Proceedings of IOE Graduate Conference, 2016
pp. 191–195

Experimental Study on the Properties of Concrete with the Partial Replacement of Sand by Rice Husk

Pushpa Poudyal [1], Ajay Kumar Jha [2]

[1, 2] *Department of Mechanical Engineering, Pulchowk Campus, Institute of Engineering, Tribhuvan University, Nepal*
Corresponding Email: [1] pushpapoudyal7@gmail.com, [2] jhaajaykumar@live.com

Abstract
The suitability of rice husk as an alternative to sand in concrete production was studied here. Rice husk is an agricultural waste obtained from the rice. For this, various properties of concrete mainly workability, bulk density, water absorption, compressive strength and flexural strength were experimentally determined with the partial replacement of sand by rice husk at 0, 10, 20, 30, 40 and 50 percent respectively. M15 grade of concrete was prepared at 0.60 water cement ratio considering weight batching. The experimental results showed that the workability of the concrete increased with the increase in percent replacement of sand by rice husk. Similarly, the water absorption also increased while the bulk density, compressive strength and flexural strength of the samples decreased with the increasing amount of rice husk content in the mixtures. The research suggested that up to 10 percent replacement of sand by rice husk, the concrete so produced could be used for building compressive and flexural members of the structure.

Keywords
concrete – rice husk – sand – workability – bulk density – water absorption – compressive strength – flexural strength

1. Introduction

In various civil engineering works, the concrete is used extensively worldwide. As a composite material, the constituents of concrete include binding material (mostly cement), aggregates (fine and coarse) and water. In concrete work, the main function of fine aggregate or sand is to produce workability and uniformity in the mix due to its well graded nature. According to the Indian Standard Soil Classification System, the soil having grain size ranging between 0.075mm to 4.75mm is considered as sand.

With the concern rising about the environmental conservation, the issues of degradation and pollution of environment have become the hot topic in today's world. As concrete composes the sand as essential constituents, the main source of it is, naturally flowing rivers. On the extraction of huge amount of sand from rivers not only causes the shortage of it but also creates the serious problem to the environment. Erosion and failure of river banks, lowering of river beds and damage of structures situated closer to the rivers are the major adverse effects of it. According to Obilade[1], the use of agricultural and industrial wastes to complement other traditional materials in construct in provides both practical and economic advantages. In the world, to find the best alternative of the concrete constituents, various experiments have been carried out by the replacement of certain portion of concrete constituents with materials such as rice husk ash[2], corn cob ash[3], fly ash[4], hemp[5] etc. Also with the replacement of fine aggregate partially by rubber[6], saw dust and waste paper[7], waste glass powder or polyethylene aggregates[8] etc., the study of various physical and mechanical properties of concrete had been carried out.

According to the report of Economic Survey[9], for the fiscal year 2014/15, nearly 1051 thousand Metric Tons of rice husks were produced as a waste in Nepal. In Nepal, the rice husk has not been used significantly for any purposes besides manufacturing some rice husk stoves targeting the poor people, whose commercialization at large scale is yet to take place.

This shows that the huge amount of rice husk is left unused as waste material annually in Nepal. On the other hand, the waste material rice husk, which is a byproduct of rice, on burning too causes pollution to the environment. So, with motive to utilize the rice husk as an alternative to the sand, this research was designed to investigate the effect of rice husk content on the properties of concrete mainly workability, density, water absorption, compressive strength and flexural strength.

2. Methodology

2.1 Materials

The materials used in this experimental research work were cement, fine and coarse aggregates or gravel, rice husk and water. Cement used was Ordinary Portland Cement of Shivam brand. Fine and coarse aggregates available in Institute of Engineering, Pulchowk Campus had been used for the experiment. Similarly rice husk used for the experiment was collected from local mills located at Surya Binayak, Bhaktapur District. The water used was free from impurities.

2.2 Experimental Works

The physical properties of materials were determined at first. As per IS[10] and [11], the normal consistency, soundness, initial and final setting time, compressive strength and specific gravity of cement were determined as 31%, 2 mm, 64 minutes, 280 minutes, 58.30 N/mm^2 and 3.15 respectively. Water absorption and specific gravity of aggregates were determined as 2.74 and 1.42% respectively for fine aggregates and 2.70 and 1.19% respectively for coarse aggregates. Sieve analysis was performed as per IS[12] to determine the particle size distribution of rice husk, sand and gravel.From the fineness modulus, the average size of particle of sand was found between 0.3mm to 0.6mm while coarse aggregate was found between 20mm to 25mm and rice husk was found between 1.7mm to 2.0mm. At 0%, 10%, 20%, 30%, 40% and 50% respectively, the sand was partially replaced by rice husk. The rice husk used was first soaked in water for 24 hours and then allowed to remain in atmosphere for 1 hour before using in the mix. Mix proportions considering M15 grade of concrete with 0.60 water cement ratio for different percent replacement of sand by rice husk was determined according to IS[13] and [14] shown in Table 1.

Table 1: Mix Proportions

	water	cement	rice husk	sand	gravel
0%	0.60	1	-	1.95	3.87
10%	0.60	1	0.195	1.755	3.87
20%	0.60	1	0.390	1.560	3.87
30%	0.60	1	0.585	1.365	3.87
40%	0.60	1	0.780	1.170	3.87
50%	0.60	1	0.975	0.975	3.87

Concrete cube of size $150 \times 150 \times 150$ mm and beam of size $75 \times 75 \times 300$ mm were prepared by weight batching for the tests. The concrete was manually mixed, placed in three layers compaction. As per IS[15], slump tests were performed to determine the workability of fresh concretes. After the 24 hours of sample preparation, they were cured in curing tank for 28 days. As per IS[16], the bulk density, water absorption and compressive strength were determined afterwards taking the average of three cube samples for each different mix. Similarly, the flexural strength was determined taking the average of three beam samples considering three point loadings.

3. Results and Discussion

The experimental results obtained are shown in Table 2. Six different concrete mixes containing different percentage of rice husk as replacement of sand were tested. The results are represented as an average of three samples for each.

Table 2: Experimental Results

	slump (mm)	Bulk Density (kg/m^3)	Water Absorption (%)	Compressive Strength (MPa)	Flexural Strength (MPa)
0%	13	2353.33	0.51	20.73	3.80
10%	21	2246.67	0.55	16.06	2.86
20%	30	2186.67	0.58	9.70	2.51
30%	40	1930.00	0.62	5.04	1.96
40%	56	1570.00	0.70	2.28	1.14
50%	75	1220.00	0.88	0.91	0.57

3.1 Workability

The results of slump obtained are shown in Table 2. The value of slump increased with the increase in amount of rice husk in the concrete mixes. The slump values varied between 13 mm to 75 mm. The increase in slump must

be due to the use of saturated rice husk in the mixtures. Figure 1 shows the exponential relationship between the slump and percent of sand replacement by rice husk.

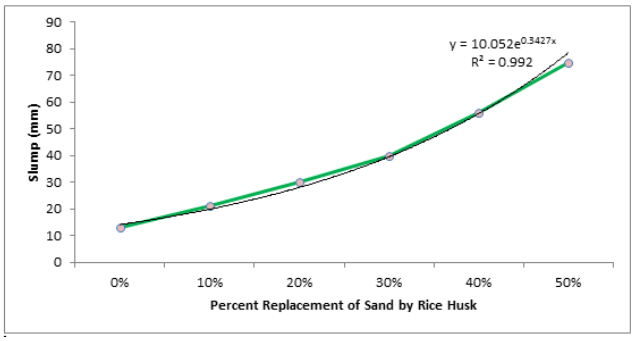

Figure 1: Variation of Slump of Fresh Concrete containing different percentage of Rice Husks

3.2 Bulk Density

The results of bulk density obtained from experimental works are shown in Table 2.The bulk density decreased with the increase in amount of rice husk resulting a lightweight concrete. Lightweight concretes are mainly suitable to build moderate bearing capacity structures with the use of less reinforcement[17].Figure 2 shows the graphical relationship between bulk density and percent replacement of sand by rice husk.

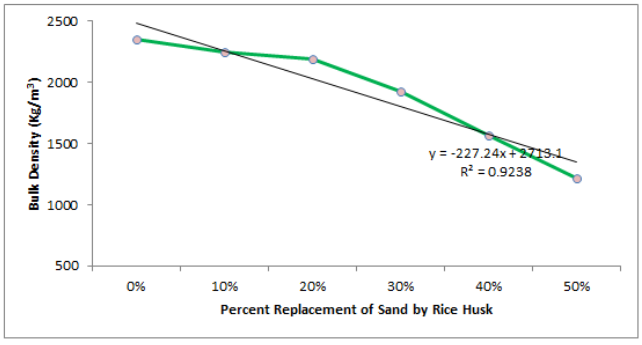

Figure 2: Variation of Bulk Density of Concrete containing different percentage of Rice Husks

3.3 Water Absorption

The results obtained of water absorptions are shown in table 2. The water absorption increased with the increase in amount of rice husk in the mixes. Higher water absorption indicates a higher porosity in the sample[18]. Due to the hand mix and compaction of sample, the values of water absorption are highly affected here. Figure 3 shows the graphical relationship between water absorption and percent replacement of sand by rice husk.

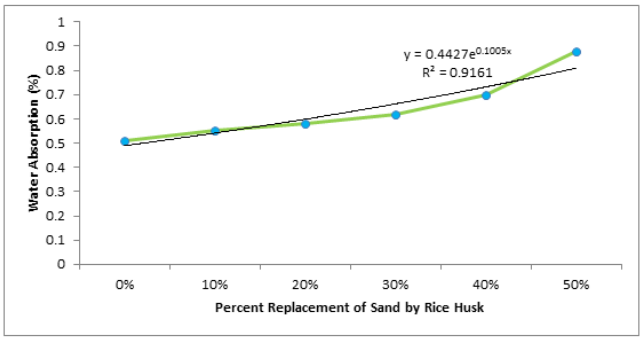

Figure 3: Variation of Water Absorption of Concrete containing different percentage of Rice Husks

3.4 Compressive Stength

The average compressive strength, containing different proportions of rice husk obtained after 28 days of curing are shown in Table 2. From the results plotted in graph as shown in figure 4, the compressive strength of concrete decreases with the increase in contain of rice husk in the mix.

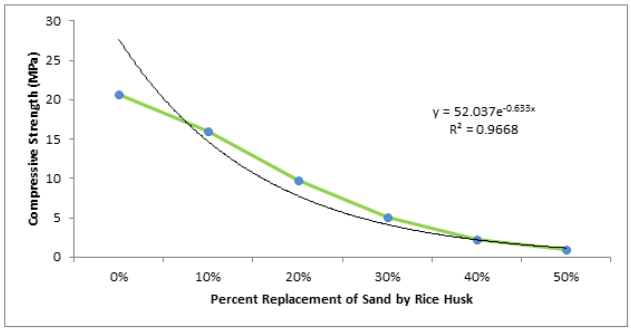

Figure 4: Variation of Compressive of Concrete containing different percentage of Rice Husks

It is observed that for 0 percent replacement of sand the average compressive strength was 20.73 N/mm^2. Similarly for 10 percent, 20 percent, 30 percent, 40 percent and 50 percent replacement of sand by rice husk the average compressive strength were 16.06 N/mm^2, 9.70 N/mm^2, 5.04 N/mm^2, 2.28 N/mm^2 and 0.91 N/mm^2 respectively. Decrease in strength must be due to high water absorption capacity of rice husk. It is

observed that up to the 10% of replacement of sand by rice husk gives the required designed strength of concrete i.e. 15MPa.

3.5 Flexural Strength

The average flexural strength, containing different proportions of rice husk are shown in Table 2. From the results plotted in graph as shown in figure 5, the flexural strength of concrete decreases with the increase in contain of rice husk in the mix. It is observed that for 0 percent replacement of sand the average flexural strength was 3.80 N/mm^2. Similarly for 10 percent, 20 percent, 30 percent, 40 percent and 50 percent replacement of sand by rice husk the average flexural strength were 2.86 N/mm^2, 2.51 N/mm^2, 1.96 N/mm^2, 1.14 N/mm^2 and 0.57 N/mm^2 respectively. Decrease in strength must be due to high water absorption capacity of rice husk.

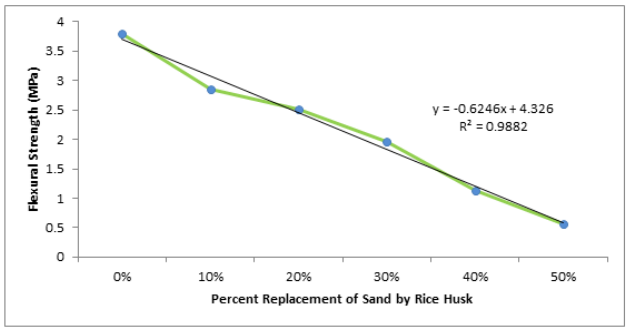

Figure 5: Variation of Flexural Strength of Concrete containing different percentage of Rice Husks

3.6 Relation of Water Absorption with Compressive Strength of concrete

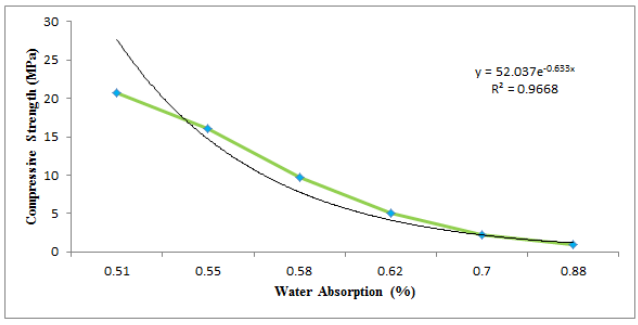

Figure 6: Relation of Water Absorption with Compressive Strength of concrete

Figure 6 shows that with increase in water absorption, the compressive strength of concrete decreases. The value of R^2 = 0.9668, confirmed that the low compressive strength of concrete is mainly due to high water absorption.

3.7 Relation of Bulk Density with compressive strength of concrete

Figure 7 shows that with increase in bulk density, the compressive strength of concrete increases exponentially. The value of R^2 = 0.9668, confirmed that the compressive strength of concrete changes directly with the change in bulk density.

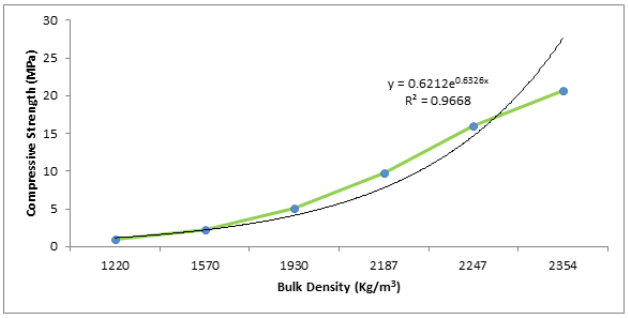

Figure 7: Relation of Bulk Density with compressive strength of concrete

3.8 Relation of Water Absorption with Bulk Density of concrete

Figure 8 shows that with increase in water absorption, the bulk density of concrete decreases linearly. The value of R^2 = 0.9238, strongly correlated the relationship between them.

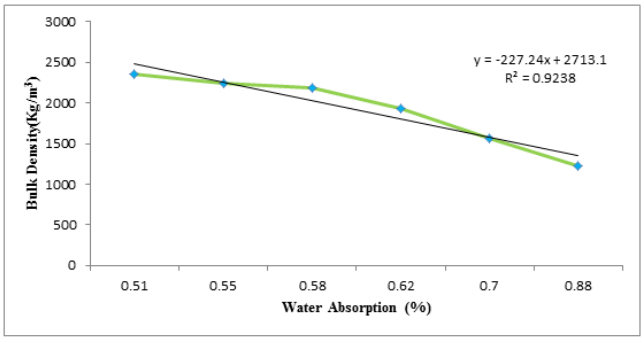

Figure 8: Relation of Water Absorption with Bulk Density of concrete

4. Conclusions

The workability and water absorption of concrete increase while the bulk density, compressive strength and flexural strength decrease with the increase in percent replacement of sand by rice husk. With the increasing amount of rice husk content, the lightweight concretes are formed which could be suitable for building non load bearing light structures. The 28 days compressive and flexural strength for up to 10 percent replacement of sand by rice husk were found to be above the specified strength of M15 grade of concrete. From the experimental results, it can be concluded that not more than 10 percent replacement of sand with rice husk is suitable for building load bearing and flexural members of the structures. These findings are important as the concern of environmental depletion issues and their conservations are rising worldwide. This study suggested that rice husk could be one of the suitable alternatives to natural sand in construction industries as a constituent of lightweight concrete.

5. Recommendation

For future work, similar research should be carried out considering different grades of concrete and water cement ratios for better results.

References

[1] I.O. Obilade. Experimental study on rice husk as fine aggregates in concrete. *The International Journal Of Engineering And Science (IJES)*, 3:9–14, 2014.

[2] M. I. Malik, A. Manzoor, B. Ahmad, S. Syed, and R. Ali. Effectiveness of use of rice husk ash as partial replacement of cement in concrete. *International Journal Of Modern Engineering Research (IJMER)*, (5):49–54, 2015.

[3] A. A. Raheem, S. O. Oyebisi, and M. I. Oyeniran. Effects of admixtures on the properties of corn cob ash cement concrete. *Leonardo Electronic Journal of Practices and Technologies*, 16:13–20, 2010.

[4] S. Wang and L. Baxter. Comprehensive study of biomass fly ash in concrete: Strength, microscopy, kinetics and durability. *Fuel Processing Technology*, 88:1165–1170, 2007.

[5] T. Colinart, P. Glouannec, and P. Chauvelon. Influence of the setting process and the formulation on the drying of hemp concrete. *Construction and Building Materials*, 30:372–380, 2012.

[6] T. C. Ling. Prediction of density and compressive strength for rubberized concrete blocks. *Construction and Building Materials*, 25:361–366, 2011.

[7] E. P. Aigbomian and M. Fan. Development of wood-crete building materials from sawdust and waste paper. *Construction and Building Materials*, 40:361–366, 2013.

[8] S. E. Chidiac and S. N. Mihaljevic. Performance of dry cast concrete blocks containing waste glass powder performance of dry cast concrete blocks containing waste glass powder. *Cement & Concrete Composites*, 33:855–863, 2011.

[9] Ministry of Finance. Economic survey. Technical report, Government of Nepal, 2014/15.

[10] Bureau of Indian Standards, New Delhi. *IS 2386-3 (1963. Methods of Test for Aggregates for Concrete, Part 3: Specific gravity, density, voids, absorption and bulking*.

[11] Bureau of Indian Standards, New Delhi. *IS 2386-5 (1963). Methods of Test for Aggregates for Concrete, Part V: Soundness*.

[12] Bureau of Indian Standards, New Delhi. *IS 2386-1 (1963). Methods of Test for Aggregates for Concrete, Part I: Particle Size and Shape*.

[13] Bureau of Indian Standards, New Delhi. *IS 10262 (2009). Guidelines for concrete mix design proportioning*.

[14] Bureau of Indian Standards, New Delhi. *IS 456 (2000). Code of Practice for Plain and Reinforced Concrete (Fourth Revision)*.

[15] Bureau of Indian Standards, New Delhi. *IS 7320 (1974). Specifications for Concrete Slump Test Apparatus*.

[16] Bureau of Indian Standards, New Delhi. *IS 516 (1959). Methods of Tests for Strength of Concrete*.

[17] L. Gunduz and I. Ugur. The effects of different fine and coarse pumice aggregate/cement ratios on the structural concrete properties without using any admixtures. *Cement Concrete Res.*, 35:1859–1864, 2004.

[18] P. O. Akinwumi, O. M. Awoyera, A. A. Olofinnade, Busari, and M. Okotie. Rice husk as a concrete constituent: Workability, water absorption and strength of the concrete. *ASIAN JOURNAL OF CIVIL ENGINEERING (BHRC*, 17:887–898, 2016.