Use of Rice Husks as partial replacement of coarse aggregates in concrete paving blocks

Mwalimu K. Musau[1], Douglas Shitanda[2], Michael Githinji[3], Caroline Mwende[4]

[1,3,4], Building and Civil Engineering Department, Machakos University- Kenya
[2]Agriculture department, Machakos University- Kenya

Published: 31 July 2020

Abstract
Concrete paver blocks were first introduced in Holland in the fifties as replacement of paver bricks which had become scarce due to the post-war building construction boom. These blocks were rectangular in shape and had more or less the same size as the bricks. The blocks are made of cement, sand, and ballast with water.
Paving blocks are widely used in Kenya in residential and commercial areas. They can be used in areas with light or heavy traffic. They come in different sizes and shapes as per structural and client requirements. Rice husks are a byproduct of rice which is widely grown in parts of Central and Western Kenya. Rice husks disposal is a big challenge in rice processing companies with only a handful of it being used by cement manufacturing companies in t heir boilers.
In order to find alternative use of rice husks, this study was carried out to investigate its suitability for use in paving blocks as partial replacement of coarse aggregates. Seven replacement ratios were used viz: 5%, 10%, 15%, 25%, 50%, 75% and 100%. The samples were tested for compressive strength, tensile splitting strength and water absorption. It was found that, at 5% replacement rate, paving blocks had compressive strength of 65.61MPa which is suitable for use in high traffic areas. In addition, 10% and 25% replacement rate produced paving blocks suitable for use in medium traffic areas with compressive strength of 46.86MPa, 45.08MPa respectively.

Key words: rice husks, compressive strength, tensile splitting test, water absorption.

Cite this article: Musau, M.K., Shitanda, D., Githinji, M., Mwende, C. (2020). Use of Rice Husks as partial replacement of coarse aggregates in concrete paving blocks. *European International Journal of Science and Technology*, 9(7), 26-34.

1. INTRODUCTION

Paving blocks are concrete products that are easy to manufacture and at any location as long as there is adequate space and water. This has made the use of paving blocks widespread. They are versatile, aesthetically attractive, functional and cost effective and require little or no maintenance if correctly manufactured and laid (B. Shanmugavalli et al., 2017).

Concrete paver blocks were first introduced in Holland in the fifties as replacement of paver bricks which had become scarce due to the post-war building construction boom. These blocks were rectangular in shape and had more or less the same size as the bricks. During the past five decades, the block shape has steadily evolved from non-interlocking to partially interlocking to fully interlocking to multiply interlocking shapes (Nataraja & Das, 2012)

The blocks are made of cement, sand, and ballast with water. To ensure the blocks are strong enough to carry vehicular loading, the mixing must be done in the right ratio and adequate curing for at least seven days. Paver block is, unreinforced pre-cast cement concrete paving units used in the surface course of pavement. They are high strength concrete mouldings in various shapes, sizes and colours(Pitroda et al., 2015).

Currently, the focal challenges facing the building and housing sector are highlighted and emphasized on the reduction of environmental impact. In this context, an environmentally and friendly sustainable materials using renewable and indigenous resources are in full development(Winarno, 2019). Agricultural waste disposal is a menace in most countries Kenya included. One of the agricultural wastes is rice husk with only a handful of the waste being used in boilers for cement manufacturing companies. Rice husks are agro-industrial by-products coming from rice hulling. Due to its low nutritional value, it is not considered appropriate for use as animal feed. The siliceous composition of rice husks makes it resistant to natural degradation which can produce large environmental load (Salas & Veras Castro, 1985).

Adequate alternative disposal arrangements must be considered to avoid environmental degradation. With the growing Kenyan population, demand for housing and commercial centers is equally increasing. This provides a large consumer for eco-friendly concrete and concrete products. This formed the basis of this research.

2. EXPERIMENTAL PROGRAM

2.1 Materials

2.1.1 Fine aggregates

River sand was purchased from local suppliers in Machakos town. It conforms with standards in BS 882 including, being clean, free of salts and other inorganic substances.

2.1.2 Coarse aggregates

Well graded coarse aggregates of sizes 5-12mm were purchased from local suppliers in Machakos town.

2.1.3 Cement

Portland cement N-32 was purchased locally in from suppliers in Machakos town. This is the most popular type of cement in Kenyas construction industry.

2.1.4 Water

Portable water from the University was used.

2.1.5 Rice husks

Rice Husks was purchased from Mwea Rice Growers Multipurpose Co-operative Society Ltd in Kirinyaga county.

Figure 1: Rice husks

3.0 MIX PROPORTIONS

The batching of materials was done using percentage by volume. The mix ratio was 1:0.5:1 (cement, sand and coarse aggregates). A control sample of M35 was prepared. Seven different samples were prepared at 5%, 10%, 15% 25%, 50%, 75% and 100% coarse aggregates replacement ratios. A constant water-cement ratio of 0.4 was used. The mix proportions are shown in the table 1.

Table 1: Mix proportions

S. No.	Description	Cement	Rice Husks	Fine Aggregates	Coarse Aggregates
1	C35	1	0	0.5	1
2	5% Replacement	1	0.05	0.5	0.95
3	10% Replacement	1	0.10	0.5	0.90
4	15% Replacement	1	0.15	0.5	0.85
5	25% Replacement	1	0.25	0.5	0.75
6	50% Replacement	1	0.50	0.5	0.50
7	75% Replacement	1	0.75	0.5	0.25
8	100% Replacement	1	1.00	0.5	0.00

All dry ingredients (cement, rice husks, fine aggregates and coarse aggregates) were carefully measured and poured in a concrete mixer where they were mixed for 3 minutes. Water was then added and mixing continued for five minutes. Due to the small volume of the concrete, it was further hand mixed in a mixing tray for two minutes. Total mixing time was ten minutes.

4. PRODUCTION OF PAVING BLOCKS

Concrete mixture was poured in a semi-automated moulding machine and well distributed. It was then vibrated for three minutes to ensure that no void spaces within the mould and to remove air bubbles present within the mix. The loaded timber mould was then transferred to a flat surface and allowed to dry for 24hrs. The demolded pavers were put in curing containers for stipulated time of 7,14,21 ad 28 days. The produced concrete blocks were rectangular in shape and measured 60mm*100mm*200mm

Fig 2: Semi-automated moulding machine

5. TESTS

A. Compressive strength test

In order to study the strength development in concrete, compressive strength tests were conducted at the ages of 7, 14, 21 and 28 days.

Compressive strength (N/mm^2)= Load at failure/area of the sample


Figure 3: Compressive strength test.

B. Split tensile test

After 28 days of curing, the samples were tested for split tensile strength.


Fig 5: Split sample

T=2P/πLd.
Where: T= splitting tensile strength
P=maximum applied load indicated by testing machine
L=length
D=diameter

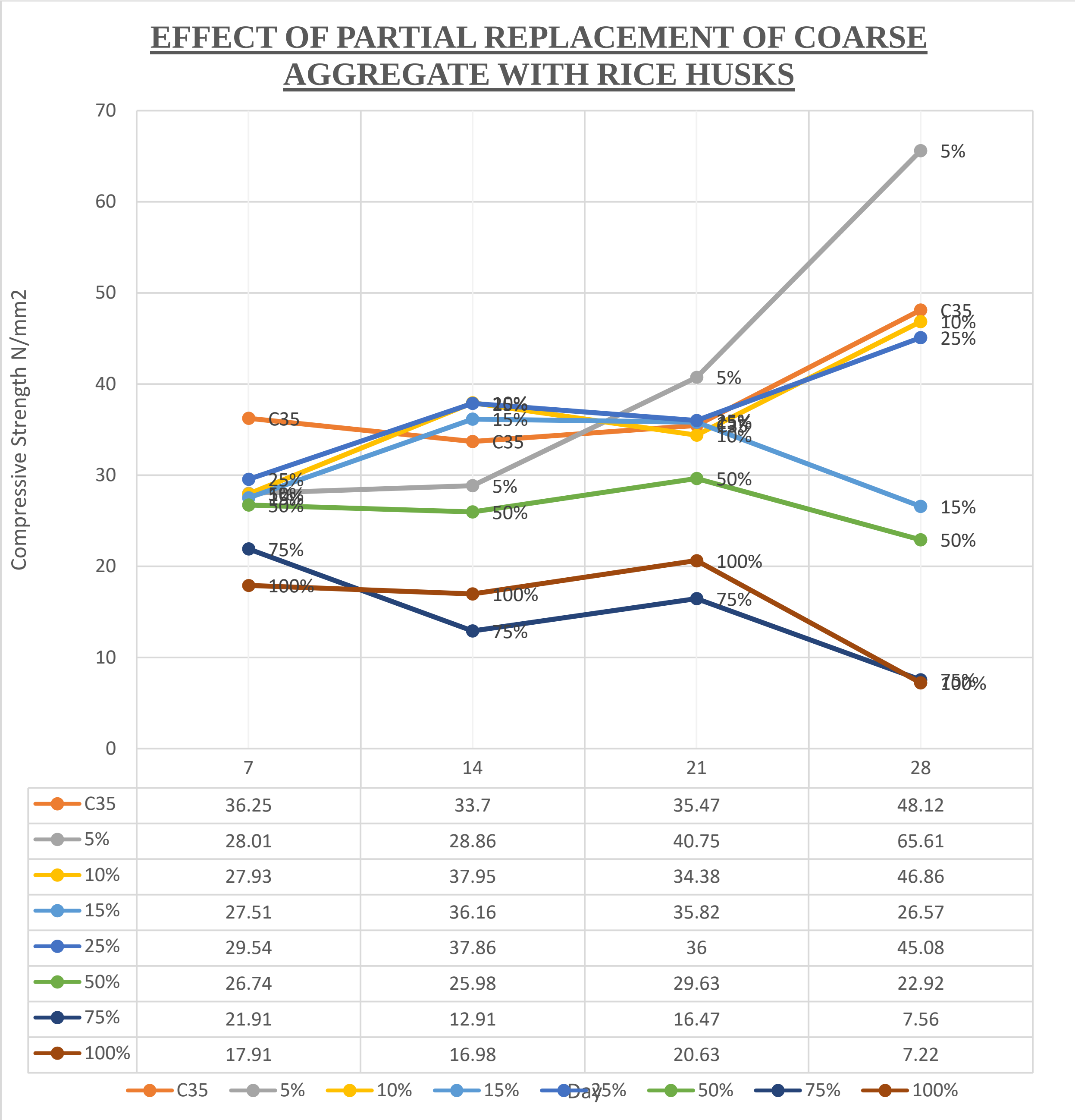
C. Water absorption

After 28 days of curing, samples were tested for water absorption. They were first weighed to get the wet weight, then placed in oven for 24 hrs. at 105^{o}C after which they were weighed to get oven dry weight.
Water absorption= ((WW-DW)/DW) *100
Where WW-wet weight
DW-dry weight after oven drying

6. RESULTS AND DISCUSSION

A. Compressive strength

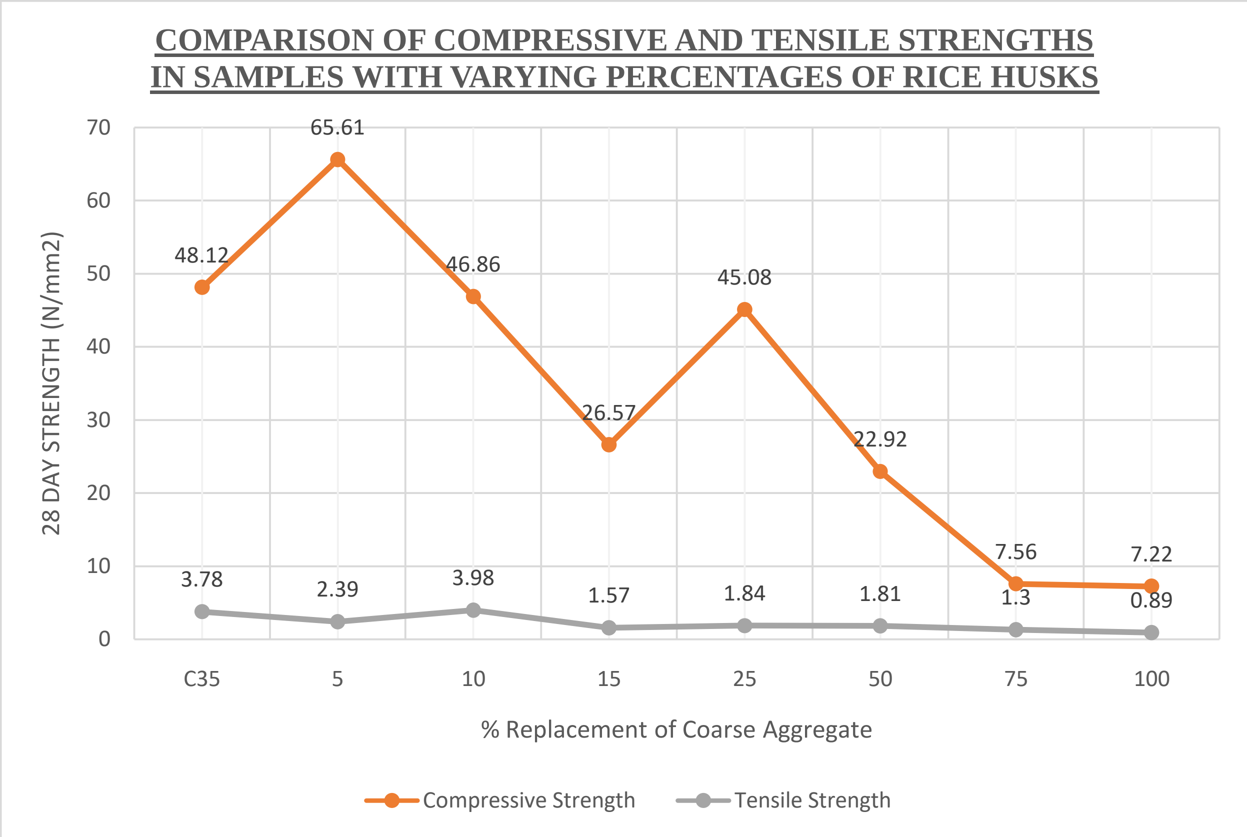
Compressive strength development over time is shown in figure 5.



	7	14	21	28
C35	36.25	33.7	35.47	48.12
5%	28.01	28.86	40.75	65.61
10%	27.93	37.95	34.38	46.86
15%	27.51	36.16	35.82	26.57
25%	29.54	37.86	36	45.08
50%	26.74	25.98	29.63	22.92
75%	21.91	12.91	16.47	7.56
100%	17.91	16.98	20.63	7.22

Fig 6: Partial replacement of coarse aggregates with rice husks.

At 5% replacement ratio of coarse aggregates, the concrete had the highest compressive strength of 65.61MPa. As the rate of replacement increased, ie, 10%, 15%, 25%, 50%, 75%, and 100% the compressive strength was 46.86MPa, 26.57MPa, 45.08MPa, 22.92MPa, 7.56MPa and 7.22MPa respectively. Paving blocks made with 5% coarse aggregates replacement ratio can be used to pave heavy traffic areas whilst those made with 10% replacement ratio can be used to pave medium traffic areas. Concrete made by rice husks provides an outstanding lightweight concrete because of the interconnected network of porosity which characterizes these materials (Winarno, 2019). In such, lightweight materials are well suitable for use in earthquake prone areas.



B. Split tensile test

Fig 7: Tensile strength test

Tensile strength was seen to decrease with increase in rice husks content. similar trend was observed for compressive strength. However, at 5% replacement ratio, tensile strength was 2.39 N/mm^2 while the compressive strength was 65 MPa. When in use therefore, the paving blocks should be laid in such a manner that the loading is axial. The splitting tensile strength of concrete is mainly affected by the paste quality. The properties of aggregates affect the quality of paste and interfacial transition zone

C. Water absorption

Results for water absorption are shown in figure 8.

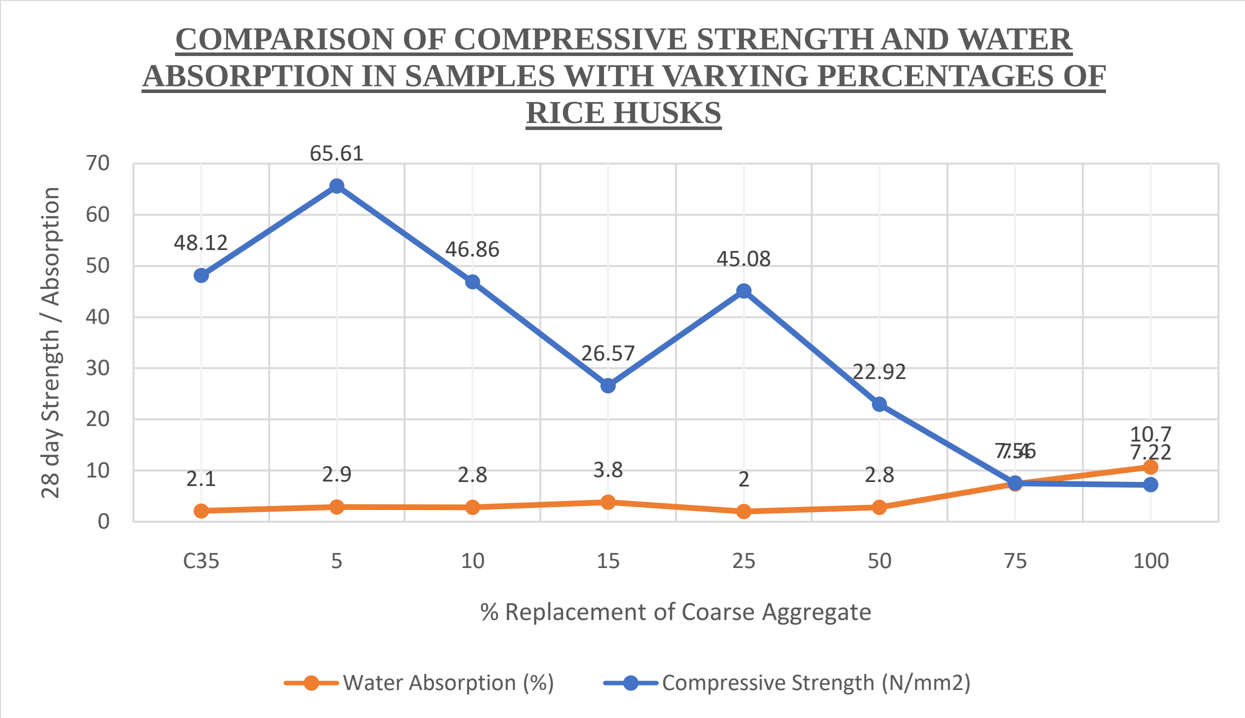


Fig 8: Rate of water absorption

Water absorption rate was varying for each replacement ratio. The highest water absorption rate was at 100% replacement rate at 10.7 %.The rate of water absorption was inversely proportional to compressive strength. ASTM states that the average absorption of test samples shall not be greater than 5% with no individual unit greater than 7%(El Nouhy & Zeedan, 2012). Higher water absorption indicates a higher porosity in concrete (Meikandaan, 2016).

7. CONCLUSION

The results of this study show that, coarse aggregates can be replaced with rice husks. Paving blocks made with 5% rice husks in place of coarse aggregates have a compressive strength suitable for use in high traffic areas. In addition, with 10% and 25% replacement rates, the paving blocks can be used for medium traffic pavements. Due to the nature of rice husks, the resulting concrete is lightweight.

REFERENCES

1. B. Shanmugavalli, K. Gowtham, P. Jeba Nalwin, & B. Eswara Moorthy. (2017). Reuse of Plastic Waste in Paver Blocks. *International Journal of Engineering Research And*, *V6*(02), 313–315. https://doi.org/10.17577/ijertv6is020162

2. El Nouhy, H. A., & Zeedan, S. (2012). Performance evaluation of interlocking paving units in aggressive environments. *HBRC Journal*, *8*(2), 81–90. https://doi.org/10.1016/j.hbrcj.2012.09.003

3. Meikandaan, T. P. (2016). Study on properties of concrete with partial replacement Of cement by rice husk ash. *Journal of Chemical and Pharmaceutical Sciences*, *9*(2), E232–E234.

4. Nataraja, M. C., & Das, L. (2012). *A study on the strength properties of paver blocks made from unconventional materials SCMS School of Engineering and Technology*. 1–5.

5. Pitroda, J., Report, F., Turbine, W., & Waste, B. (2015). *Effect on Compressive Strength and Water Absorption of Interlocking Paver Block By Addition of ...August*.

6. Salas, J., & Veras Castro, J. (1985). Materiales de construcción con propiedades aislantes a base de cascara de arroz. *Informes de La Construcción*, *37*(372), 53–64. https://doi.org/10.3989/ic.1985.v37.i372.1856

7. Winarno, S. (2019). Comparative Strength and Cost of Rice Husk Concrete Block. *MATEC Web of Conferences*, *280*, 04002. https://doi.org/10.1051/matecconf/201928004002