

Characteristics of akwara as a reinforcing fibre*

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The increasing cost of steel and the fact that it is in relatively short supply have necessitated the search for newer construction materials, with an emphasis on the utilization of materials available locally. The use of vegetable fibres is one solution to this problem. Dr Uzomaka's finding that akwara fibres improve the impact resistance is in general agreement with the findings of Sridhara et al.⁽¹⁾. However, cellulose fibres are susceptible to microbiological attack and rotting in damp environments. It should also be noted that Pama et al.⁽²⁾ have used coir fibres to make boards. They found that coir-fibre boards performed satisfactorily except in water-absorption and fire tests. So the fire resistance of vegetable-fibre-reinforced concrete is a significant problem.

Furthermore, since akwara fibres are known to be of low modulus and can be obtained in large lengths (up to 1.5 m), pressed or folded boards, perhaps even

with a preferred orientation of fibres in a cement matrix, may offer attractive possibilities for making roofing and cladding panels instead of using the materials as short chopped fibres in a concrete mix.

For structural applications the fibres, instead of being distributed throughout the matrix, should be located where they will be most effective. A similar approach was suggested by Youssef^(3,4) in his investigations into 'date-palm mid-ribs' and bamboo. The date-palm mid-ribs in particular appear to be very similar to the akwara vascular bundles. Further, the stress-strain behaviour of akwara fibres appears to vary considerably. The treated vascular bundles could be expected to behave with more consistency. These alternatives may offer some possibilities for the more effective utilization of akwara in the development of low-cost construction materials.

Reply by the author

I thank Dr Babu for his interesting discussion of the paper and for drawing attention to Sridhara's corroborative results.

Dr Babu's major reservation is that cellulose fibres, to which family akwara belongs, are susceptible to microbiological attack and rotting in damp environments. It is important to distinguish between storage of akwara in a permanently damp (or wet) environment and the embedment of akwara in concrete, albeit subjected to the fluctuations of its ambient conditions. I have not carried out any specific investigation into the long-term durability of akwara permanently immersed in water, which could typify a

situation favourable for microbiological activity and rotting. Locally, akwara is principally used for tying purlins to rafters in small low-cost houses in rural areas and as general-purpose string. When its use is interrupted, it is the local practice to store akwara string in water for days or weeks in order to retain its ductility, and it is not known that the fibre suffers any deterioration in quality.

The more pertinent and crucial question seems to be whether akwara is durable when embedded in concrete. It was claimed in the original paper that akwara showed no signs of any form of distress after 36 months in a concrete matrix environment. The situation has just been reviewed, that is after about 42 months. Figure I shows specimens of the remains of

*Pages 162 to 167 in *MCR* 96

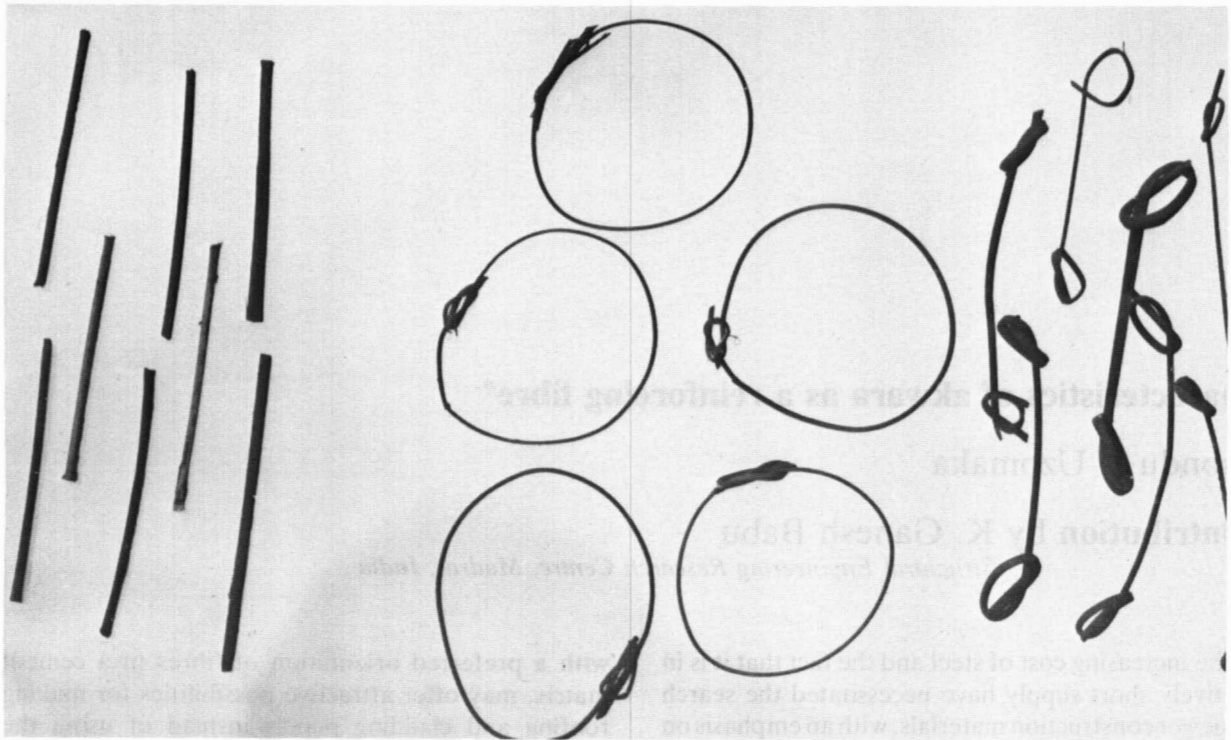


Figure 1: Akwara formations after 42 months storage in the laboratory.

the fibre formations used in the original study, which have been stored in the laboratory for 42 months. These specimens appear dry and brittle, and those on the surface of the stockpile are rather dull in appearance, but those inside still retain their original lustre.

The fibre-reinforced concrete test specimens which were used in the investigation were later utilized as

kerbs at the author's residence. These kerbs have been exposed to the seasonal variation of the Nsukka weather, which may be gleaned from Table I. The appearance of a cast surface of one such kerb, with the fibres, is seen in Figure II. These akwara formations on the surface have experienced intermittent wetting and drying over 42 months; they are dry,

TABLE I: Meteorological records for the University campus at Nsukka.

Month	Relative humidity (%)			Temperature (°C)				Sunshine (h)		Rainfall		
	Mean	Maximum daily value	Minimum daily value	Mean monthly maximum	Mean monthly minimum	Absolute monthly maximum	Absolute monthly minimum	Monthly duration	Mean daily duration	Monthly total (mm)	Days with rain	Maximum daily (mm)
1975												
Sep	81.0	95.0	68.0	27	20	29	9	98.3	3.3	309.9	19	38.1
Oct	76.5	93.0	63.0	28	21	30	18	140.0	4.5	188.0	15	38.1
Nov	70.5	88.5	47.0	29	22	32	19	169.4	5.6	15.2	6	7.6
Dec	44.0	88.0	18.5	31	18	32	14	161.1	5.2	30.5	2	15.2
1976												
Jan	48.0	74.0	16.0	31	19	35	14	196.9	6.4	0	0	0
Feb	70.5	90.5	54.0	31	22	33	19	176.7	6.1	134.6	3	99.1
Mar	71.0	86.5	53.5	31	23	33	20	178.5	5.8	35.6	4	20.3
Apr	75.5	93.0	61.0	31	23	33	19	152.8	5.1	123.1	8	36.3
May	75.5	95.0	64.0	29	22	32	19	127.1	4.1	212.3	14	55.6
Jun	78.5	97.5	67.5	28	16	30	17	160.8	5.4	124.6	15	22.1
Jul	83.5	95.0	74.0	26	21	28	18	*	*	117.6	24	21.1
Aug	85.0	98.0	74.0	26	21	28	19	73.5	2.5	104.4	16	44.2
Sep	80.5	95.0	67.5	26	21	30	19	61.5†	4.1†	268.5	17	84.4

* data not available.

† data based on records for the last 16 days of the month.

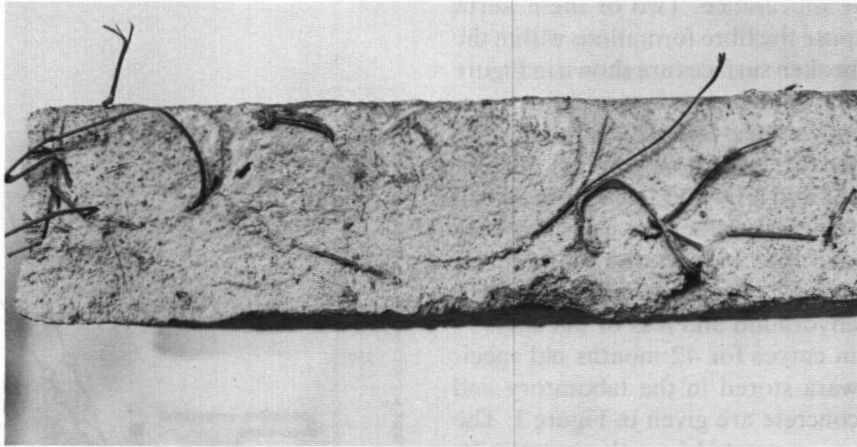


Figure II: Akwara after 42 months of exposure to the open weather.

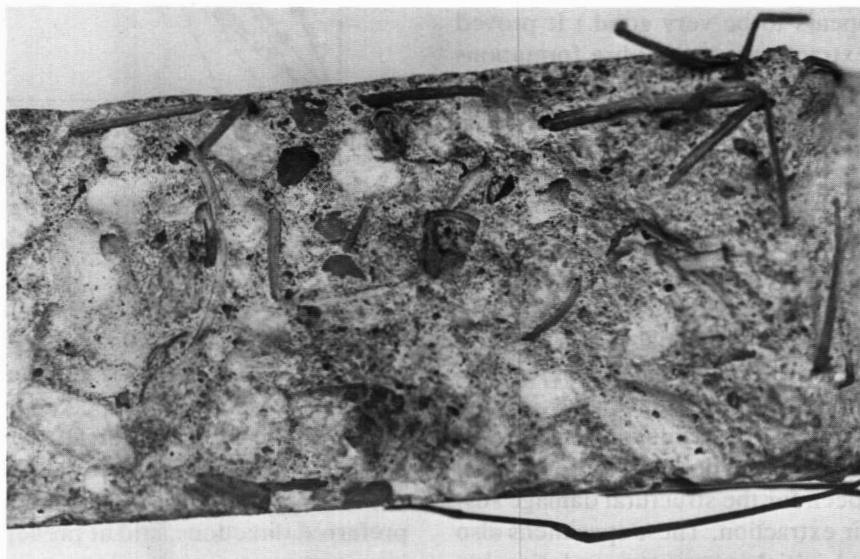


Figure III: Akwara after 42 months of embedment in concrete.

brittle and dull in appearance. Two of these kerbs were broken to expose the fibre formations within the concrete, and the broken surfaces are shown in Figure III. Both the broken concrete surface and the fibres have a brilliant appearance (coloured photographs would have revealed this lustre much better). A comparison of Figures II and III with Figure I shows that neither exposure to open weather nor embedment in concrete has caused any bio-deterioration of the fibre. The only apparent changes in relation to their initial state are dehydration and loss of ductility.

The stress-strain curves for 42 months old specimens of both akwara stored in the laboratory and akwara cast into concrete are given in Figure I. The fibre formations were extracted from the concrete by first crushing the concrete specimen in a loading machine and then carefully removing the pieces of concrete bonding the fibre. (Observation during this process indicated that the bond between the fibre formation and concrete, although not measured quantitatively, appears to be very good.) It proved very difficult to extract any of the fibre formations without their splitting longitudinally. This damage, which has the effect of reducing the effective cross-sectional area of the fibre, is considered to explain the discrepancy between the ultimate tensile strengths of the two sets of fibre specimens in Figure IV.

If Figure IV is compared with Figure 3 of the original paper, it is apparent that the tensile strength and elastic modulus of the embedded fibres after 42 months are not lower than the initial values. Rather, dehydration would have resulted in an increase in strength of the embedded formations, as is evident from the laboratory-stored specimens and also conversely demonstrated by Figure 3d of the original paper, had it not been for the structural damage sustained during their extraction. These specimens also exhibited a curved initial stress-strain relationship which straightens out to a linear upper part. Thus, this quantitative comparison further corroborates the view that, within a concrete matrix environment, akwara does not appear, at least after 42 months, to be susceptible to microbiological attack and rotting.

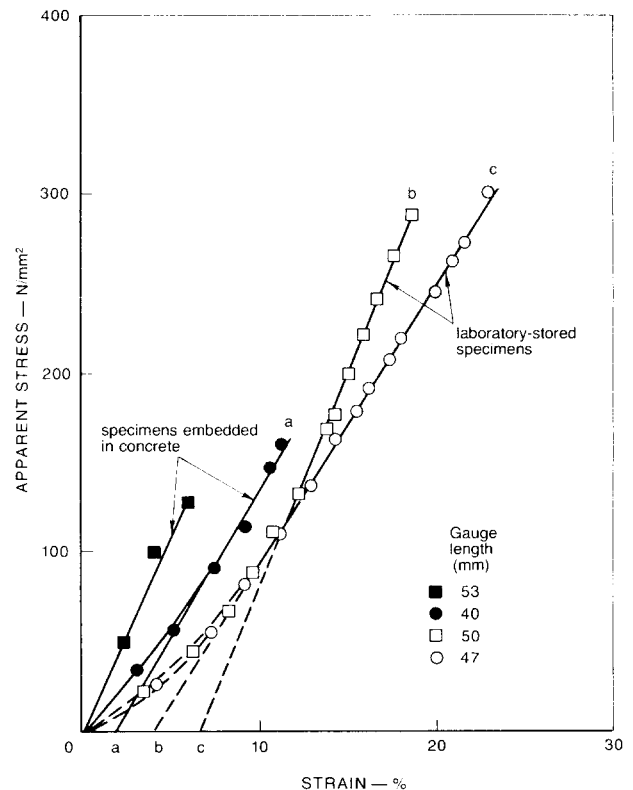


Figure IV: Stress-strain characteristics of akwara after 42 months under different conditions of storage.

The extrapolation of the performance of fibreboards to predict the water-absorption and fire resistance of fibre-concrete seems questionable. However, it is reasonable to expect that the fire resistance of vegetable-fibre-reinforced concrete would be lower than that of concrete reinforced with steel.

The suggestion of laying full lengths of akwara in preferred directions, and at predetermined locations in a mortar matrix, is a welcome one. Extension of the original project along these lines was started about 9 months ago. Furthermore, in another phase of the investigation, akwara fibre formations and coconut fibres are also being used to control shrinkage cracks, and enhance the strength of clay blocks.

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