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Comparative Study of Flexural Strenght of Rattan Fiber Concrete Beam and Reinforced Concrete Beam

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Abstract
Test was carried out on the strength of steel and rattan by placing two (2) top reinforcements and two (2) bottomreinforcement's arrangement of rattan and steel splint of 8mm, 10mm, 12mm and 16mm diameter to check the adequacy and strength values of rattan and steel reinforced concrete beam after crushing. The potential of rattan cane as a possible replacement for steel in concrete beam were investigated. The main aim was to determine the flexural behavior of rattan cane reinforced concrete beam. Tensile strength test were also carried out on the rattan fiber samples and the corresponding steel of the same diameter to ascertain the strength differences. The load carrying capacity, flexural strength and deflection characteristics of each beam were determined and compared. It was discovered that rattan fiber can be used as a possible replacement for reinforcement, especially in structures that require lighter weight and lesser load. It was also observed that steel reinforced beam yields higher flexural strength when compared to rattan fiber. The research also recommended the use of rattan can in structural construction especially, where lesser load and lighter weight concrete has been recommended.

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I. Background of study

Reinforced concrete structures have been known as the major construction facilities globally and it has shown great performance when the right reinforcement is used. Through effective bonding between concrete and reinforcement, stresses can be transferred from concrete to steel. The dangers of maximizing profit at the expense of quality was exposed byprevious research work on the physical characteristics, chemical characteristics and strength characteristics of steel reinforcing materials.This situation pose a major threat to the structural durability, strength and reliability of buildings and civil structures. Thus, indebt studies were carried out on fibers and synthetic reinforcing materials in the past decades.However, natural reinforcement is still an interesting field of further studies (Akinyele, J.O. and Olutogo, F.A. 2011).

Rattan fiberoccurs naturally in nature and it is mainly found in tropical Africa with good mechanical and physical properties. Rattan fiber has made mark in many part of the world as a good structural material both in compression andtension.Rattan fiber can be introduced to replace steel reinforcement in concrete due to its reputation and value.It serves as a reinforcement with a very high strength. Some rattans cane grows leaves and also have extended whip-like structure that are called cirrus. While others may have flagellum, which is whip-like in shape and it grows from the axil of the leaf sheath. The cirri and flagella helps the palm to climb adjacent trees for support (Akinyele, J.O. and Aresa, S.W. 2013).

Rattan fiber has been known as a member of rattan cane family, which has always been used as a structural material fit for construction in certain geographical areas for years, though, its use as reinforcement in concrete structures had received minor attention. It has the durability and strength high enough to be used as a material for the manufacture of reinforced concrete structures. Indonesia weekly newspaper reported the use of rattan as replacement for reinforcement. In some rural areas in Africa, rattan is used for thatch houses where its stems were tied into already made framework of houses before daubing it with mud (Schreckenbach and Abenkwa, 2000).

Steel is also as very necessary as building materials and can be used extensively in structural engineering. It is a bye product ofiron ore and was subjected to a high temperature during production. Presently, attention is moving towards the use of rattan (Bambusa vulgaris) and rattan (calamusdeerratus) as alternative replacement for reinforcement in concrete after successfully using Fiber reinforced polymer to replace steel reinforcement.

This work is geared toward studying and then comparing the characteristics, differences and effects rattan fiber and reinforced concrete beams can have on a structure and will help to improve localtechnology in order to minimize over-reliable on developed nations and to improve the economic situation of the nation. It allows for modification based on indigenous need, preserves and maintains knowledge, innovation and practice.

This suggest that students in tertiary institutions in the field of construction can have sound, strong and basic background on the characteristics of concrete beams.

Recently, the high demand and shortage in supply of steel reinforcement in so many parts of the globe has increased the search for alternative source of reinforcement locally. In the developing Nation like Nigeria were most of the population are residing in the rural area, rattan fiber has been used as alternative source of structural materials. Serious research is being carried out on how to modify rattan fiber to completely replace steel in concrete structure.

Objective of the study

The main objective of this study is to study and compare the flexural strength of concrete made with rattan can fiber and normal steel reinforcement. The specific objectives are;

i. To minimize the high cost of construction materials by introducing rattan can fiber as a replacement for reinforcing steel.

ii. To generate profit by replacing the reinforcing steel with rattan cane fiber in structural construction

iii. To evaluate the flexural behavior of rattan can fiber and steel reinforcing bar by subjecting them to center-point flexural loading.

iv. To study and compare the flexural strength of rattan and steel under varying percentage, as well as to study the effect of various curing period under different exposure condition.

II. Literature Review

Rattan cane fibers are very old in existence, they climbing palms and belonging to sub-family Calamoideae which includes tree palms such as Metroxylon (Sago palm), Raphia (Raffia) and shrub palms such as Salacca (Salak) (Sunderland, Terry C.H. 2003).

It was discovered in ancient Egypt first by an Egyptian craft man named Wicker. He uses rattan to produce basket weaving. Lately, the Romans were amazed by Egyptian woven furniture, and accepted wicker’s technique as their own technique, and spread the style across their region (Paolo Moschino, 2019).

Rattan is not just suitable for furniture; certain types are edible, and it is often collected to build housing in more rural areas. It is strong and pliable, which is why it is commonly used in basket-weaving and to make woven products, such as storage boxes, coasters and placemats. (Amara interior blog awards, 2021).

Rattan as a word is derived from Malay "rotan", and it is and indigenous name for climbing palms. Rattan cane are spiny palms that can be seen in the ancient world tropics and sub-tropics. They can be used as the source of cane fiber for the progressive developing rattan fiberindustry that recently generates US$6.5 billion yearly,theinternational Tropical Timber Organization (ITTO, 1997). Majority of the rattan entering the world market originates from Southeast Asia and is gathered mainly from the wild populations, however, attention have recently been shifted on the future provision of raw rattan fiber from mechanized sources (Dransfield and Manokaran, 1993).

Most of the developing nation have relied on rattan as the basis of their thriving economy by widening the export market. Rattan cane contribute to most communities within their range as an economic boost when cultivated and harvested in large quantity.Most of the locals utilize the rattan resources as a direct cash inflow, especially during those periods that other products are in extinction. Cane fiber harvesting is always a secondary activity for most farmers that depends on the cash made from the fiber to develop their agricultural base or at the time cash is immediately needed for family support, such as the school fees payment or medical bills. (Terry C.H. Sunderland and Profizi, Jean Pierre, 2000).

Akinyele and Olutoge (2001) carried out research on the flexural behavior of two-way reinforced slabs that used rattan and steel reinforcements under axial loading for their work. Thus, they made extensive literatureon natural reinforcement in concrete structures, but none of the previous authors have comparatively investigated the use of steel, cane fiber and rattan under the same geometric and loading conditions to obtain the relative capacities and also establish the limits to natural fibers can be applicable.

Lucas and Dahunsi (2007) described the construction of beams made of rattan cane reinforcements and steel reinforcements, ten number model sized elements of area $0.15m^2$, and a depth of 0.04m were considered, with five beams for each reinforcement type. The elements were subjected to incremental load of 1kN until failure occurred. Deflection were measured for each element, and crack width was measured at failure load. The results for both types of reinforcements when compared showed the rattan reinforced panels failing. Concludes that the lower crack width formed after failure in the rattan reinforced panel gave it advantage over the steel.

Mahzuz, H. M. A. Mushtaq Ahmed, Md. Ashrafuzzaman, Rejaul Karim and Raju Ahmed (2012), Determined ultimate tensile strength,modulus of elasticity of fiber cane (Calamusguruba) and yield strength from the experimental investigation. Large quantity of embedding Bond strength and Young’s modulus in concrete of cane fibers trees that are two years and older are obtained.

Mahzuz, H. M. A. Mushtaq Ahmed, Jotan Dutta, Rezwanul Haque Rose (2013) reported comprehensive research on the behavior of cane fibers, although only few comprehensive values are known on flexural and tensile properties of cane fiber. The result obtained proved that the bond stress was 43% position behind the corresponding shear stress obtained from the experiment.

Thus in-depth literature are available on the natural reinforcement in concrete works, steel and cane fibers have not been comparatively investigated on the basis of similarity in geometric and loading condition. There is need to establish limit to the applicability of rattan fiber. Hence, this paper presents the experimental study to comparative evaluate the flexural behavior of concrete beams reinforced with steel and rattan. The physical and tensile strength properties of steel and rattan were first determined and the flexural strength of concrete beams reinforced with the rattan and steel bars were evaluated respectively. The limits of usage of cane fiber as replacement for steel reinforcement were established.

III. Materials and Method

Rattan canes used for this study were obtained from Ezza Mgbo in Abakaliki, Ebonyi State, Nigeria. It was 12mm in diameter and was divided into 700mm long each as required for the research work. Coarse aggregates used were 12mm in size and sourced from Ishiagu in Ebonyi State. The fine aggregates were sourced from Imo river in Obowo, Imo State. While the 12mm steel reinforcements and Cements were purchased from timber maket in Ahiaeke Abia State. The concrete used in this research work was made from ordinary Portland cement, sands and quarry stones. Concrete mix proportion was designed for 20n/mm2 at 28days characteristic strength and mix ratio of 1:2:4.

Testing of samples

The tests were carried out at standard organization of Nigeria (SON), located at Emene express road Enugu, Enugu State. The tensile strength test was carried out on 12mm steel rod samples as well as 12mm size cane fiber rod samples. Thetensile load was applied until fracture occur when the specimens were placed in Technotest-Eurotronic machine. Universal testing machine was used in determining the flexural test on the concrete beams. The weight of the sample was recorded before moving it to the flexural machine. Each specimen was placed on a simply supported effective span of 450mm. The beams were tested in flexure under third point loading. The loads were applied between the supports at third point and at a distance of 150mm from each support. The loads were on the beam and kept increasing until the first crack and final collapse of the beam were notice and the corresponding deflections recorded.

Table 1: Flexural strength of reinforced beam

Curing period (days)	Size of rod (mm)	Average load (kN)	Flexural strength (N/mm^2)
7	8	48.52	7.33
14	8	50.14	7.58
21	8	53.19	8.04
28	8	57.09	8.63
7	10	50.12	7.57
14	10	52.13	7.88
21	10	57.02	8.62
28	10	59.97	9.06
7	12	61.28	9.26
14	12	64.14	9.70
21	12	70.36	10.63
28	12	73.05	11.04
7	16	69.62	10.52
14	16	71.31	10.78
21	16	73.11	11.05
28	16	74.17	11.21

Table 4.2: Flexural strength of Bamboo rattan

Curing period (days)	Size of rod (mm)	Average load (kN)	Flexural strength (N/mm^2)
7	8	17.59	2.66
14	8	18.39	2.78
21	8	18.93	2.86
28	8	19.71	2.98
7	10	17.66	2.67
14	10	18.41	2.78
21	10	19.27	2.91

28	10	20.04	2.03
7	12	18.67	2.82
14	12	19.04	2.88
21	12	20.30	3.07
28	12	23.37	3.52
7	16	19.23	2.91
14	16	20.06	3.03
21	16	23.56	3.56
28	16	25.42	3.84

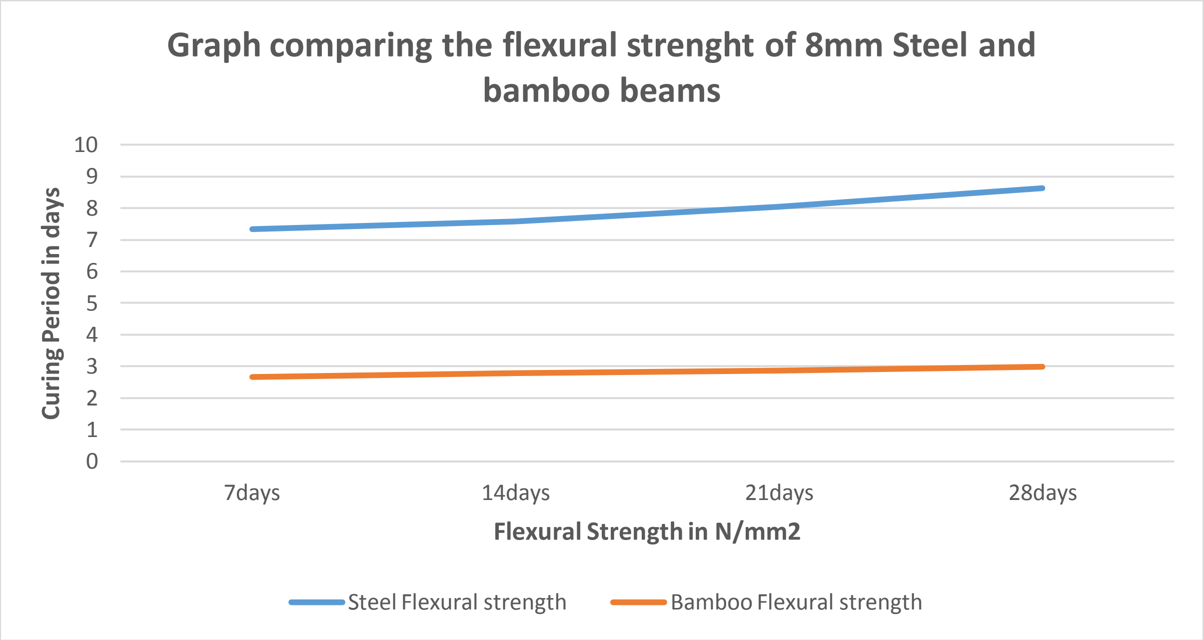

Figure 1: Graph comparing the flexural strength of 8mm steel and bamboo beam

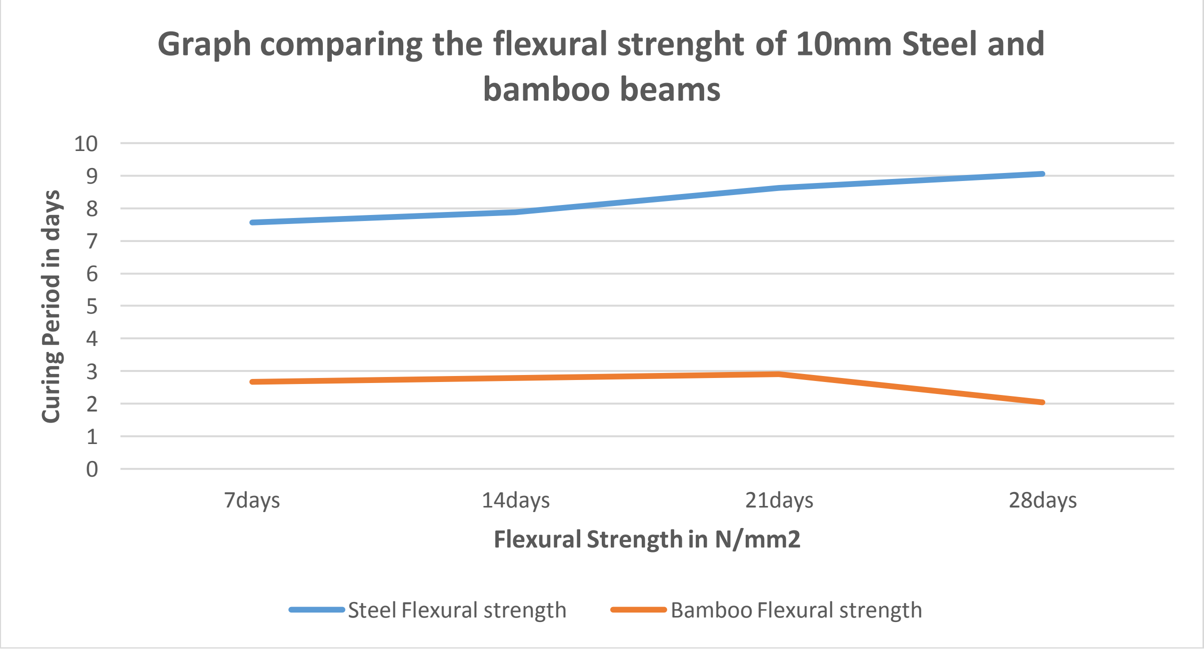

Figure 2: Graph comparing the flexural strength of 10mm steel and bamboo beam

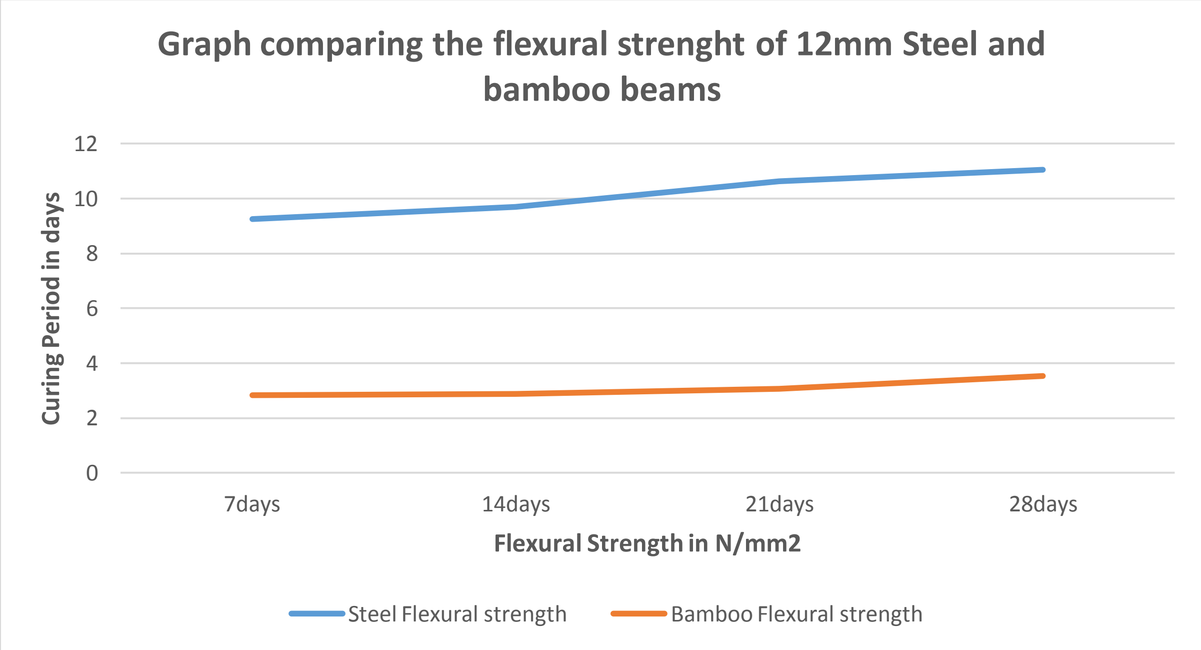

Figure 3: Graph comparing the flexural strength of 12mm steel and bamboo beam

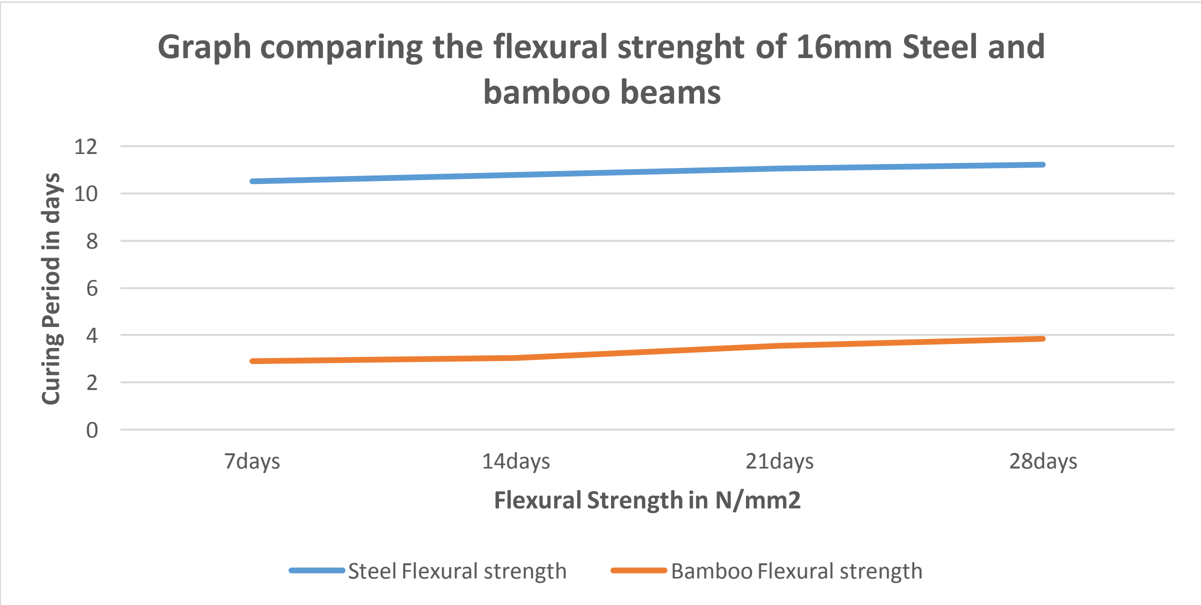

Figure 4: Graph comparing the flexural strength of 16mm steel and bamboo beam

Table 3: Tensile strength of steel reinforcement

Size of steel (mm)	Tensile strength (N/mm^2)
8	206
8	207
8	205
8	210
10	208
10	207
10	210
10	211
12	207
12	210
12	208
12	212

16	208
16	212
16	210
16	213

Table 4: Tensile strength of rattan fiber reinforcement

Size of rattan (mm)	Tensile strength (N/mm^2)
8	110
8	106
8	112
8	120
10	114
10	113
10	122
10	118
12	116
12	121
12	120
12	119
16	114
16	122
16	126
16	130

Analysis of the results from the figures and tables

Figure 1 and Table 1 show that the beam reinforced with steel have a greater chance of resisting flexure and the flexure kept on increasing as the concrete beam get older likewise the beam made with bamboo. However the beam made with bamboo has lesser flexure at all the ages and also increases gradually as the ages increase.

Similarly, Figure 2, Figure 3, Figure 4 and Table 2 follows the same trend but the only difference here is that due to high tensile as a result of size the flexural strength obtained in those samples are also higher.

Table 3 and Table 4 show the tensile strength of steel reinforcement and rattan cane fiber. From both tables it is observed that steel possesses better tensile strength and should be averagely 1.8 times higher than rattan cane fiber reinforcement.

IV. Conclusion and Recommendations

From the investigation carried out, the following conclusion was made: Using rattan fiber as a replacement for reinforcement can improve the load carrying capacity of beams that have the same dimensions. At ultimate load, the double cane fiber beam reinforcement can crush under heavy load as a result of rupture of the cane fiber whereas the steel may not rupture but may lose it elasticity. The maximum deflection of double steel concrete beam reinforcement is about 1.8 times higher than that of the maximum deflection of double cane fiberconcrete beam reinforcement. Both double cane fiber and double steel reinforced concrete beam showed elastic behavior while performing flexural tests on them. However, double steel concrete beam reinforcement has better elastic behavior than double cane fiber concrete beam reinforcement but the later can be used in structures that requires lighter weight and lesser loading.

Recommendation

Having built a prototype to demonstrate the workability of this scheme, it is thus necessary at this stage to, mention a few recommendations necessary for the advancement of the versatility of rattan cane as alternative in concrete reinforcement. The following are recommended from this study: Durability studies should be performed on the use of rattan cane as replacement for reinforcement.Rattan can reinforcement should also be tested with concrete made with improved strength like concrete made from addition of admixtures, etc. The shrinkage and creep characteristics of rattan cane should be investigated.

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