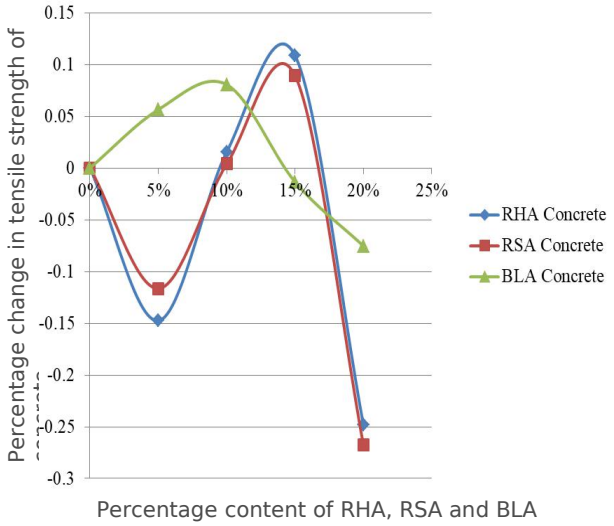

Fig. 2 Percentage change in tensile strength of RHA, RSA and BLA concrete at different % content

It again decreases at 20% RSA content. The tensile strength of the concrete at 15% RSA content is higher than the normal concrete i.e. when the RSA content is 0%. It is also observed that the tensile strengths of 10% RHA concrete and 10% RSA concrete are slightly higher than that of the normal concrete mix.

For BLA concrete, the tensile strength increases till 10% BLA content and then decreases. The tensile strength of the concrete at 10% and 5% BLA content is higher than the normal concrete i.e. when the BLA content is 0%. This pattern is similar to its percentage change in its compressive strength.

From Fig. 2, it is observed that the tensile strength of RHA concrete with 15% content is the highest, followed by 15% RSA concrete and then by 10% BLA concrete.

Sorptivity

To compare the sorptivity of RHA concrete, RSA concrete and BLA concrete at different percentage of cement replacement, the percentage change in their sorptivity values are calculated and given at TABLE 7. Illustration of this change is also given at Fig. 3.

The sorptivity value of RHA concrete decreases till 10% RHA content. It then slightly decreases and then increases

TABLE 7
PERCENTAGE CHANGE IN SORPTIVITY VALUE OF RHA, RSA AND BLA CONCRETE AT DIFFERENT % CONTENT

% Content	Percentage change in Sorptivity value		
	RHA Concrete	RSA Concrete	BLA Concrete
0%	0	0	0
5%	-0.01402	-0.03079	-0.03623
10%	-0.03079	-0.03639	-0.03643
15%	-0.03079	-0.01782	-0.03722
20%	-0.02911	-0.00832	-0.03564

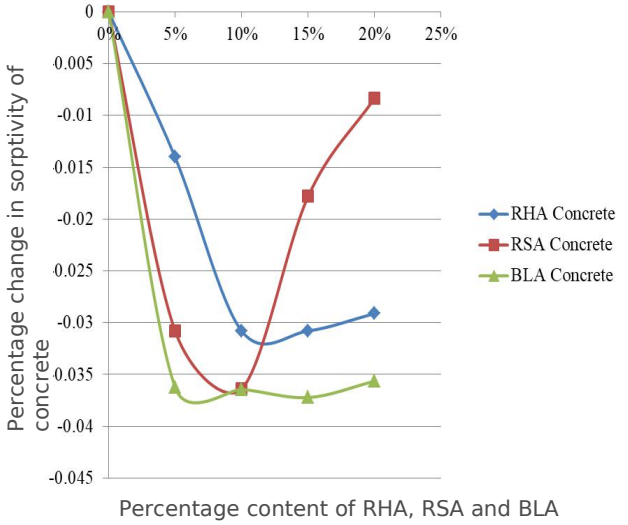

Fig. 3 Percentage change in sorptivity value of RHA, RSA and BLA concrete at different % content

till 20% RHA content.

For RSA concrete, the sorptivity value decreases till 10% RSA content and then it increases till 20% RSA content.

The sorptivity value of BLA concrete decreases at 5% BLA content and then it slightly decreases and then increases till 10% BLA content. This value decreases at 15% content and then increases again at 20% BLA content. Compared to the normal concrete, sorptivity decreases for all of the different mixes of RHA, RSA and BLA. From Fig. 3, sorptivity of BLA concrete at 15% of its content is the lowest.

CONCLUSIONS

Based of this study, following conclusions can be drawn:

1. The compressive strength of concrete replaced with 15% RHA content is higher than the rest of the concrete with different percentage of RHA, RSA and BLA. It is followed by 10% BLA concrete and then by 5% BLA concrete. Other mixes give the compressive strengths lower than that of the normal concrete mix.
2. The tensile strength of concrete replaced with 15% RHA content is higher than the rest of the concrete with different percentage of RHA, RSA and BLA. It is

followed by 15% RSA concrete and then by 10% BLA concrete.

3. The sorptivity value of concrete replaced with 15% BLA content is lower than the rest of the concrete with different percentage of RHA, RSA and BLA.

REFERENCES

[1] N. Zainudeen and J. Jeyamathan, “Cement and its effect to the environment: A case study in SriLanka,” *Proc. from Int. Conf. Build. Educ. Res.* , pp. 1408–1416, 2008, [Online]. Available: http://www.irbnet.de/daten/iconda/CIB11336.pdf.

[2] D. D. Bui, “Rice Husk Ash as a Mineral Admixture for High Performance Concrete.” p. 122, 2001.

[3] M. A. El-Sayed and T. M. El-Samni, “Physical and Chemical Properties of Rice Straw Ash and Its Effect on the Cement Paste Produced from Different Cement Types,” *J. King Saud Univ. - Eng. Sci.*, vol. 19, no. 1, pp. 21–29, 2006, doi: 10.1016/S1018-3639(18)30845-6.

[4] P. Asha, A. Salman, and R. A. Kumar, “Experimental Study on Concrete with Bamboo Leaf Ash,” *Int. J. Eng. Adv. Technol.*, no. 6, pp. 2249–8958, 2014.

[5] G. Rodríguez De Sensale, “Strength development of concrete with rice-husk ash,” *Cem. Concr. Compos.*, vol. 28, no. 2, pp. 158–160, 2006, doi: 10.1016/j.cemconcomp.2005.09.005.

[6] S. Munshi and R. P. Sharma, “Experimental Investigation on Strength and Water Permeability of Mortar Incorporate with Rice Straw Ash,” *Adv. Mater. Sci. Eng.*, vol. 2016, 2016, doi: 10.1155/2016/9696505.

[7] A. A. Umoh and A. O. Ujene, “Empirical Study on Effect of Bamboo Leaf Ash in Concrete,” *J. Eng. Technol.*, vol. 5, no. 2, pp. 71–82, 2014.

[8] O. Onikeku, S. M. Shitote, J. Mwero, and A. A. Adedeji, “Evaluation of Characteristics of Concrete Mixed with Bamboo Leaf Ash,” *Open Constr. Build. Technol. J.*, vol. 13, no. 1, pp. 67–80, 2019, doi: 10.2174/1874836801913010067.

[9] G. Dhinakaran and G. H. Chandana, “Compressive strength and durability of bamboo leaf ash concrete,” *Jordan J. Civ. Eng.*, vol. 10, no. 3, pp. 279–289, 2016, doi: 10.14525/jjce.10.3.3601.

[10] M. T. Ibrahim, G. A. Hamdy, R. M. Abdel-naby, and T. A. El-sayed, “Study of Properties of Concrete Containing Recycled Rice Straw and Rice Husk,” vol. 1, no. 40, pp. 87–101, 2019.