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Deflection characteristics of concrete beams reinforced with fan palm coated with blocking agents

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KEYWORDS

Deflection,
Fan palm,
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Blocking agent

A B S T R A C T

The load carrying capacities and the deflection characteristics of fan palm reinforced concrete elements for short term loadings have been studied extensively especially researchers from university of Ilorin, Nigeria. Fan palm was found to have similar characteristics trend similar to that of steel, however, it was found to deflect about four times of the equivalent steel reinforced concrete beams. In this study, deflection characteristics of the beams reinforced with fan palm coated with blocking agents (sodium sulphate, magnesium sulphate and hydroxylamine) were examined. Fan palm specimens were sliced and smoothen to 10x10x500 mm. Another set were uncoated to serve as control. 75 x 100x500 mm wooden moulds were made as formwork. Fan palm reinforcement inserted and the concrete mixed of 1:2:4 poured and converted to fill the mould with the fan palm reinforcement. The moulds were removed after 24 hours. The beams then removed and cured for 28 days in water. Day were then air dried for 2 hours before soaked in 0.1M NaOH solution for 7, 14, 28, 56, 90, 180, 270 and 365 days. They were then subjected to flexural deflection test on UTM machine. The result showed that beams reinforced with fan palm coated with hydroxylamine suffer less deflection while those with uncoated fan palm suffered the highest deflection.

Introduction

Fan palm is a natural Vegetable fibre common in tropical countries especially middle zone of Nigeria. Natural fibres are prospective reinforcement material and their use until now has been more traditional than technical. They have long served many useful purposes but the application of materials technology for the utilization of natural fibres as reinforcement in concrete has only taken place in comparatively recent years. The distinctive properties of natural fibre reinforced concrete are: improved tensile, bending strength, greater ductility, greater resistance to cracking and hence

improved impact strength and toughness (Toledo et al., 2000). Besides its ability to sustain loads, natural fibre reinforced concrete is also required to be meet serviceability conditions especially deflection. Fan palm has characteristics strength behaviors similar to that of steel, although of lower ultimate tensile strength. It was reported that air dried fan palm ultimate tensile strength is just 1/3rd of the ultimate tensile strength of high yield steel. Also beams reinforced with fan palm deflect four times the equivalent beams reinforced with steel (Audu and Raheem 2015).

The deflection of a structural member is one of the major criteria to be considered in limit state design of reinforced concrete member (BS 8110). A structural member must not only be able to sustained the load its carrying but must also not deflect excessively as the create fear to the users. The idea of using coated fan palm as reinforcement to replace steel in structural member that carries light load was suggested by Audu (2015) after noticing that fan palm could be made durable in concrete by coating with bitumen before inserting into the concrete. There are earlier studies on the use of wood fibre as a possible replacement for steel in structural members for short term.

Adetifa (1988), Bystriakova et. al (2010) studied extensively on the physical, mechanical properties and the use of bamboo as reinforcements in concrete elements. The materials were found out to be highly susceptible to dimensional changes and lose strength with time in alkaline media and concrete elements reinforced with it had excessive deflection. Studies on the physical and mechanical characteristics and the use of fan palm as reinforcement for concrete elements for short-term uses of recent gained studied in the past decades. Fan palm, Borassus aethiopum, commonly called African fanpalm is a species of Borassus palm from Africa. Physical and mechanical properties of fan palm as reported by Fache (1983), Omotosho (1988), Jimoh (1990) shows that its moisture content is between 10 – 12% air dried, fresh fan palm has moisture content as high as 100%. Air dried fan palm could only absorbed up to 7% moisture and hence stable dimensionally. The tensile strength of fan palm was reported to be within 70 – 150N/mm^2, Fache (1983), Omotosho (1988), the study on the load carrying capacities were carried on of fan palm reinforced concrete beams and slab by Omotosho (1988), Audu (1989), Ibi (1988). It was reported that fan palm reinforced members could carry 2 to 3 times the ultimate load of an equivalent unreinforced members but the deflection is 3 – 4 times the deflection of equivalent steel reinforced members. Omotosho (1988) further reported that fan palm reinforced members behave similarly to steel reinforced members provided the load did not exceed 55% of the failure load.

Concrete is a composite inert material comprising of a binder course (e.g cement), mineral filler (aggregates) and water, Neville, 1989. Aggregates are of two types, fine and coarse. They are usually graded from sand to stone. There are two types of concrete; light weight concrete and dense concrete. The light weight concrete weighed between 1600 to 2000 kg/m^3, while the dense concrete has an average density of 2400 kg/m^3 (Orchard, 1976).

Decomposition of fibre in concrete is a consequence of the material being attacked by alkaline pore water in the concrete. Audu and Raheem (2015), in the report on deflection characteristics of concrete beams reinforced with fan palm coated with blocking agents concluded that coating fan palm with water repellant especially

bitumen will offered beams to deflect less at age above 270 days in alkaline media. Decomposition of fan palm fibre could delayed or eliminated by impregnate the fibre with an agent who reacts with certain fibre components and build up compounds which are difficult to dissolve in an alkaline environment called blocking agents. Different impregnating agents such as sodium silicate, sodium sulphate, magnesium sulphate, iron and copper compounds, barium salts, anti oxidants, hydroxylamine, etc have been used on sisal fibre but the results according to Gram, (1987) showed improvement on the durability of the sisal fibre in a cement matrix which was also confirmed by Bindganavile and Banthia (2001).

Methodology

Fan palms were sliced to 10 x 10 x 450 mm to serve as reinforcements. Sets of three fan palm reinforcements were coated with sodium sulphate, other sets of three with magnesium sulphate, another with hydroxylamine and the final sets uncoated to serve as control.

The arrangements of fan palm reinforcements per set are shown in Figure 1. Flexural wooden moulds of 75 mm x 100 mm x500 mm were made to accommodate the flexural reinforcements and provide forms for the fresh concrete beams. Concrete mix of 1:2:4 by weight were prepared with water cement ratio of 0.55 using concrete mixer. The prepared concrete was then poured in the mold and compacted manually using tampering rod. The molds were removed after 24 hours. The beams were cured for 28 days by wetting in the morning and evening.

After 28 days the beams were conditioned in the alkaline medial for the desired ages. The beams were completely immersed in alkaline solution. Flexural strength test were carried out at room temperature and as per the British Standard, BS 1881, 1983. The test was carried out on an Automatic Universal Testing Machine [(AUTM). Middle span line loading were applied on reinforced concrete beams at the compression zone of the AUTM. The specimens were placed on 100 tones capacity loading frame and a diaguage was attached to measure the deflection readings at mid span. The loads were applied on the flexural specimens through the load engaging knob at the speed of 2 kN/min.

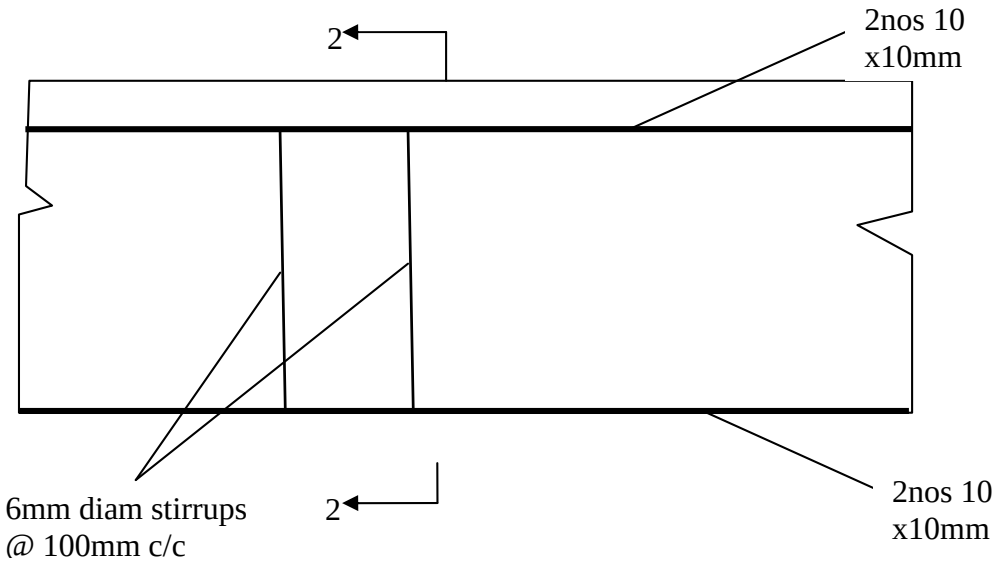
Results and Discussion

The results of flexural deflections obtained from the tested fan palm reinforced concrete beams coated with blocking agents are presented in; Figure 2, Figure 3, Figure 4, Figure 5, Figure 6, Figure 7 And Figure 8 presents the graphical deflection as the beams at 7, 28, 56, 90, 180, 270 and 365 days conditional in 0.1M Na0H solution. At 7 days, the mean deflections are close at computing loads but beam reinforced with fan palm coated with hydroxylamine had the highest mean deflection of 46 mm at failure load of 8kN.

At 14 days, the mean deflections are close for all the reinforce beams and also beams reinforced with fan palm coated with hydroxylamine had the maximum deflection of 45 mm at 14 days. While at 28 days, beam reinforced with fan palm coated with sodium sulphate suffered the highest deformation of 45 mm. The results for the beams soaked in alkaline 56 days showed that beam specimens reinforced with fan palm coated with sodium sulphate had the maximum deflection of 45 mm. At 90 days, beams reinforced with fan palm coated with sodium sulphate suffered the maximum

deflection of 34 mm. At 180 days, it was the concrete beam reinforced with magnesium sulphate that undergone maximum deflection of 38 mm. While at 270 days beams reinforcement with hydroxylamine suffered the maximum flexural deflection of 39.00 mm. It was observed from figure 9 that beam reinforced with fanpalm coated with hydroxylamine also had maximum deflection of 45.50 mm at 365 days. It was also observed that at 365, the deflections of the beams are not as closed as those between ages 7–270 days. It could be said that at the age below 270, the deflection of the beam are close and the treatments applied do not have significant effect of the deflection of the beams. But at the ages between 270–365 days, the effects of the treatment on the fan palm reinforcement on the deflection of the beams began to manifest. Also beams reinforced with uncoated fan palm suffered higher deflection compared with beam reinforced with coated fan palm.

Figure.1 Position of fan palm reinforcement in concrete beams



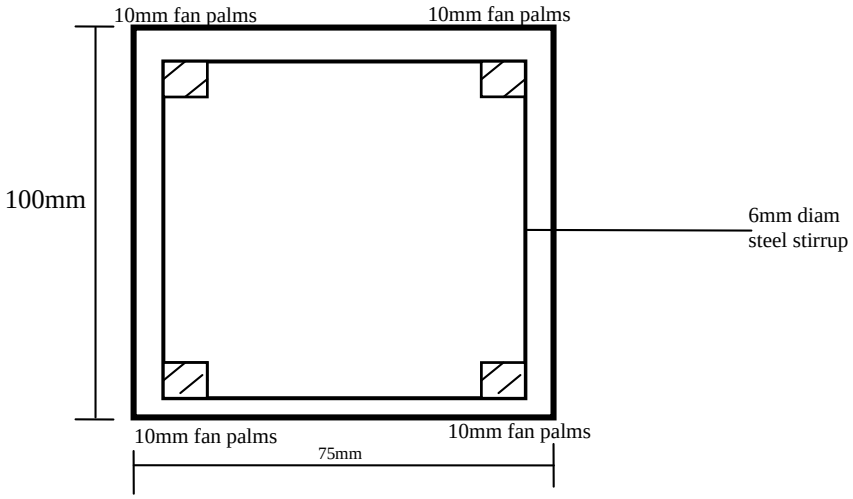


Figure.2 flexural deflection of concrete beams reinforced with fanpalm specimens at 7 days in alkaline solution

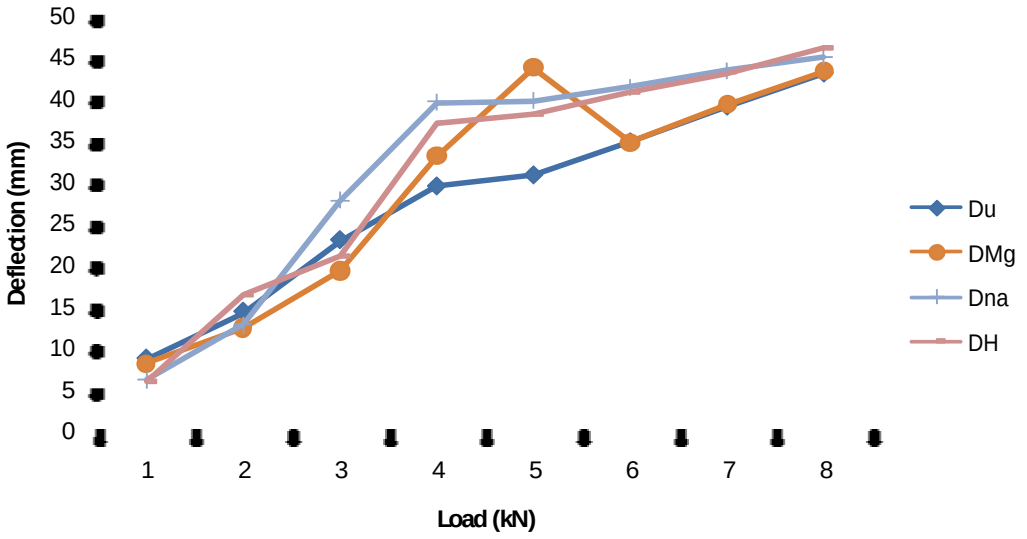
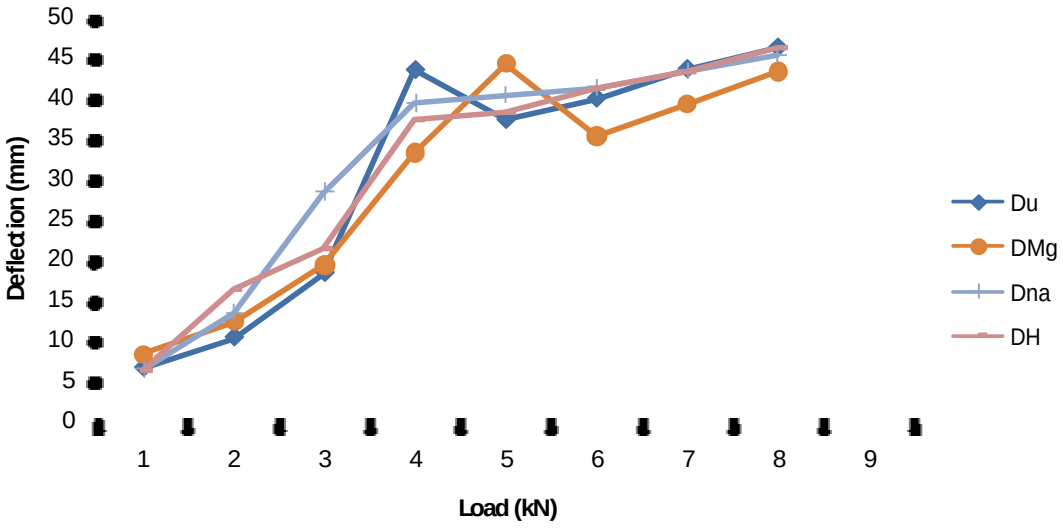


Figure.3 flexural deflection of concrete beams reinforced with fanpalm specimens at 56 days in alkaline solution



D_U: Flexural deflection of concrete beams reinforced with uncoated fanpalm specimens
D_{Mg}: Flexural deflection of concrete beams reinforced with Fan palm coated with magnesium sulphate
D_{na}: Flexural deflection of concrete beams reinforced with Fan palm coated with sodium sulphate
D_H: Flexural deflection of concrete beams reinforced with Fan palm coated with hydroxylamine

Figure.4 Flexural deflection of concrete beams reinforced with fanpalm specimens at 28 days in alkaline solution

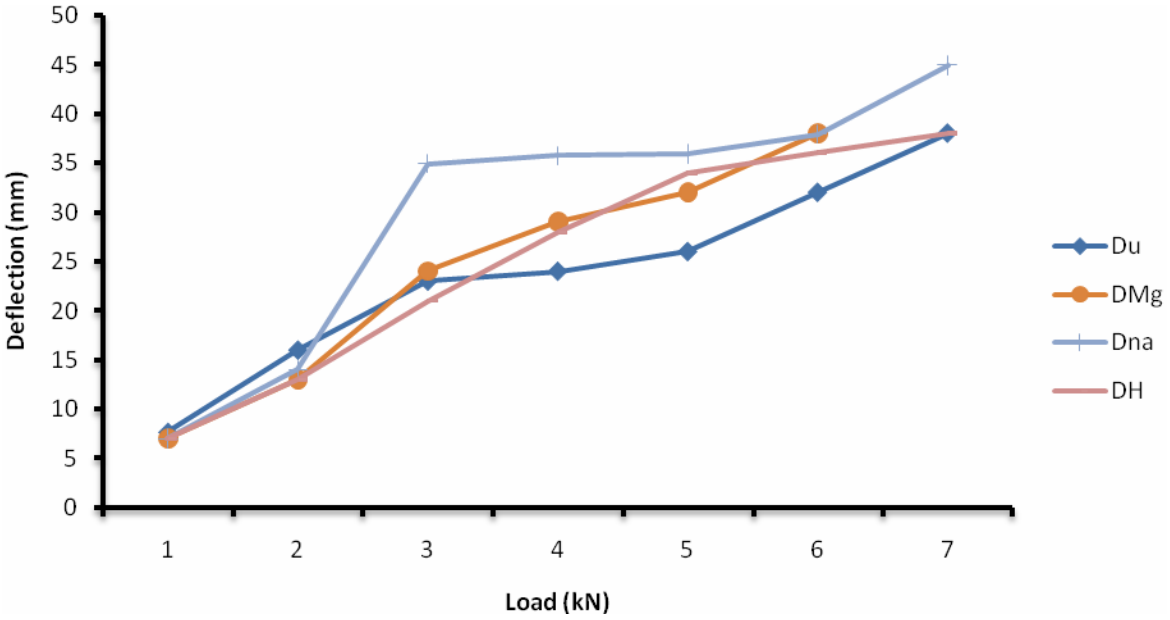
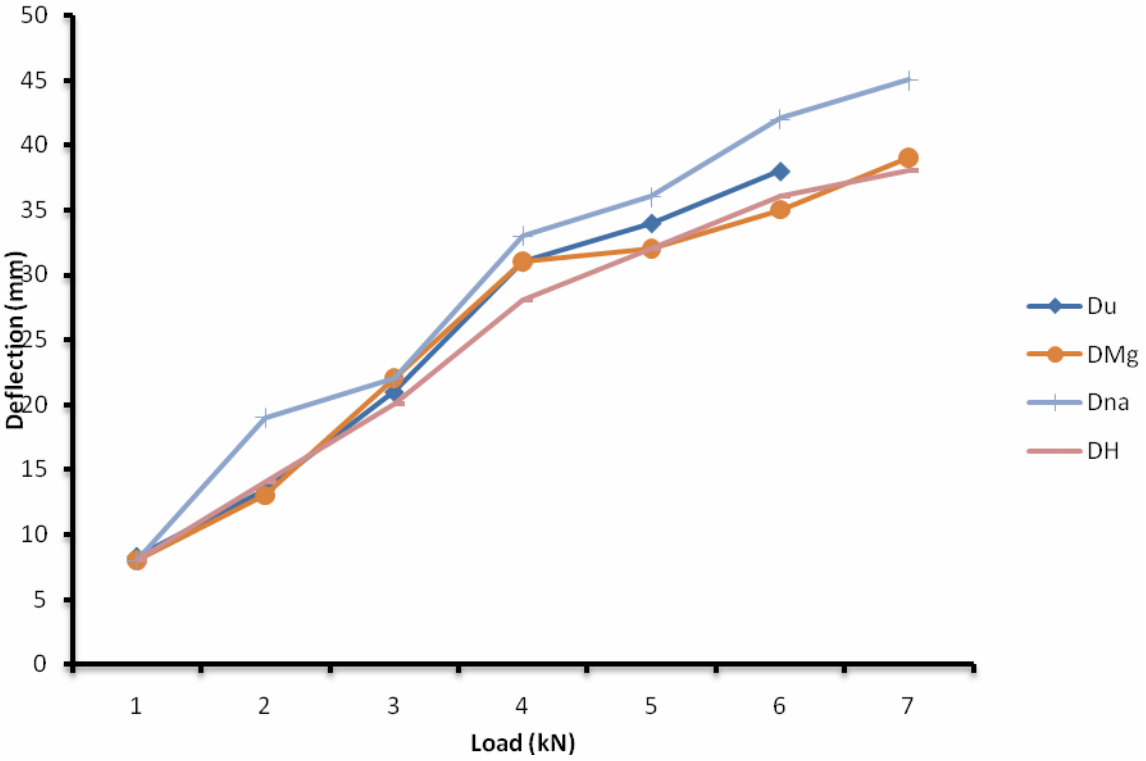


Figure.5 Flexural deflection of concrete beams reinforced with fanpalm specimens at 56 days in alkaline solution



D_U: Flexural deflection of concrete beams reinforced with uncoated fanpalm specimens
D_{Mg}: Flexural deflection of concrete beams reinforced with Fan palm coated with magnesium sulphate
D_{na}: Flexural deflection of concrete beams reinforced with Fan palm coated with sodium sulphate
D_H: Flexural deflection of concrete beams reinforced with Fan palm coated with hydroxylamine

Figure.6 Flexural deflection of concrete beams reinforced with fanpalm specimens at 90 days in alkaline solution

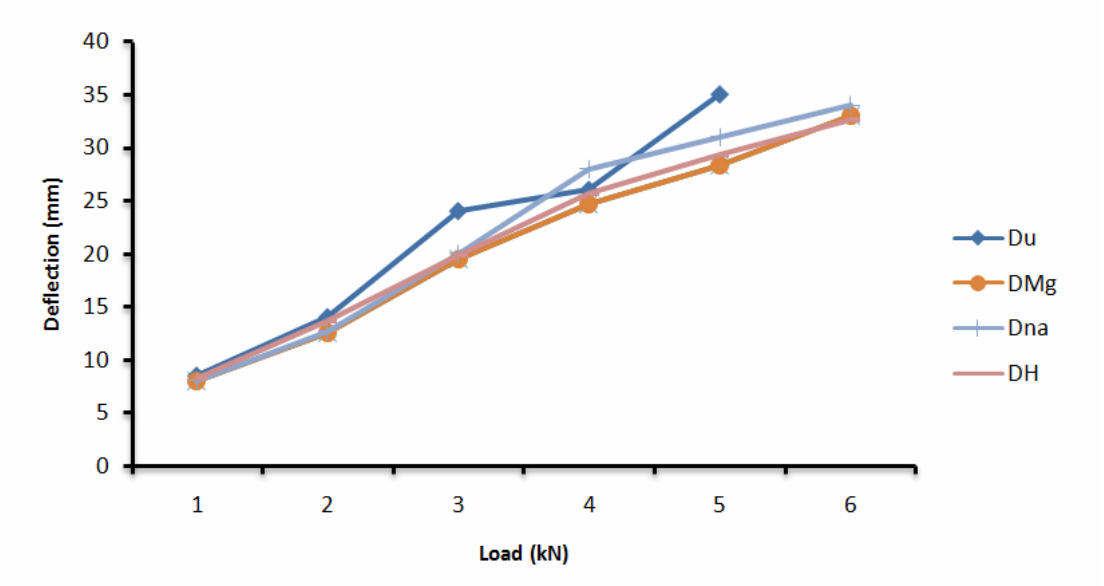
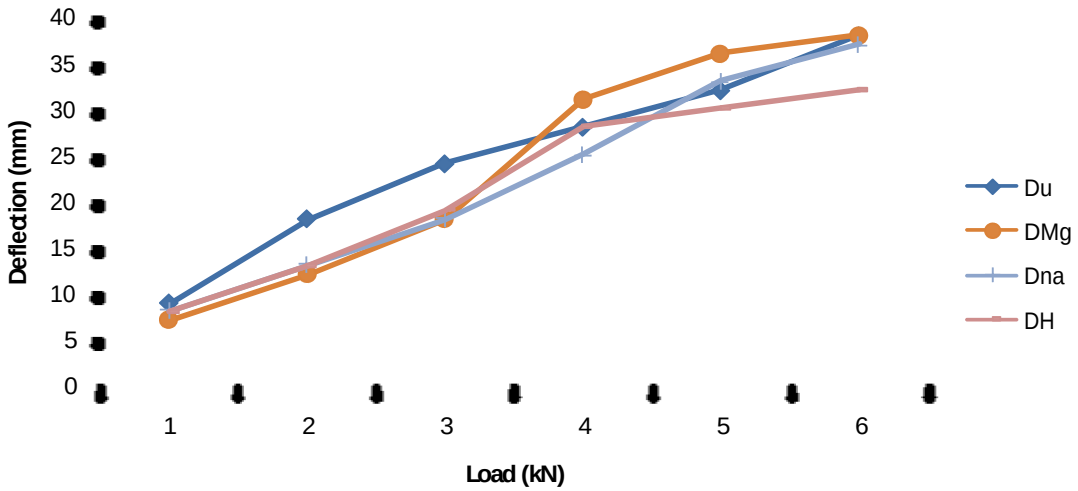


Figure.7 Flexural deflection of concrete beams reinforced with fanpalm specimens at 180 days in alkaline solution



D_U: Flexural deflection of concrete beams reinforced with uncoated fanpalm specimens
D_{Mg}: Flexural deflection of concrete beams reinforced with Fan palm coated with magnesium sulphate
D_{na}: Flexural deflection of concrete beams reinforced with Fan palm coated with sodium sulphate
D_H: Flexural deflection of concrete beams reinforced with Fan palm coated with hydroxylamine

Figure.8 Flexural deflection of concrete beams reinforced with fanpalm specimens at 270 days in alkaline solution

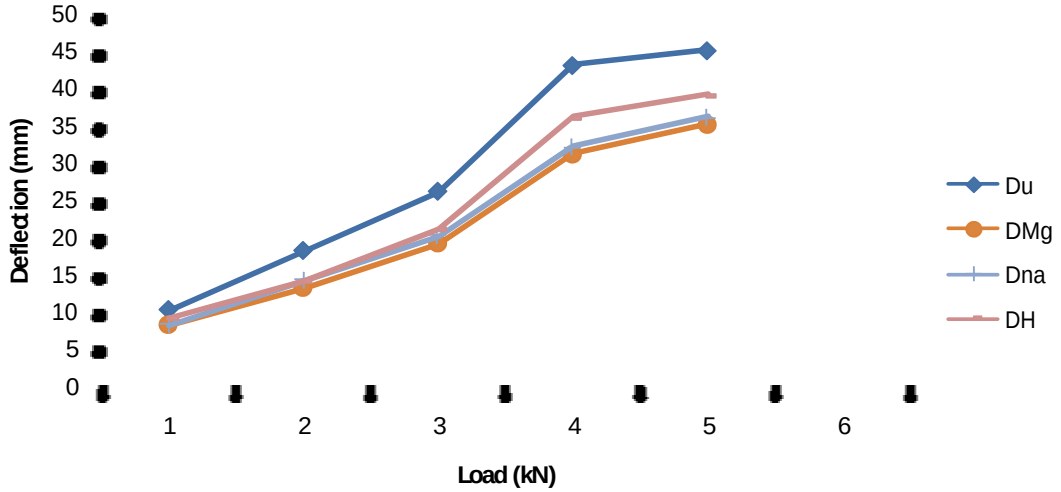
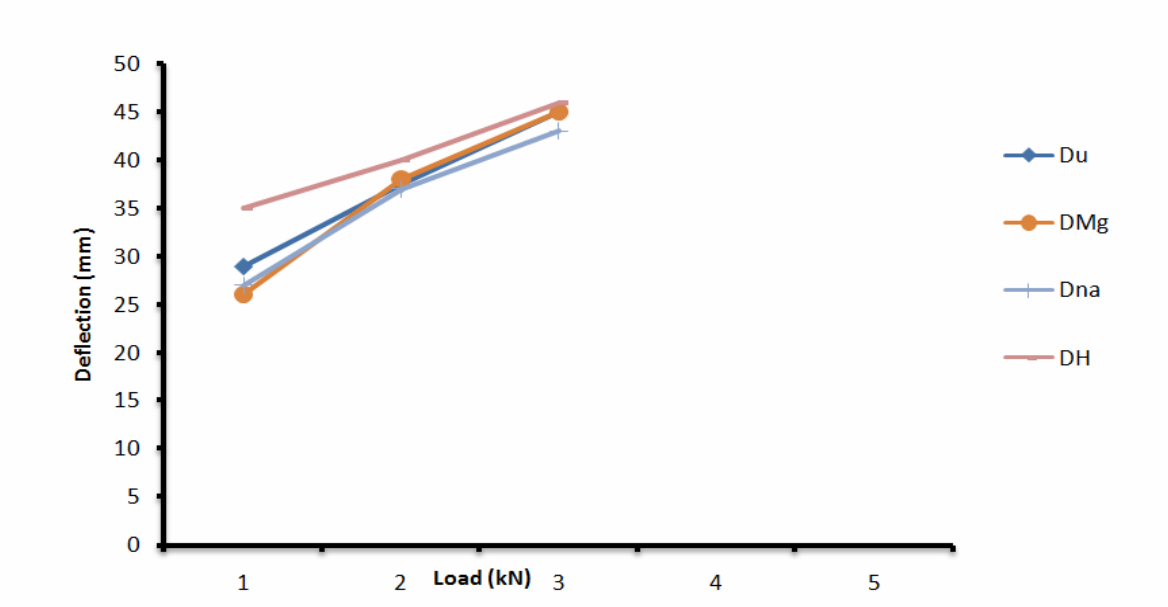


Figure.9 Flexural deflection of concrete beams reinforced with fanpalm specimens at 365 days in alkaline solution



D_U: Flexural deflection of concrete beams reinforced with uncoated fanpalm specimens
D_{Mg}: Flexural deflection of concrete beams reinforced with Fan palm coated with magnesium sulphate
D_{na}: Flexural deflection of concrete beams reinforced with Fan palm coated with sodium sulphate
D_H: Flexural deflection of concrete beams reinforced with Fan palm coated with hydroxylamine

Conclusion and Recommendation

Coating the fan palm specimen with blocking agents reduce the rate of deflection in alkaline ratio very similar to water repellants investigated by Audu and Raheem (2015). The deflection of fan palm reinforced concrete beams ranged between 32.00 – 63.00 mm at 7 - 365 days. Coating fan palms reinforced with hydroxylamine will offer good protection to fan palm at the age above 270 days. an average deflection of 32mm was recorded for beams reinforced with fan palm coated with hydroxylamine as against deflection value of 45 mm recorded for beams reinforced with uncoated fan palm. Hence coating fan palm with blocking agent was found to improved deflection resistance of concrete beams.

It is recommended that further studies be conducted on beams reinforced with fan palm coated with other blocking agents.

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