Journal for Worldwide Holistic Sustainable Development
ONLINE ISSN: 2409 9384
PRINT ISSN: 2414 3286

2016 VOLUME 2 ISSUE 2 (ONLINE VERSION)

Recommended Citation: Ojo AR, Adejoba OR, Adesope AS, & Ogutuga SO. (2016) "Evaluation of Dimensional Stability of *Bambusa Vulgaris* Schrad Ex J. C. Wendl. Culm along the Three Orthotropic Axes Growing in Nigeria" JWHSD, 2(2), 24-30. Available at: http://wwhsdc.org/jwhsd/articles/.

EVALUATION OF DIMENSIONAL STABILITY OF *BAMBUSA VULGARIS* SCHRAD EX J. C. WENDL. CULM ALONG THE THREE ORTHOTROPIC AXES GROWING IN NIGERIA

AR Ojo, OR Adejoba, AS Adesope, & SO Ogutuga
Forestry Research Institute of Nigeria, P.M.B 5054, Jericho Hill, Ibadan, Oyo State, Nigeria
*Corresponding author: ojo.ar@frin.gov.ng; +234 8056163056

Abstract

The resulting dimensional changes in wood are one of the major sources of defects in furniture and other wood structure. This paper therefore assesses the shrinkage level of Bambusa vulgaris along the three planes to explore its dimensional stability.

Test specimens of 10cm length and different thickness and width were prepared for this test at the base (5%), middle (50%) and top (90%) of the merchantable length of the culm. They were properly aligned and denoted 'T', 'R' and 'L' for Tangential, Radial and Longitudinal planes, respectively. They were soaked in water for 48 hrs in order to get them conditioned to moisture above Fibre Saturation Point (FSP).Specimens were removed one after the other and their dimensions in wet condition were taken to the nearest millimetre with the aids of veneer slide calliper. The specimens were oven dried to 12% moisture content and their dimensions were taken. Then the shrinkage was evaluated along the three planes and data were subjected to analysis of variance

The Tangential, Radial, Longitudinal and Volumetric shrinkage were 4.55±1.77, 5.61±2.19, 0.19±0.12 and 10.35±2.77, respectively. For longitudinal shrinkage it was 0.11±0.06, 0.22±0.11 and 0.22±0.15 at the top, middle and base, respectively. It was 6.17±2.35 at top, 5.67±2.07 at middle and 5.00±2.09 at the base for radial shrinkage while the tangential shrinkage was 4.42±1.77, 4.77±1.88 and 4.46±1.69 at the top, middle and base, respectively. The volumetric was 10.70±2.93 at the top, 10.66±2.66 at the middle and 9.69±2.71 at the base. The result of ANOVA shows that there is significant difference along the sampling height for longitudinal shrinkage, but no significant difference was observed for tangential, radial shrinkage and volumetric shrinkage at 5% level of probability. From this study, it can be concluded that B. vulgaris is slightly dimensionally stable.

Keywords: dimensional stability, Shrinkage, *B. vulgaris*, Tangential, Radial, Longitudinal and Volumetric

1. Introduction

The dimensional changes that accompany the shrinking and swelling of wood are major sources of both visual and structural problems in utilization (Carl, 2012). Shrinking and swelling occur as the wood changes moisture content in response to daily as well as seasonal changes in the relative humidity of the atmosphere, that is, when the air is humid, wood adsorbs moisture and swells; when the air is dry, wood loses moisture and shrinks likewise bamboo (Ahmad, 2000). Various finishes and treatments may be used to slow this process, but, in general, they do not stop it (Carl, 2012). Likewise, air drying and kiln drying the wood do not prevent the wood from subsequently gaining or losing moisture. Thus, wood that is kiln dried to 6 percent moisture content and stored in a dry shed outdoors in a temperate climate such as that found in Indiana will regain moisture until it eventually reaches about 12 percent moisture content (Carl, 2012); under the same conditions in a tropical climate, the wood will come to a moisture content of about 16 percent. The changes in the dimensions of wood are of importance to anyone who uses wood, whether for tanks or toys, shoe lasts or ships, because wood readily takes on or gives off moisture, even from the atmosphere. Successful use of wood for exacting purposes under wide variations in atmospheric humidity shows that the problems arising from the shrinking and swelling of wood can be surmounted.

Good practice, in general, requires that efforts be made to reduce the changes in dimensions that take place while wood is in use and to minimize their effects by methods of installation and construction. Fortunately, wood is somewhat plastic, so that it can conform to a certain amount of dimensional changes without serious damage. On the other hand, the stresses developed in shrinking or swelling may cause a great deal of damage. The use of insufficiently dried lumber that shrinks under service conditions commonly results in subsequent checking, opening of joints, loosening of nails, and the warping and distortion of wood structures as a whole. If lumber is dried too far below the moisture content it will reach in use, swelling may cause drawers, windows, and doors to stick.

Sometimes the swelling and shrinking of wood can be used to advantage, as in operating humidity indicators and regulators. Swelling is employed to close seams in barrels, tubs, tanks, and boats, and to tighten handles on tools. This means of tightening is only temporary, however, as it causes compression of the wood followed by greater than normal shrinkage (FPL, 1957).

It is well known that wood is an anisotropic material which presents differential dimensional changes in different structural directions. The change in dimensions as a consequence of changes in the moisture content of wood is of great practical importance in seasoning which has a direct effect on the manufacture of furniture and joinery (Usta and Guray, 2000). Wood swells when it comes in contact with water, therefore it is obvious that wood absorbs water and thus increases in size to incorporate the water. This means that if a dry piece of woodwork is unprotected and comes into contact with water, its dimensions change and the piece of wood might not work as designed, for instance a door frame made from wood could get wet, causing swell and stopping the door from fitting. Wood could also shrink when dried, causing similar problems. Since shrinking of wood can cause so many problems and wood is anisotropic in nature, it is important to determine the shrinkage regime of lignocelullosic material along the three axis to reduce the associated problems. It is therefore germane to assess the shrinkage regime of *Bambusa vulgaris* (commonly available bamboo species in Nigeria) in the longitudinal, tangential and radial directions along the height of the bamboo culms.

Also, as bamboo is one of the oldest building materials used by mankind (Abd.Latif*et al.,*1990), it has traditionally been used as scaffoldings for low-rise houses, short-span roofs, flooring, door shutters, and as construction platforms. In recent times, bamboo has attracted more attention in view of the need for environmental conservation and wood resource shortage. Bamboo is an eco-friendly plant that grows and matures quickly between 3 to 5 years (Liese, 1987).

According to Gardener (1945), Mathew and Nair (1990), Gnanaharan, *et al. (*1993), and.Latif*et al.,* (1990), the durability and service life of bamboo is influenced by its chemical composition and high starch content. However, appropriate treatment techniques have been developed over time that can be easily adopted even with the available facilities in developing countries. But in the recent past, the dimensional stability of the bamboo growing in Nigeria has not been explored and as can been seen from

Journal for Worldwide Holistic Sustainable Development
ONLINE ISSN: 2409 9384
PRINT ISSN: 2414 3286
2016 VOLUME 2 ISSUE 2 (ONLINE VERSION)

the above, the dimensional stability of bamboo is very important to determine its behaviour in service. Therefore, this paper focuses on the shrinkage of bamboo grown in Nigeria along the three orthotropic directions

2. Materials and Method

Bamboo culms were harvested from the Asanmagbe stream of Forestry Research Institute of Nigeria, (FRIN) located in Ibadan, Oyo State at the South-western region of Nigeria with latitude $7^0$22"N and longitude $3^0$53"E. Test specimens of 10cm length and different thickness and width were prepared for this test at the base (5%), middle (50%) and top (90%) of the merchantable length of the culm; the dimensions of the specimens along the sampling height were impossible to standardize due to the tapering of bamboo from base to top, the culm wall thickness and the diameter are larger at the base compared to the top. They were properly aligned and denoted 'T', 'R' and 'L' for Tangential, Radial and Longitudinal planes, respectively in line with Ahmad (2000) (Fig. 1). They were soaked in water for 48 hrs in order to get them conditioned to moisture above Fibre Saturation Point (FSP). When wood looses moisture below FSP, it shrinks and swells when water is absorbed. The percentage change in wood dimension as a result of moisture loss is termed shrinkage (Dinwoodie, 1989). Specimens were removed one after the other; their dimensions in wet condition were taken to the nearest millimetre with the aids of Veneer slide calliper and the dimensions were also taken after oven-dried to a constant weight. Shrinkage of the specimens was measured at 12% MC. Bamboo is assumed to shrink and swell similar to wood, and therefore could be investigated using the standard methods of testing small clear specimens of timber, ASTM D 143-94 (1997). Percentage shrinkages along the three planes were calculated as:

$$S = \frac{D_S - D_O}{D_S} X100 \qquad (1)$$

Where: S = shrinkage %

D_S = dimension at saturated condition

D_O = dimension of oven dry condition

$$VS = S_R + S_T + S_L \qquad (2)$$

Where: VS = Volumetric shrinkage

S_R = Radial shrinkage

S_T = Tangential shrinkage

S_L = Longitudinal shrinkage

The approximation was done in accordance with Dinwoodie, (1989).

Journal for Worldwide Holistic Sustainable Development
ONLINE ISSN: 2409 9384
PRINT ISSN: 2414 3286
2016 VOLUME 2 ISSUE 2 (ONLINE VERSION)

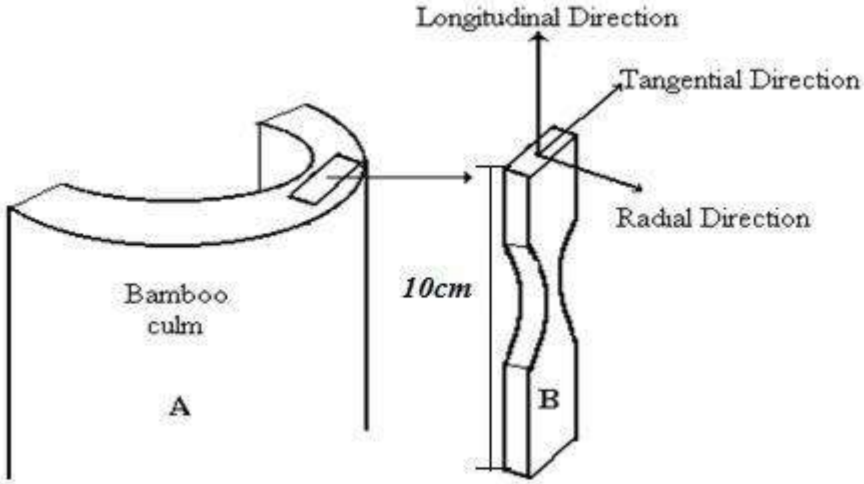

Fig. 1: specimen showing the three directional dimension of Bamboo
Source: Ahmad, 2000 (adapted)

The experimental design adopted for the experiment was a Randomized Complete Block Design with the individual culm serving as block with five replications. Data were analysed using analysis of variance.

3. Result and Discussion

The longitudinal shrinkage of *Bambusa vulgaris* was 0.19±0.12%. The highest longitudinal shrinkage was observed in the middle and base of *B. vulgaris* (0.22±0.11% and 0.22±0.15%, respectively), while the least shrinkage was observed at the top with 0.11±0.06%; the trend is different radially where the highest shrinkage was observed at the top (6.17±2.35%) followed by the middle (5.67±2.07%) and the least was observed at the base (5.00±2.09%); the radial shrinkage of *Bambussa vulgaris* was 5.61±2.19%**.** (Fig. 2).Tangentially, the shrinkage is put at 4.55±1.77%, ranging between 4.42±1.77%, 4.77±1.88% and 4.46±1.69% for the top, middle and the base respectively (Table 1). Ahmad (2000) observed radial shrinkage of Calcutta bamboo (*Dendrocalamusstrictus*) to be 2.5%, 3.1%, 3.2% and 3.7% at four different locations from the base to the top along the culm height and that of tangential shrinkage to be 2.9%, 3.7%, 3.2% and 3.3%, while that of longitudinal shrinkage were 0.43%, 0.16%, 0.17% and 0.19%. The radial and tangential shrinkage of *Bambusabluemeana* ranges from 5.4% to 9.5% and 6.4% to 20.1% respectively along the culm length from base to top (Abd. Latif, *et al.*, 1993). The observed changes in wood dimension as a result of shrinkage are unequal along the three structural directions. This behaviour of wood has been documented widely by various authors (Panshin and de Zeeuw, 1980; Dinwoodie, 1981; Lausberg, *et al.*, 1995, Ogunsanwo, 2000, Ahmad, 2000, Erakhrumen and Ogunsanwo, 2009). However, Panshin and de Zeeuw (1980) noted that the geometric disposition of cells along the principal directions and the chemical composition such as ligin are responsible for this observation.

The greatest dimensional shrinkage occur along the tangential plane for conventional wood; shrinkage along the radial plane is considered less while the longitudinal shrinkage has been widely reported to be the least and it ranges from 0.1 to 0.3% (Desch, 1988; Dinwoodie, 1989). This contradicts what is observed in *B. vulgaris* as the shrinkage observed in the radial plane is higher than the tangential plane (5.61±2.19% and 4.55±1.77%, respectively). It may be as a result of the fact that bamboo is a woody grass and a monocotyledon wood.

The result for the longitudinal direction is in line with the widely reported result for conventional wood which is between 0.1 to 0.3% and for *B. vulgaris* in this study is 0.19%. Ogunsanwo and Ojo (2011) put the radial shrinkage and tangential shrinkage of *Borassus aethiopum* palm to be 3.66% and 3.84%, respectively. Lausberg, *et al.* (1985) reported that this could have been caused by the presence of ray cells on the radial plane with their horizontally aligned cells producing a restraining effect on radial shrinkage. However, Panshin and de Zeeuw (1980) noted that it is related to the rapid reduction of the microfibrilla angle in the cell wall.

The result of analysis of variance of longitudinal shrinkage shows that there is significant difference along the sampling height, but no significant difference among the blocks (culms). For radial shrinkage, no significant difference was observed in the sampling height and among the blocks (culms) but in tangential shrinkage, no significant difference was observed in the sampling, significant difference was observed in the blocks (culms). The same trend was observed in volumetric shrinkage as a result of changes in sampling heights revealed that there is no significant difference but there is significant for blocks (culms) at 5% level (Table 2).

Table 1: Mean (%) for Longitudinal Shrinkage, Radial Shrinkage, Tangential Shrinkage and Volumetric Shrinkage

Parameters	Sampling Height	Mean
Longitudinal Shrinkage	Top Middle Base	0.11±0.06 0.22±0.11 0.22±0.15
Mean		**0.19±0.12**
Radial Shrinkage	Top Middle Base	6.17±2.35 5.67±2.07 5.00±2.09
Mean		**5.61±2.19**
Tangential Shrinkage	Top Middle Base	4.42±1.77 4.77±1.88 4.46±1.69
Mean		**4.55±1.77**
Volumetric Shrinkage	Top Middle Base	10.70±2.93 10.66±2.66 9.69±2.71
Mean		**10.35±2.77**

Table 2: Analysis of Variance for the parameters assessed (Longitudinal 'L', Radial 'R', Tangential 'T' and Volumetric shrinkage 'VL')

		ftab	**Fcal**			
Sources of variation	Df		L	R	T	VL

SH	2	3.5	8.63*	1.84^{ns}	0.33^{ns}	1.21^{ns}
Blocks (Bamboo culms)	4	2.53	0.87^{ns}	1.10^{ns}	3.82*	3.53*
Error	68					
Total	74					

*=significant at 5% level of probability
ns=not significant at 5% level of probability

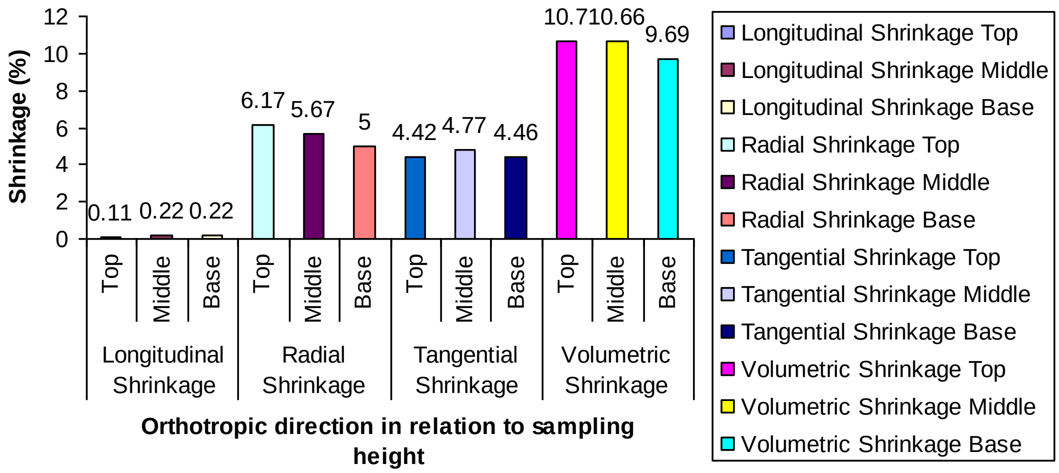

Figure 2: Shrinkages along the sampling height

4. Conclusion

Tangential shrinkage increased consistently from the top to the base, while radial shrinkage and volumetric shrinkage decreased from the top to the base. Volumetric shrinkage varied consistently and significantly along the culm height. The radial shrinkage of *Bambusa vulgaris* is not statistically different from tangential shrinkage but a bit higher. Longitudinal shrinkage is very small and is significantly different when compared to the other directions.

References

Abd.Latif, M., Ashaari, A., Jamaludin, K. and Mohd. Zin. J. (1993): Effects of anatomical characteristics on the physical and mechanical properties of *Bambusabluemeana*. Journal Tropical Forest Science 6(2): 159-170.

Abd.Latif, M., Wan Tarmeze, W.A. and Fauzidah, A. (1990): Anatomical features and mechanical properties of three Malaysian bamboos. Journal Tropical Forest Science 2(3): 227-234.

Ahmad, M. (2000): Analysis of Calcutta bamboo for structural Composite materials. A PhD thesis in Wood Science and Forest Products, Virginia Polytechnic Institute and State University. August 11, 2000, Blacksburg, Virginia. pp 210

American Society of Testing Materials (ASTM). (1997): Standard methods of testing small clear specimens of timber. Annual Book of ASTM Standards Des. ASTM D 143-94 (Reapproved 1997) Vol –4.10. Philadelphia, PA

Carl A. Eckelman (2012): The Shrinking and Swelling of Wood and Its Effect on Furniture. Forestry and natural resources. FRN 163. purdue university cooperative Extension Service.Department of Forestry &Natural Resources • 1159 Forestry Bldg. West Lafayette, IN 479071

Desch, H. E. 1988: Timber: Its structure, properties and utilization. 6th Edition. Pub. Macmillian Education. 410pp

Dinwoodie, J. M. 1981: Timber: Its nature and behaviour. Published by Van Nostrand Reinhold. 190pp

Dinwoodie, J. M. 1989: Wood: Nature’s cellular, polymeric fibre composite. Pub. *The Institute of Metal London.* pp 138

Erakhrumen, A. A and Ogunsanwo, O. Y, (2009): Water abpsortion, Anti-swell efficiency and dimensional stability Properties of Neem Seed-Oil Treated Wild grown *Bambusa vulgaris*. Schrad. Ex. J. C. Wendl. In Southwest Nigeria. *BioResources 4 (4). Pp 1417-1429. available at www.bioresources.com*

FPL (1957): Shrinking and Swelling of Wood in Use. Forest Products Laboratory, Forest Service U. S. Department of Agriculture. No 734. Information Reviewed and Reaffirmed August 1957. Original report issued July 1931 at Madison, Wis., in cooperation with the University of Wisconsin

Gardener, J.C.M. 1945. A note on the insect borers of bamboos and their control. Indian Forest Bulletin 125. Forest Research Institute, Dehra Dun, India. 17 PP.

Gnanaharan, R.; Mohanan, R.C.; Basha, S.C. 1993. Post-harvest technology of reed bamboo. Bamboo Information Centre India Bulletin 3(l), l-6.

Lausberg, M. J. F., D. J. Cown., MacConchie and J. H. Skipmith. 1995: Variation in some Wood Properties of *Pseudotsugamenziensii*. Provenancies grown in New Zealand”. *New ZealandJournal of Forestry Scienc*e 25 (2): 133- 146

Liese, W. 1987. Anatomy and properties of bamboo. *In* Rao, A.N.; Dhanarajan, G.; Sastry, C.B. ed., Recent Research on Bamboo. Proceedings of the International Bamboo Workshop, Hangzhou, China, 6-14 October 1985. Chinese Academy of Forestry, Beijing, China; International Development Research Centre, Ottawa, Canada. pp. 196-208.

Mathew, G.; Nair, K.S.S. 1990. Storage pests of bamboos in Kerala. *In* Ramanuja Rao, I.V.; Gnanaharan, R.; Sastry, C.B., ed., Bamboos: current research. Proceedings of the Inter-national Bamboo Workshop, Cochin, India, 14-18 November 1988. Kerala Forest Research Institute, Kerala, India; International Development Research Centre, Ottawa, Canada. pp. 212-214.

Ogunsanwo, O.Y and Ojo, A.R (2011): Density and Dimensional stability of *Borassusaethiopum* (Mart) Wood from A derived savannah zone in Nigeria. *Nigeria Journal of Forestry. Vol. 43. pp 31-38*

Panshin, A. J and de Zeeuw. C. 1980: Textbook of Wood Technology. 4th Edition MacGraw-Hill Book Company. pp722

UstaIlker and GurayArif (2000): Comparison of the Swelling and Shrinkage Characteristics of Corcisan Pine (Pinusnigra var. mantima) Turk J AgricFor 24 (2000) 461–464