# USE OF RICE HUSKS ASH AS PARTIAL REPLACEMENT OF CEMENT IN CONCRETE PAVING BLOCKS

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**ABSTRACT:**

*Concrete paving blocks were first introduced in Holland to replace paver bricks which had become scarce due to the post-war building construction boom. In Kenya, paving blocks are used in construction of pavements in both residential and commercial areas. They can be used in areas with light or heavy traffic. Rice husks are a byproduct of rice and its disposal has always been a challenge in Kenya. When the husks are burnt, they produce rice husks ash which was used in this study as partial replacement of cement at 5%, 10%, 15% and 25%. Compressive strength and water absorption tests were carried out. As the content of rice husks increased, compressive strength decreased. At 5% and 10% replacement ratios, concrete compressive strength was 36.76MPa and 33.79MPa. which is suitable for use in light traffic areas. Water absorption increased as rate of replacement increased. However, it was below 5% recommended by ASTM.*

**Keywords**: *paving blocks, compressive strength, water absorption.*

## 1.0 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. 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. Concrete Paving Blocks consists of a surface layer of small-element, solid unreinforced pre-cast concrete paver blocks laid on a thin, compacted bedding material which is constructed over a properly profiled base course and is bounded by edge restraints/kerb stones. The block joints are filled using suitable fine material (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.

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).

Rice is widely grown in different parts of the country including Mwea in Kirinyaga county. A visit to Government owned rice milling company; Mwea Rice Millers pointed the menace rice husks waste is to the country. Cement manufacturing companies buy the by-product to use in their boilers. The same applies to majority of rice production companies with some like Mwea Rice Growers Multipurpose Co-operative Society Ltd burning 20% of the husks while mechanically drying paddy rice during rainy season.

The growing Kenyan population resonates with increasing demand for food, rice inclusive. This calls for alternate immediate ways to use the agricultural by-product in order to protect the environment whilst creating employment for the increasing population. Rice husks Ash is a by-product from the burning of rice husk (Omoniyi *et al.,* 2013). The burning process should be carried out under controlled temperature of below 800oC (Zareei *et al.,* 2017).

The need to reduce the high cost of Ordinary Portland Cement in concrete has intensified research into the use of some locally available materials that could be used as partial replacement for Ordinary Portland Cement (OPC) in Civil Engineering and Building Works (Al-Khalaf *et al.,* 1984)

It is generally recognized that incorporation of pozzolanic materials as partial replacement to Portland cement in concrete is an effective means for improving the properties of concrete. This is due to the fact that calcium hydroxide produced by cement hydration reacts with pozzolana and produces additional calcium silicate hydrate (CSH) gel, blocking existing pores and altering the pore structure (Omoniyi *et al.,* 2013). Pozzolanic activity of rice husks ash (RHA) depends on silica content, silica crystallization phase and size and surface area of ash particles. In addition, only a small amount of carbon must be present in ash. Combustion of rice husk at controlled temperature produces RHA that has amorphous silica content and large surface area (Al-Khalaf & Yousif, 1984). It has been reported to be a good pozzolan by numerous researchers. It improves transition area leading to concrete with more packing density (Zareei et al., 2017)

Chindaprasirt *et al.,* 2008; Rukzon *et al.,* 2013 worked on the effect of rice husk ash on cement mortar and concrete, the results showed that compressive strength of concrete samples showed maximum increase 3.08% between RHA 7.50% to 10.00% which decreased further for higher percentage of RHA. They also observed that 12.5% of rice husk ash by mass of cement is the optimum dose to be added in concrete production particularly when the husk is burnt under filed conditions. Zemke, 2009 concluded that it is important to use rice husk ash substitution for ordinary Portland cement up to 30% so as to decrease the weight of the finished project, decrease the cost and dispose of the rice husk ash waste product.

Kartini *et al.,* 2012 stated that higher percentage of rice husk ash replacement leads to decrease in the compressive strength. However, 10% replacement ratio of cement with rice husk ash attained the targeted compressive strength. Rice husk ash as a reactive pozzolan contributes considerably on optimization of microscopic transition interface zone between paste and aggregate surface in high performance concretes (Bui *et al.,* 2005).

This study was carried out to determine the effect of partial replacement of cement with Rice Husk Ash on compressive strength and water absorption in concrete paving blocks. Concrete samples with cement replacement ratios of up to 25% were prepared and subjected to testing.

# 2.0 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 Ash*

Rice Husks Ash was purchased from Mwea Rice Growers Multipurpose Co-operative Society Ltd. Burning of rice husks produces about 25% ash containing 85% to 90% amorphous silica plus about 5% alumina, which makes it highly pozzolanic (Zareei et al., 2017). Use of rice husk ash compensates the problem of recycling huge amounts of rice husks waste.

**Figure 1: Rice Husks Heap Outside Mwea Rice Growers Multipurpose Co-Operative Society Rice Factory**

## 2.2 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 with 100% cement content was prepared. Four different concrete samples were prepared with 5%, 10%, 15% and 25% cement replacement ratios with Rice Husk Ash. For each replacement ratio, three samples were prepared and tested for compressive strength after 7, 14, 21 and 28 days. Three samples were also tested after 28 days for water absorption. For each run therefore, a total of 15 samples was prepared. A constant water-cement ratio of 0.4 was used for all samples. All dry ingredients (cement, rice husks ash, 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.

The mix proportions are shown in the ***Table 1.***

**Table 1: Mix Design Used in The Study.**

| S. No. | Description | Cement | Rice Husk Ash Parts | Fine Aggregate Parts | Coarse Aggregate Parts |
|---|---|---|---|---|---|
| 1. | C35 Control Sample | 1 | 0 | 0.5 | 1 |
| 2. | 5% Cement Repl. with RHA | 0.95 | 0.05 | 0.5 | 1 |
| 3. | 10% Cement Repl. with RHA | 0.90 | 0.10 | 0.5 | 1 |
| 4. | 15% Cement Repl. with RHA | 0.85 | 0.15 | 0.5 | 1 |
| 5. | 25% Cement Repl.  with RHA | 0.75 | 0.25 | 0.5 | 1 |

*Legend*

*RHA-Rice Husks Ash*

### 2.3 Production of Paving Blocks

Concrete mixture was poured in a semi-automated moulding machine and well distributed using a straight rod. 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. A rectangular mould was used. The loaded timber mould was then transferred to a flat surface and allowed to dry for 24hrs. The demoulded 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.

**Figure 2: Paving Blocks Before Curing**

## 3.0 METHODS

### 3.1 COMPRESSIVE STRENGTH TEST

In order to study the strength development of Rice Husks Ash concrete in comparison to control concrete, compressive strength tests were conducted at the ages of 7, 14, 21 and 28 days. This standard practice of curing is found to be adequate for compressive strength and chloride permeation properties.

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

**Figure 3: Concrete Sample Under Compressive Strength Test**.

### 3.2 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°C after which they were weighed to get oven dry weight.

Water Absorption= ((WW-DW)/DW) *100

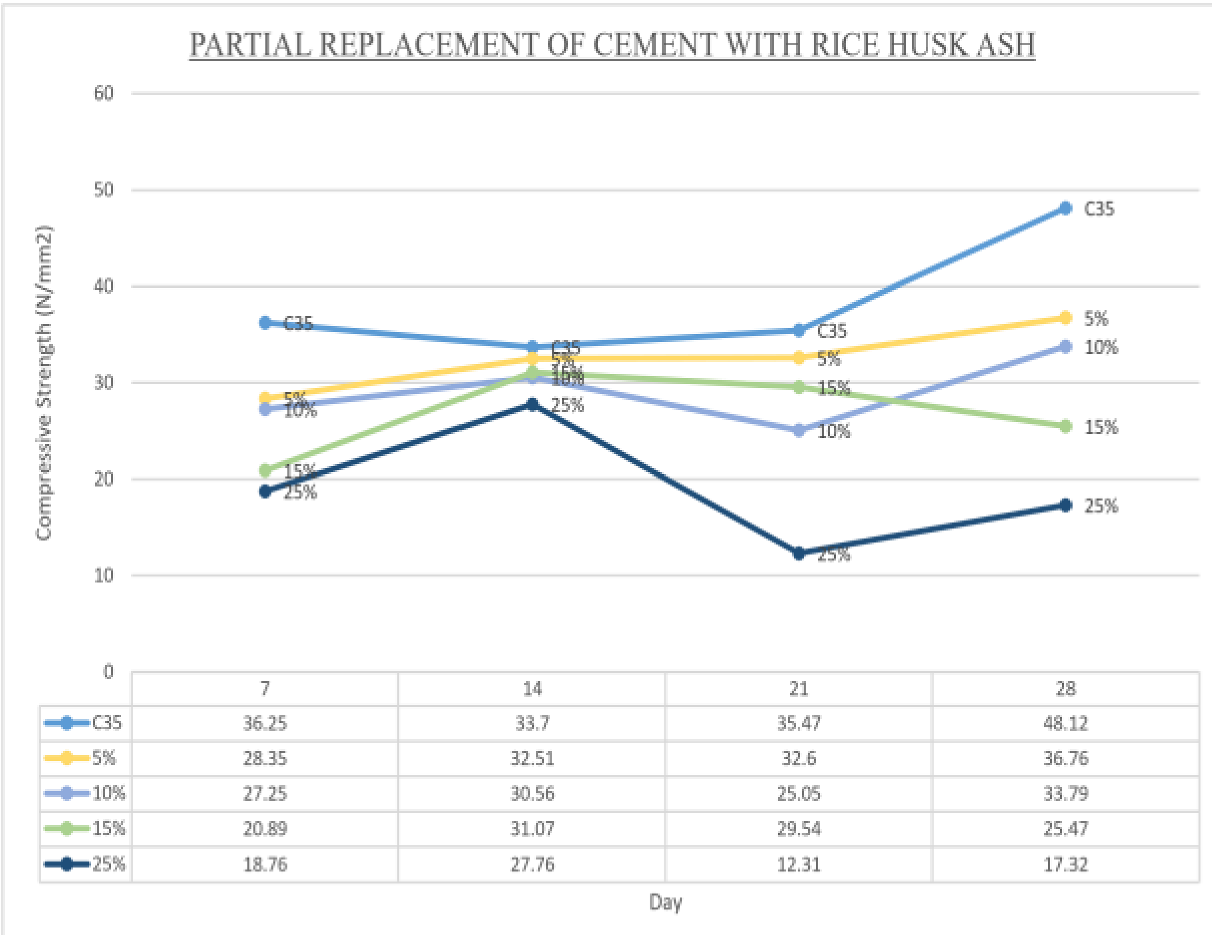
Where WW - Wet Weight

DW - Dry Weight After Oven Drying

## 4.0 RESULTS & DISCUSSION

### 4.1 COMPRESSIVE STRENGTH

Figure 4 shows the compressive strength at different ages of curing.




| | 7 | 14 | 21 | 28 |
|---|---|---|---|---|
| C35 | 36.25 | 33.7 | 35.47 | 48.12 |
| 5% | 28.35 | 32.51 | 32.6 | 36.76 |
| 10% | 27.25 | 30.56 | 25.05 | 33.79 |
| 15% | 20.89 | 31.07 | 29.54 | 25.47 |
| 25% | 18.76 | 27.76 | 12.31 | 17.32 |

**Figure 1: Compressive Strength of Concrete with Different Cement Replacement Ratios**

For cement replacement ratios of 5% and 10% the compressive strengths were 36.76MPa and 33.79MPa. Although these strengths were below that of the control sample, they were above 30 MPa which is suitable strength for paving areas with light traffic. Beyond 10% replacement ratio, the compressive strength started declining up to 17.32MPa at 25% replacement ratio. Concrete blocks with 25.47MPa compressive strength can be used in non-traffic areas.

The increase in strength may be attributed partially to the pozzolanic reaction as reported by many researchers in the past. Similar results were obtained by Zareei et al., 2017 who stated that as the rice husks ash content increased beyond 20%, compressive strength begun to decrease by about 4.5%. Al-Khalaf & Yousif, 1984 concluded that, compressive strength of concrete having 10% replacement was higher than other levels of replacement (5% and 15%). At 28days, concrete containing 10% rice husk ash achieved the highest value of compressive strength of 68N/mm$^2$ against control at 70N/mm$^2$ (Kartini et al., 2012).

## 4.1 Water Absorption

**Table 2: Results for Water Absorption**

| S/No | Description | Wet Weight | Dry Weight | Difference in Grams | % Absorption |
|---|---|---|---|---|---|
| 1 | M35-Control Sample | 3053.6 | 2991.6 | 62 | 2.1 |
| 2 | 5% Cem Replacement With RHA | 2974.8 | 2912.7 | 62.1 | 2.2 |
| 3 | 10% Cem Replacement With RHA | 3170.6 | 3094.9 | 75.7 | 2.5 |
| 4 | 15% Cem Replacement With | 3016.5 | 2930.1 | 86.4 | 3 |
| 5 | 25% Cem Replacement With RHA | 2853.4 | 2756 | 97.4 | 3.6 |

As the content of rice husks ash increases from zero to 25% replacement, the rate of water absorption increases from 2.1% to 3.6%. This was attributed to the increase in solid-volume ratio of the concrete. Increased surface area from the rice husks ash provides attachment avenue for the water molecules. If concrete absorbs excessive water, then its strength starts decreasing and hence the durability of the blocks is reduced. 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).

If water absorption rate is below 10% by mass of the concrete, it can be considered as good concrete. All mixture designation in the present research can therefore be considered as good concrete since the percentage absorption rate only lies between 2.1% to 3.6%. Neville, A.M. (1997).

## 4.0 CONCLUSION AND RECOMMENDATION

The compressive strength of concrete having 5% replacement was found to be more than other levels of replacements (i.e., 10%, 15%, and 25%). The study shows that compressive strength of concrete is optimal by replacing cement with 5% Rice husks ash. However, at 10% replacement rate, the compressive strength of 33.79MPa is also suitable for M30. These results show that, the optimum rate of replacement for supplementary cementitious material is 10%.

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