Determination of Shrinkage and Water Absorption of Ceramics Tile Clay Body from Bauchi And Gombe States, Nigeria

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Abstract
Clear understanding of the physical characteristics of one's clay body is paramount to any successful ceramist. Bauchi and Gombe states in Nigeria is abound with deposits of silicates and limestone, that could constitute a suitable clay body for the production of ceramics tiles. Three; A, B, and C Lime clay bodies were formulated and their shrinkage and water absorption values were determined according to ASTM –C-34-71 Standard. 4.86 %, 5.07% and 4.52% were recorded for the A, B and C bodies respectively as shrinkage values. 4.4%, 0.3% and 3.6% were recorded as the A, B and C bodies respectively as water absorption results. The above obtained values were within the limits of suitable clay bodies for ceramics wall tiles production.

Key Words: *Ceramics, Tiles, Shrinkage, Water absorption, Clay body.*

Introduction

Bauchi and Gombe states of Nigeria have silicates and limestone deposits which form the components for ceramic tiles raw materials. It is important to investigated for their suitability for the production of ceramic wall tiles (Carter et al, 1963; Zaborki, 1997; Obaje et al,1999; Umar, 2000; Litan, 2007). This study has been carried out on the said materials. Ashaka limestone, Alkaleri kaolin and Bagali quartz were used, based on their qualities reported by Ofulume (2008), Umar (2000) and Munai (2018).

There is a great deal that can be learned about a clay by feeling it when it is moist. Plasticity and working quality can be judged that way. However, until you try it out, you will not be sure at what temperature the clay matures. There are other things which should be measured: (i) density, (ii) porosity, and, (iii) degree of shrinkage.

Berry (1971), United Nations Industrial Development Organization; UNIDO (1986), Ryan and Radford (1987), Rhodes (1996), American Standard for Test and Materials (ASTM), as well as Kenneth (2002), affirmed that the following physical characteristics for wall tile product are necessary:

Die to fire contraction – 0.8%. Note that the body expands or "springs" from the die when it is removed to give an expansion of 0.35% over the metal die size.
On firing there is an overall contraction in this case 1.15% to give a die to fired contraction of 0.8%.
Water absorption – 18%. This is based on soaking tiles in water for 24 hours.
UNIDO (1986), gave a range of 6 – 24% absorption.
Modulus of rupture; fired – 2300 lb. in^2 (162 kg cm^2).
Thermal expansion – 0.38% at 500^{o}C.
Moisture expansion – 0.06%.
Glaze thickness unfired – 0.010 in (o.25 cm).
Firing – Bisque 1080^{o}C, glost 1120^{o}C, glaze – low soluble.
Glaze resistance against crazing after Harkort minimum for white ware – 150^{o}C.
Dimension-tolerance maximum – 0.4 – 0.6%.
Deviation from right angle, maximum – 0.5% of the edge length.
Warp age of facial edges, maximum – 0.3% of the edge length.

Materials and Methods:

Shrinkage level test

Since clay shrinks as it dries and shrinks further some more when it is fired, ASTM -212, (2018), BSI -1281 -F, (1974) and Kenneth (2002) recommended shrinkage level test through the following formula:

Original length minus fired length X 100 = % Shrinkage.
Original length

Above theory was used for this study.

Water Absorption test

Water absorption test is an accurate measure of density**.** Kenny (1976) guided as follows: Weigh a piece of fired clay, then let it stand in water overnight. After it has soaked for 12 hours, take it out of the water, remove any surface moisture, and weigh the piece again. Its percentage of absorption will be indicated by the following formula as affirmed by the American National Standard Institute ANSI; 137.1 (1988) together with the American Standard for Testing of Materials (ASTM, 2018).

$$\frac{\text{Weight of wet minus weight of dry X 100}}{\text{Weight dry}} = \%\ \text{Absorption}\{\frac{ww - Dw}{Dw} x100 = \%Absorption$$

Three bodies were formulated as in table 1 below:

Table 1: New tile Body formulated for the Study.

Material	A	B	C
Kaolin	55	50	50
Quartz	30	30	35
Lime	15	20	15

20% of Plastic clay was added to each body

From each clay body A, B and C, 5 specimens were tested for shrinkage as in tables 2 below:

Table 2: Shrinkage Percentage of the Produced Tile Specimens

S/No	Batch	Specimen	Original length	Fired length	% Aver. Shrinkage
1	**A**	1	30	28.7	
		2	30	28.7	
		3	30	28.7	4.4
		4	30	28.7	
		5	30	28.6	
	B	1	30	28.7	
		2	30	29.4	
		3	30	29.4	0.33
		4	30	29.4	
		5	30	29.3	
	C	1	30	28.9	
		2	30	28.9	
		3	30	28.9	3.66
		4	30	28.8	
		5	30	28.9	

Kenneth (2002), stated that for wall tile, shrinkage to the fired state should not exceed 10%.

Discussion

Shrinkage

The value recorded as the shrinkage levels of ceramic tile clay bodies: A, B, and C of 4.4%, 0.33% and 3.66% respectively were within the range of ceramic uses of not more, than 10%. However, for ceramic wall tile production, UNIDO (1986); Ryan and Radford (1987); Rhodes (1996); ASTM 212

(2018) as well as Kenneth (2002), presented 0.8% as the maximum shrinkage level of clay. Therefore, only sample 'B' has the shrinkage requirements for the ceramic wall tile.

Water Absorption

Clay bodies tested as A, B and C were 4.86%, 5.07% and 4.57% respectively. The maximum of 18.5 % limit as water absorption for any wall tile body is recommended by ASTM-C34-71 and Kenneth (2002) has not been reached. It is obvious therefore that both tile bodies do not absorb moisture too much. They are therefore suitable for the tile production.

Conclusion

Based on the standards mentioned above, the values of shrinkage and water absorption recorded of clay body 'B' is more qualitative and therefore more suitable for the production of ceramics wall tiles. Bauchi and Gombe states of Nigeria are potential sources of ceramic wall tiles raw materials for Industrial production.

References

Avbovbo, A. A., Ayoula, E. O. and Osahon, G. A. (1986): Depositional and Structural styles in Chad Basin of North East Nigeria, AAPG Bull. 70, 12, 1787-1798

ASTM International (2018). Annual Book of ASTM Standards -34-71.

Ashaka Cement Company, (2010). A Monthly Chemical Analysis Report of Ashaka Limestone.

Berry, J. (1971): Making Mosaic. Studio Vista Publishers, Blue star House, High Gate Hill, London.

BSI, (1974). A Report of British Standards Institution; Specification for Glaze Ceramics Tile and Tile Fittings for International Walls. 2 Park Street, London.

Carter, J. D., Barber, W., Tait, E. A. and Jones, J. P. (1963). Geochemistry, Mineralogy and Economic Potential of a Pegmatite Residual Soil Profile in SW-Nigeria. Journal of Sciences, University of Ibadan. 22(1), 91-98

Jordan, M.M., Sanfeliu, T. and Fuente, D. C. (2001). Firing Transformation of Tertiary Clays used in the Manufacture of Ceramic Tile Bodies. *Journal of Applied clay science,* 20, 87-95. ELSEVIA, Netherlands.

Kenneth, C. (2002): The Tile: Making, Design and Using. The Crowood Press Ltd. Ramsburry, Marlborough Wiltshire SN82HR

Kenny, J. B, (1976). The Complete Book of Pottery Making. Radnor, Pennsylvania: Chilton Publishers.

Munai, D. M. (2018). Development of Lime-Siliceous Clay Body for the Production of Ceramic Wall Tiles from Bauchi and Gombe State, Nigeria. Unpublished PhD Dissertation, Submitted to Department of Industrial Design, Abubakar Tafawa Balewa University, Bauchi.

Obaje, M. G., Pearson, M. J., Suh, C. E. and Dada, S. S. (1999). Organic Geochemical Characterization of Potential Hydrocarbon Source Rocks in the Upper Benue Trough. Journal of Mining and Geology. 35/2, 137-152

Ofulume, A. B. (2008), Geology, Geochemistry and Economic Potentials of Nigerian Limestone and Marble Resources. Unpublished PhD Theses Submitted to the Geology Programme, Abubakar Tafawa Balewa University, Bauchi.

Rhodes, D. (1975). Stoneware and Porcelain. Radnor, Pennsylvania. Chilton Publishers, U.S.A.

Ryan W. and Radford, C. (1978) Properties of Ceramic Raw Materials. Second Edition Published by Pergamum Press, Oxford U.K.

Sadiq, M.A. (2000). Clay Minerology and Geochemistry of the Keri-keri Formation; Upper Benue Trough, NE Nigeria (MSc Thesis) Abubakar Tafawa Balewa University, Bauchi.

Sanfeliu, T. & Jordan, M.M. (2009). Geological and Environmental Management of Ceramic Clay Quarries: A Review. Environmental Geology, 57, 1613-1618. Springer, Berlin, Germany.

Sulayman, U.A. (2006). Utilization of Local Raw Materials for the Production of Dense Aluminosilicate Refractories Using Press forming method. Unpublished (PhD. Dissertation) Ahmadu Bello University, Zaria.

Umar, A.D.A. (2000) Studies on The Qualities of Alkaleri kaolin in High Fired Ceramics. An unpublished PhD thesis, Industrial Design Programme, Abubakar Tafawa Balewa University, Bauchi.

UNIDO, (1986). United Nation Industrial Development Organisation. www.thepoteries.org. Accessed on 12/12/2006.

Zaborski, P., Ugodulunwa, F., Idornigie, A., Nnabo, P., and Ibe, K., (1997). Stratigraphy and Structure of the Cretaceous Gongola Basin, North East Nigeria. Bulletin Centre of Research and Production, Elf Aquitaine. 22,153-185.