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(RESEARCH ARTICLE)

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Investigation on the influence of date palm fiber on the strength and durability of concrete with rice husk ash as partial replacement of cement

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Abstract

The utilization of waste materials in concrete production has gained significant attention in recent years as a sustainable approach to mitigate environmental concerns and enhance the performance of construction materials. This research presents the results of laboratory work carried out to determine the strength of concrete reinforced with date palm fiber while replacing cement partially with rice husk ash (RHA). The effect of the use of Date palm fiber was investigated on grade 15 concrete (1:2:4) with water cement ratio of 0.5 with an addition of date palm fiber at 0.5% and replacement of cement with rice husk ash at 0%, 5%, 10%, 15% and 20% of concrete composite. A total of 45 cubes and 45 cylinders were cast to evaluate the workability of freshly mixed concrete, the compressive strength and split tensile strength after 7, 14 and 28 days of curing. Preliminary tests were also carried out to determine some physical/mechanical properties of the materials used, these tests include; Specific Gravity Tests, Sieve Analysis, Crushing Value Tests, Impact Value Tests, Normal Consistency Tests, Setting Time Tests, and Soundness Tests. The results indicate that the optimal compressive strength was achieved with a 10% RHA replacement with the following values; 9.3N/mm2, 11.1N/mm2, 16.9N/mm2, 11.8N/mm2 and 11.7N/mm2 after 28 days of curing. Conversely, the optimum split tensile strength was observed at 5% RHA replacement, measuring; 7.6N/mm2, 7.0N/mm2, 6.4 N/mm2, 5.7N/mm2 and 5.2N/mm2 over the same period.

Keywords: Date palm fiber; Rice husk ash; Concrete; Tensile strength; Compressive strength

1. Introduction

Concrete is a widely used construction material known for its strength and durability. It consists of three main components: aggregates, cement and water. Concrete has very high compressive strength, but it is weak in tensile strength. Steel reinforcements are added to concrete to improve its tensile strength and to prevent cracks, forming a reinforced concrete. However, this approach has limitations, such as cost and potential corrosion due to high permeability of reinforced concrete. Fiber Reinforced Concrete (FRC) is a type of concrete that contains fibrous material which improves its structural integrity. It contains short discrete fibers that are uniformly distributed and randomly oriented. Fibers include steel fibers, glass fibers, synthetic fibers and natural fibers each of which lend varying properties to the concrete. In addition, the character of fiber reinforced concrete changes with varying fiber materials, geometries, distribution, orientation, and densities. The concept of using fibers as reinforcement is not new. Researchers have investigated the use of natural fibers, such as date palm fibers, as reinforcements in cementitious composite, because of their abundance, affordability, and advantageous mechanical qualities.

Date palm fibers (DPFs), which are natural fibers derived from the leaves of date palm trees (Phoenix dactylifera), have been employed as a sustainable reinforcement material for concrete. Cement is one of the most expensive constituents in concrete production and demand for it is steadily rising worldwide. Therefore, it is critical to use contemporary waste materials, mineral admixtures, and other materials to accommodate the growing usage of concrete in order to keep

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building costs under control. In place of cement, different alternative waste materials and industrial by-products such as rice husk ash, fly ash, bottom ash, recycled aggregates, crumb rubber, saw dust, brick bats etc. can be used (Morsy, 2015).

Rice husk Ash is an agricultural by-product on which rice husk is burnt into ashes. RHA is found to be good material which fulfils the physical characteristics and chemical composition of mineral admixtures (Ghosal and Moulik, 2015). It is the hard-protective coverings of rice grains which are separated from the grains during milling process. Rice husk is an abundantly available waste material in all rice producing countries, and it contains about 30%-50% of organic carbon. It can be used for partial replacement of cement or sand in light weight concrete. Usage of the fine rice husk ash reduces the temperature as compared to the normal ordinary Portland cement temperature. RHA depends mainly on silica content, silica crystallization phase, and size and surface area of ash particles (Chirsty, 2021). Hence this research work will look at the possibility of using rice husk ash in other to reduce the usage of cement in concrete, where as the date palm fiber will mitigate the crack in concrete.

2. Material and methods

2.1. Materials

All materials used for the research are locally available and are commonly used in general construction work in the country they include: Cement, Fine aggregate, Coarse aggregate, rice husk ash, date palm fiber and water.

2.1.1. Portland Lime Cement

A Portland limestone cement of grade 42.5N was used in this research work and it was sourced from a dealer in Samaru market.

2.1.2. Fine Aggregate

The fine aggregates used was natural sharp sand having a maximum nominal size of 2.36mm. The fine aggregate used for this research was sourced from a local quarry in Zango, Zaria, Kaduna State.

2.1.3. Coarse Aggregate

These are bigger particles, such crushed stone or gravel, usually larger than 4.76 mm. They give the concrete mixture body and enhance its strength and longevity. The coarse aggregates were sourced from a local quarry in Zango, Zaria, Kaduna State.

2.1.4. Rice Husk Ash

The specimen of rice hush ash was obtained after an open controlled burning of the rice husk in a local furnace for four hours at a temperature range of 600°C to 700°C which was measured with pyrometer. The finely burnt ash was left to cool for 24 hours inside the furnace. It was then grinded for five minutes to obtain a finer particle size with the aid of a stone.

2.1.5. Date Palm Fiber

The date palm fiber was locally sourced within ABU school environment and it was added to the concrete mixture.

Figure 1 Date Palm fiber

2.1.6. Water

Clean tap water from the University (ABU) pipe-borne water system was used for this research.

2.2. Methods

The compressive and tensile strengths of on the date fiber reinforced concrete were carried out in accordance to the BS EN 12390-3 (2019). The compressive and tensile strength tests were carried out to determine the strength of date palm fiber reinforced concrete with rice husk ash as partial replacement. A total of 45 cubes (Figure 2) and 45 cylinders (Figure 3) using varying percentages of RHA to replace cement with 0.5% of date palm fiber were cast with the same W/C ratio of 0.5. the cubes and cylinders were tested each at 7, 14 and 28 days after curing. Three cubes and cylinders were each tested for 7, 14 and 28 days for the varying percentages of RHA.

Figure 2 Fiber reinforced concrete cube samples

Figure 3 Fiber reinforced concrete cylinder samples

3. Results and discussion

3.1. Compressive strength

The results of the compressive strength at various percentage replacement of cement with RHA in the date palm fiber reinforced concrete are presented in figure 4. The compressive strength of the fiber reinforced concrete cubes increases as the RHA replacement percentage increases but a decline was seen as the RHA replacement percentage increases beyond 10%. Therefore, for applications requiring high compressive strength, the RHA replacement should be limited to a maximum of 10%.

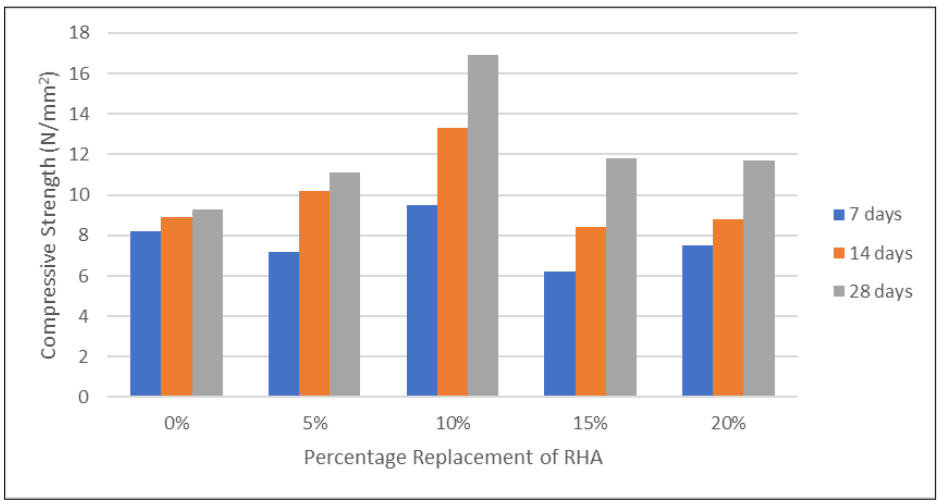

Figure 4 Compressive strength of fiber reinforced concrete at various RHA percentage replacement

3.2. Tensile strength

The results of the tensile strength at various percentage replacement of cement with RHA in the date palm fiber reinforced concrete are presented in figure 5. The tensile strength of the fiber reinforced concrete cylinders decreases as the RHA replacement percentage increases. Therefore, for applications requiring high tensile strength, the RHA replacement should be limited to a maximum of 5%.

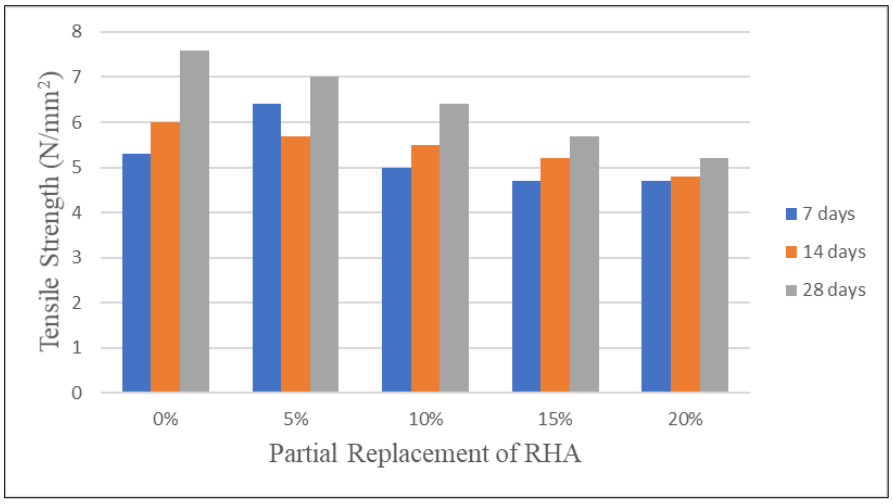

Figure 5 Tensile strength of fiber reinforced concrete at various RHA percentage replacement

3.2.1. Water Absorption

The durability of the date palm fiber reinforced concrete with RHA was determined using the water absorption test. The result is shown in figure 6 for the samples cured for 28 days.

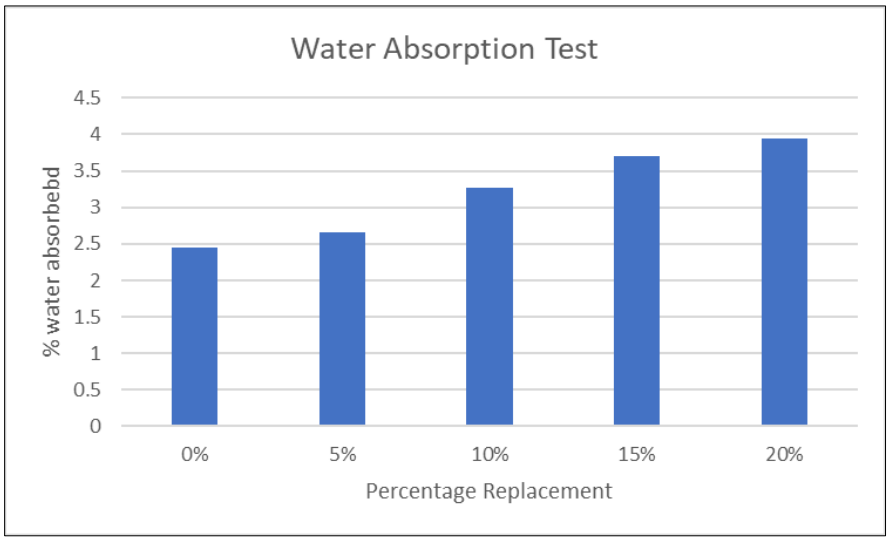

Figure 6 Water absorption test of fiber reinforced concrete at various RHA percentage replacement

4. Conclusion

This research has been carried out to study the effect of incorporating date palm fiber and the partial replacement of cement using rice husk ash on concrete properties. From the results and analysis of the various test results presented earlier, the following conclusions are drawn from the study:

- The workability of concrete was maintained due to the addition of 0.5% date palm fiber.
- The study of the date palm fiber reinforced concrete and replacement of cement with rice husk ash partially, shows that the compressive strength increases after 7, 14 and 28 days and the tensile strength also increases after 7, 14 and 28 days.
- The optimal compressive strength was obtained at 10% replacement with rice husk ash.
- The optimal tensile strength was obtained at 5% replacement with rice husk ash

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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