



Strength Property of Bamboo Fiber in Reinforced Laterite Concrete

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Abstract: This paper examines the compressive strength of bamboo fiber reinforced laterite concrete. It aims at establishing the effect of bamboo fiber content on the compressive strength of lateritized concrete and also the effect of bamboo fiber without any laterite content. It also aims at finding a reliable replacement for sharp sand so that it can reduce the high price of sharp sand and also to serve as a substitute for sharp sand if sharp sand is not readily available. The materials used for this research work were all obtained from Iree and its environs. 10%, 20%, and 30% of partial replacement of sharp sand with laterite were considered. The mix used for this research work was 1:3:6 concrete mix. The test used was the compressive strength of bamboo reinforced laterite concrete at 28 days curing. The maximum compressive strength was 17.8N/mm² for 28 days curing age of specimen with no replacement of sharp sand and the minimum compressive strength was 7.6N/mm² for 28 days curing age of specimen with 30% replacement of sharp sand. It was observed that the compressive strength at all the partial replacement that is 10%, 20%, and 30% partial replacement of sharp sand with laterite increases with the age of curing of the specimens. It was observed that compressive strengths obtained were sufficient at 10% and 20% partial replacement of sharp sand with laterite. It is only at 30% partial replacement that has the strength of 7.6N/mm² which fall below the minimum compressive strength of 10N/mm²

Keywords: Laterite, compressive strength, bamboo fiber, sand.

1. Introduction

Clients in the construction industries are beginning to demand for more value for their money and this followed by specifics and more complex designs. The cost of building construction is also increasing and this is as a result of the complexity of design, inflation in the nation and cost of supply of construction materials on the site. The use of locally available materials for the manufacturing of building components can reduce the rate of manufacture of low standard materials but these locally available materials cannot be used except their properties are known and the limits to their use or un-use is set (Lasisi & Ogunjide, 1984). The trend worldwide shows that all economy drives are towards economic construction (in terms of cost) and this has led to researches into the possible replacement of conventional building materials with locally available materials without delirious effects on the components (Balogun & Adepegba, 1992). The recent trend in Nigeria as regards building collapses is a source of major concern to the construction industry due to the loss of lives and properties, people are beginning to lose confidence in the construction industry. This problem is compounded by the sale of low quality materials in the market as most of the building collapses are due to combination of bad workmanship, defective design and use of low quality materials (Neville & Brooks, 2002). Concrete is a material which determines to a large extent the overall strength of a building (especially framed structures) and thus if concrete is of adequate

strength, the building has a low possibility of collapsing all other factor being equal (Shetty, 2006).

Conventional concrete is made up of cement, sand, gravel and water. Earlier researches in Nigeria have revealed that partial replacement of sand in concrete by laterite is seen to be effective. Replacement up to about 40% of sharp sand with laterite gives optimum strength (Falade, 1991). This type of concrete is called lateritized concrete. Plain concrete posses a very low tensile strength, limited ductility and little resistance to cracking. Internal micro-cracks are inherent present in the concrete and its poor tensile strength is due to the propagation of such cracks eventually leading to brittle fractured of the concrete. It has been recognized that the addition of small closely spaced and uniformly dispersed fibers to the concrete would serve as a crack arrester and would substantially improves its strength and dynamic properties. This type of concrete is known as fiber reinforced concrete.

This research work is intended to explore the possibility of reinforcing lateritized concrete with bamboo fiber which is generally available in Nigeria. The research is intended to establish the requirement of obtaining strength from this product. This research work arises as a result of the need to develop alternative materials that compete favorably with the existing conventional materials. This can eventually results in bringing down the prices of building materials.

2. Definition and Nature of Laterite

Laterite is a soil type that is rich in iron and aluminium that is formed in hot and wet tropical areas (Babalola & Osunade, 1991). Most of all laterites are rusty-red in colour simply because of the iron oxides that is present in it. They are formed and developed by intensive as well as long lasting weathering of the underlying parent rock. Tropical weathering which is also known as laterization can be defined as a prolonged process of chemical weathering which produces a wide variety in thickness, grade, and mineralogy of the resulting soils. Laterites are majorly found in the land area between the tropics of cancer and Capricorn (Falade, 1991).

2.1 Fiber reinforcement

Concrete made with ordinary Portland cement has certain characteristic: it is relatively strong in compression but weak in tension and tends to brittle (Shetty, 2006). This weakness can be overcome by the use of conventional rod reinforcement and to some extent by inclusion of a sufficient volume of certain fiber (Falade, 1991). The use of fiber alters the behavior of concrete by enhancing the flexural tensile strength, crack arresting system and post cracking ductility (Ikpomwosa, 2000).

2.2 Compressive Strength of Concrete

According to concrete mix design as per India standard code (IS 10262-1982), the compressive strength of hardened concrete is generally considered to be an index of its other properties depends upon many factors, examples are quantity and quality of cement, water, and aggregates, batching and mixing, placing compaction and curing. For concrete with undemanding performance, nominal or standard mixes of 1:3:6 prescribes in the codes by quantities of dry ingredients per cubic meter may be used only for very small job when the 28 days strength of concrete does not exceed 30N/mm. Concrete with mix ratio 1:3:6 has the minimum compressive strength of 10N/mm² at a curing age of 28 days (Shetty, 2006).

3. Materials and Methods

3.1. Materials

The major materials and equipment employed and their uses in this work are:

Laterite: This was used as a fine aggregate in laterized concrete specimens. The maximum size of laterite used passed through 5mm sieve.

Sharp sand: This was used as a major constituent of the laterized concrete

Granite: This material served as the coarse aggregate in the laterized concrete specimen. The maximum size used passed through 14mm BS sieves

Cement: Ordinary Portland cement complying with BS 12(1969) was used as a binding material. The actual source was from the West Africa Portland cement company at Ewekoro in Ogun state.

3.2. Methods

Tapping rod: It was used to compact the laterized concrete during casting.

BS sieve: The test sieve used for the aggregates have a circular openings.

Hand trowel: This was used extensively in the mixing, filling and leveling of wet bamboo fiber reinforced laterized concrete in the moulds.

Shovel: This was used to obtain the aggregates from their stacks and also for mixing specimens.

Water: The water used was obtained from a reservoir tank near the construction and materials laboratory of the department of civil engineering Osun State Polytechnic Iree and it was also used for curing.

Curing tank: A curing tank made of concrete is located at the construction and laboratory of the department of civil engineering of Osun State Polytechnic Iree. It was used for curing the specimen up to the test days.

Mould: A wooden mould of size 150x150x150mm was used for the cubes according to BS 12

Mould oil: This was used to lubricate the mould inside to enhance easy de-moulding as well as a smooth surface

3.3. Sample Location

The laterite and granite used throughout the research work was obtained from Iree, Otan/Iresi environs. For the purpose of this research works, various tests and analysis were carried out on the sample of the laterite soil collected. The cement used was purchased locally from Iree although the actual source was the west Africa Portland cement company Ewekoro, Ogun State. All other materials and equipment were got from civil engineering laboratory of Osun State Polytechnic Iree. The bamboo fibers used was collected from the bamboo tree along Ada road Iree.

3.4. Testing

Sample grading

According to BS 882:1992, before the commencement of the sieving, the empty weights of the sieves were measured and the sieves were arranged according to the sizes of their openings with the sieve having the largest opening at the top in which the sample was introduced. A receiver was then placed at the bottom of the lowest sieve and the arrangement was thoroughly shaken. The sieve was well shaken for 20-minutes after which the sieve were dismantled and were re-weighed to determine the weight of the contents.

Preparation of Bamboo Fiber Reinforcement

The cane fiber was measured with a venire caliper to have a diameter of 10mm. The canes were cut into smaller length of 120mm. The bamboo was split into half along the hollow section using the machine saw. The bamboo revealed an inner disc called a septum along the Culm on the portion where nodes showed on the outer portion. The spectrum or discs were removed by chiseling. The width of the split bamboo was measured to be 100mm and the depth was measured to be 50mm. Holes of 10mm diameter (diameter of cane fiber) were drilled into sides of the split bamboo at 80mm interval. The holes were drilled that the coarse aggregate in the concrete would slip under the cane fiber

freely. Two half splits were placed side by side and connected using the 120mm lengths of cane.

Mix Proportion

The mix used for this research work is 1:3:6. Being the most accurate the method of batching by weight was adopted and used for all the test samples. After measuring out the required quantities of the components, they were introduced into the mixing platform in the following sequential order. Sand – laterite – cement – coarse aggregate – water – bamboo cane fiber.

Control specimens were also cast without any replacement of sand with laterite. Specimens were also cast for 10%, 20% and 30% partial replacement of sand with laterite each for 7days, 14 days, 14 days, 21 days and 28 days.

Workability

Before the start of casting operations and just after mixing the laterized concrete, the workability was measured by the slump test. The slump test was placed with bigger opening on a smooth rigid and non absorbent surface where there was no vibration or shock. The internal surface of the cone was thoroughly cleaned and oiled to facilitate the flow of the sample before it was poured into the cone. The filling was done with hand trowel in three layers of approximately one quarter of the height of each layer and while filling the mould was held firmly to the surface by footplates. Each layer was compacted with strokes of the tapping rod, well distributed in a uniform manner over the cross section of the mould. The top surface was leveled and smoothed with the hand trowel and the surrounding cleaned before lifting the mould. The cone was then slowly removed and the unsupported materials slumped. This was carried out according to BS 1881: Part 102:1983

Casting of Test Sample

The inner of 150mm x 150mm mould were coated with mould oil to ensure easy de-moulding and smooth surface finish. Immediately after the mixing, the wet mixture was cast into the mould using the hand trowel. The mould were filled layers and each layer was well compacted to ensure uniform distribution over the cross section of the mould .After the top layer has been well compacted, the surface of the specimen was finished level with the top of the mould by means of the hand trowel. The specimens were then marked for later identification.

Curing of the Specimen

Immediately after the specimens were mould, the test specimens were stored in a cool place free from vibration and not exposed to direct sunlight or other sources of heat. The specimens were demoulded after 24 hours of casting and immediately submerged in the curing tank and kept there until they were taken out just before test. as specified by BS 1881: 1983.

Compressive Tests

On the day of each test, the specimens were removed from curing tank and left to dry up to about two hours before the tests using the compression machine as specified by BS

1881: 1983. Sixteen specimens were tested and their strengths were recorded.

4. Results and Discussion

The Tables 1-6 below shows the result of grading of laterite.

Table 1: Result of sieve analysis of laterite.

Sieve No	Sieve opening	Weight of sieve (g)	Weight of sieve + soil (g)	Weight of soil retained (g)	Percentage retained (%)	Percentage passed (%)
4	4.760	400	650	250	18.12	81.88
8	2.360	1000	1400	400	28.99	81.88
16	1.180	400	500	100	7.25	45.64
20	0.850	350	600	250	18.12	27.52
40	0.425	350	480	130	9.42	18.10
70	0.212	300	350	50	3.62	14.48
100	0.150	280	300	20	1.45	13.03
200	0.075	220	250	30	2.17	10.86
Receiver	-	500	650	150	10.87	-

Considering the result from the Table 1, it is observed that the laterite used for the research work was well graded (Lasisi & Ogunjide, 1984).

Natural moisture content

The natural moisture content determination test carried out on laterite was shown on Table 2.

Table 2: Natural moisture content of the sample

Determination number	1	2	3
Weight of container (W ₁) (g)	50	50	50
Weight of container + wet soil (W ₂) (g)	150	150	150
Weight of container + dry soil (W ₃) (g)	135.45	135.75	136.13
Weight of water (W ₂ -W ₃) (g)	14.55	14.25	13.13
Weight of dry soil (W ₃ -W ₁) (g)	85.45	85.75	86.13
Water content (%)	17.03	16.62	16.10

Table 3: Compressive strength of concrete with no replacement of sharp sand

Age (days)	Weight of cube (gm/cm ³)	Density of cube (gm/cm ³)	Crushing load (KN)	Crushing strength (N/mm ²)
7	8945	2.65	280	12.4
14	8975	2.66	300	13.3
21	8960	2.65	340	15.1
28	8980	2.66	401	17.8

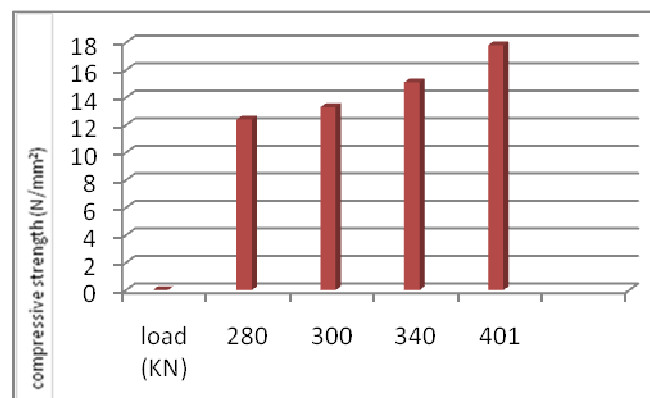


Figure 1: Compressive strength of laterized at 0%

Table 4: Compressive strength of laterized concrete at 10% replacement of sharp sand

Age (days)	Weight of cube (gm/cm ³)	Density of cube (gm/cm ³)	Crushing load (KN)	Crushing strength (N/mm ²)
7	8466	2.51	200	8.9
14	8510	2.52	220	9.8
21	8570	2.54	240	10.7
28	8598	2.55	286	12.7

Table 5: Compressive strength of laterized concrete at 20% replacement of sharp sand

Age (days)	Weight of cube (gm/cm ³)	Density of cube (gm/cm ³)	Crushing load (KN)	Crushing strength (N/mm ²)
7	7970	2.36	180	8.0
14	8005	2.37	195	8.7
21	8040	2.38	220	9.8
28	8066	2.39	257	11.4

Table 6: Compressive strength of laterized concrete at 30% Replacement of sharp sand

Age (days)	Weight of cube (gm/cm ³)	Density of cube (gm/cm ³)	Crushing load (KN)	Crushing strength (N/mm ²)
7	7838	2.32	120	5.3
14	7899	2.34	130	6.0
21	7902	2.34	150	6.7
28	7943	2.35	171	7.6

The control specimen for the research work is the one without replacement of sharp sand as shown in Table 3. Considering the effect of bamboo fibre on the compressive strength of laterized concrete, results in Tables 4, 5, and 6 show that all the cubes at 10%, 20% and 30% partial replacements has a considerable increase in their compressive strength based on the numbers of days of curing that is their compressive strength increases with increase in the days of curing.

The control specimen has the compressive strength of 17.80N/mm² at curing age of 28 days. The compressive strength for other specimens which are 10%, 20% and 30% of curing age of 28 days are 12.7N/mm², 11.4N/mm² and 7.6 N/mm² respectively. The compressive strength of hardened concrete which is generally considered to be an index of its properties for mix 1:3:6 at a curing age of 28 days must not exceed 30N/mm². For mix ratio concrete 1:3:6, the

minimum compressive strength is 10N/mm² for curing age of 28 days. Therefore, the compressive strengths at 10% and 20% show that bamboo has a appreciable impact on the laterized concrete unlike that of 30% in which the compressive strength at a curing age of 28 days fall below 10N/mm² (Lasisi & Osunade, 1984).

5. Conclusion

Bamboo fibre improves the strength of laterized concrete. Also bamboo fibre should not be used for laterized concrete containing more than 20% of laterite.

References

- Babalola, J. I., & Osunade J. A. (1991). Effect of mix proportion and reinforcement size on the anchorage bond stress of laterized concrete, Building and environment, pergamon press, Great Britain
- Balgun, E. R., & Adepegba, D. (1992). Effects of varying sand content in laterized concrete. In J. cement composite and light weight concrete, 4, No 4, 235-241.
- Chandrakaran, S., Krishina, M., & Tiwan, A. (1996) "Characteristics behavior of laterite concrete", IE Journal, 77, 129-131
- Falade, F. (1991). Influence of method and duration of curing and mix proportion on concrete containing fine aggregate. Building and Environment, 26(4), 453-459
- Ikpomwosa, E. E. (2000). A study on the properties of fiber reinforced laterized concrete. Great Britain: Pergmon Press
- Lasisi, F., & Ogunjide, A. M. (1984). Effects of grain size on the strength characteristics of cement-stablized laterite soil. Building and Environment, 19(1), 49-54.
- Maruthachalam, M, Moulin. E. and Kurtis, K. (2012). Studies of durability aspects of fibre reinforced concrete. *International Journal of Engineering Science and Technology. (IJEST)*, 4(02), 620-628.
- Neville, A. M., & Brooks. (2002). *Concrete Technology*. Harlow, England: Pearson education limited,
- Olusola, K. O. (2003). Factors affecting compressive strength and elastic properties of laterized concrete. PhD thesis department of building Obafemi Awolowo University.
- Shetty, M. S. (2006). *Concrete Technology*. Ram Nagar, New Delhi: S. Chand and Company Limited 7361