MATERIAL COMPATIBILITY IN CONSERVATION OF TRADITIONAL EARTH BUILDING IN NIGERIA CASE OF ORIGBO COMMUNITIES IN OSUN STATE IN SOUTH-WEST OF NIGERIA

Akinkunmi Olukunle Joel

Osun State College Of Technology, Esa-Oke.

ABSTRACT: *This paper analysed intervention strategies for the conservation of traditional earthen architecture which are selected in response to ageing earth building walls, being exposed to agents of degradation, some superficial deterioration were observed pointing to necessity of applying a compatible conservation to specific deterioration defects of earth building. There are various methodological approaches to conservation, it is therefore essential to understand material compatibility for implementing proper intervention. The study examined the major origin of defects on earth building due to wrong material composition used in conservation especially the damaging effects of cements on earth building. The paper presented conservation structure as related to appropriate material composition and compatibility. Also, properties of earth were examined that enables compatibility in conservation, this include permeability, plasticity, density, thermal conductivity, capillary absorption and drying shrinkage. The paper then concludes with essential factors of material compatibility to effective earth building conservation.*

KEYWORDS: Earth Building, Conservation, Deterioration, Material Compatibility.

INTRODUCTION

Earth construction has been in use since mankind learned how to build shelter (Bernards, 2003, Giorgio, T. 2009). Bascom, (1955) explained further that in Southern Nigeria, almost every dwelling built prior to ’50s has earth based wall, the exterior walls were made using earth techniques and interior walls with same techniques.

The durability and longevity of the earth wall dependent upon the nature of raw material originally employed as it is on the degree of care with which the building will have long lifespan.

Understanding how earthen construction material deform and carry loads is important in the development of design rules, for un-stabilized earthen construction materials, the inherent properties earth are of major significance.

Due to the permeability and hydrophilic nature of earth building, water can easily penetrate into earth as a buildings material; therefore water penetration becomes an important factor affecting durability of earth construction and conservation. The inherent weakness of earth in the presence of moisture makes the earth structure an impractical choice due to the subsequent deterioration under natural climatic conditions (Doat, p. et al, 1991, Michael, F. 2007).

The study has observed the use of Portland cement stabilizer to improve the durability of earth structure however, due to hydrophilic nature of cement earth material, which attracts water penetration. Cement stabilizers cannot solve the problems associated with water penetration for earth buildings under natural weathering conditions. When cement is added to earthen

ISSN 2056 - 5771(Print), ISSN 2056 - 578X(Online

materials, water permeation often leads to another problem such as efflorescence this has detrimental effect on the appearance of earth building (Bernards, 2003, Giorgio, T. 2009).

The conservation of an existing building stock instead of creating a completely new building takes advantage of the energy embodied in the fabric of that building. The energy expended in the manufacture of materials, transportation and construction of a new building is estimated to equal the energy necessary to heat, light and ventilate or condition the building between five and ten years (Matthew, et al, 2012, Bernard, 2003). Akinkunmi (2012), substantiate further that, sustainability favours the retention of existing building stock. Improving and maximize use of existing buildings is the cheapest and lowest-impact solution to the provision of housing presently at rural communities in Nigeria using Origbo communities as case study, the surface and other general portions of those traditional building are deteriorating fast: plaster spalling, fine and wide cracks developed, partial and total collapse of walls are also prominent on these structures. This work examines the cause of decay and the extent of damages to those buildings due to effect of rainfall, sun, radiation, wind, effect and other meteorological variables on various common conservation materials used. Understanding of material characterization is extremely important for implementing proper conservation intervention (Mileto et al, 2012).

According to Doat (1991), shows that building with earth is necessary to understand constructional methods, characteristics of the materials used and mechanism of degradation, this will provide proper conservation intervention. The earth construction process begins with soil selection, soil used to make earth building must have appropriate ratio of sand, gravel and clay to give adhesion, stability, and strength in the wall (Norton, 1997). Commonly, soil used in the construction of earth building is taken directly from the site, moistened, and compacted as to its precise composition. In this region where earth building has existed for hundreds of years appropriate soil is selected by location, visual inspection, smell, feel and even taste. Traditional builders also found many ways to adapt their materials to local conditions by inserting plant branches, or lime to prevent cracking or to increase cohesion and durability. Occasionally, long branches or bamboo are placed in the wall between compaction layer and parallel to the ground, to act as reinforcement and reduce shrinkage as the wall dries (Akinkunmi, 2014, Michael, 2007, Michael, 2008).

The remaining process begins by spreading the soil up to 8 inches at a time and compressed to 50 percent of its un-compacted height. Traditionally, this was achieved by taping with hand until appropriate level of density is achieved. The process of addition and compaction soil continues until the desired height of the structure is achieved.

According to Poul, B. And Robert, B. (1995), conservation process and materials used must compatible with the original materials, failure to observe this has led to rapid deterioration of traditional housing stock at the study area. Poul explained further that the quality of conservation process will influence the weathering performance of exposed earthen walls. If the conservation work is too weak and porous, it will be eroded too quickly, if it is too strong, it will be invariably too impervious, water will be trapped into the earthen wall, preventing trapped water from draining down, and this will cause spalling-off the face of the earthen wall. Also, Portland cement causes prevention of slight sliding of the wall when they are subjected to impose deformation such as differential settlement;this usually leads to crack especially at the joint. The current consensus is that conservation material should have a composition characteristic as close to original as possible (Michael, F.2007).

ISSN 2056 - 5771(Print), ISSN 2056 - 578X(Online

Conservation status of traditional earth building

The earthen traditional architecture has evolved through generation using local materials. The earthen material has proven its validity through ages, its efficiency in architectural solutions and ability to appropriate design against the influence of climatic and environmental factors (Momcmanova, 2007. Michael, F, 2008). The earth buildings at the study area are at advanced state of degradation, thus accelerated in part by the action of many factors this includes: rain, moisture, temperature variation, and erosion. Also, it was noticed infiltration of rain water, erosion and loss of mass earthen walls, cracking walls and peeling of plaster coatings. It was noticed at the study area that most of the traditional housing stock has been either partly or totally plastered with Portland cement,the prevailing situations are characterized with lack of good quality control measure; this resulted in several multiple cracks failure, partial collapse and dilapidation. It was noticed that the behavioural elements of those building falls basically as traditional process that lacks maintenance. These findings therefore emphasize the need for a comprehensive programme of effective conservation for the improvement of technical, functional performance of the existing rural dwelling.

Theoretical consideration

Compatibility in conservation process is the action taken to prevent deterioration process and to manage decay dynamically; it embraces all acts to prolong the life of cultural architectural heritage. The concept of conservation with minimum effect is always the best in prolonging effective performance of traditional building; it reflects the social and economic value of a society as it is the best physical and historical expression by what society valued (Gans, 1962; Raven, 1967). Historical analysis has proven that man has tried to reshape his environment to persuade himself with suitable habitation. Rapport corroborate further in his writing that house-form is not simply the result of physical forces but a consequence of a range of socio-cultural consideration. The human dwelling according to Osasona *et al* (2007) revealed that house-form is the one tangible thing that combined with cultural identity. Traditionally, house-form has always evolved based on both physical and cultural considerations. Thus every civilization produces its own house-form pattern which is highly reflective of historically prevalent. Therefore conservation must preserve and enhance the message of cultural earthen building; historical evidence must not be removed and must be harmonious with material and construction process that form bedrock for future architectural civilization. The uses of non-compatible material for conservation of earth building createa damaging stress on the earth, promoting faster deterioration process on earthen walls.

Background of the study area

Origbo communities in Ife North Local Government area of Osun State comprise of seven sister towns with the headquarters being Ipetumodu and its geographical coordinates are 7°22'N, 4° 28'E, 7.367° N and 4.467° E, (fig. I). The seven sister towns are collectively known as Origbomeje, they are: Ipetumodu, Eduabon, Moro, Asipa, Yakoyo, Akinlalu and Isope. The morphological characteristics of the area exhibits features of typical traditional Yoruba towns which are king's palace (*afin*) and traditional king market (Oja Oba) in the front of the palace. The traditional market is to promote the cultural heritage of specific town for instance, at Ipetumodu they are known for poetry works of various kinds. Surrounding the king's palace is the high concentration of traditional residential houses for the indigenous occupants and intermediate zone of contemporary face-me-i-face-you vernacular earth dwelling, whereas the outskirt consist of sparsely distributed modern single family dwelling intercepted with few

ISSN 2056 - 5771(Print), ISSN 2056 - 578X(Online

traditional and vernacular houses. Origbo rural communities have undergone considerable growth in the recent time as influxes of people were necessitate by spontaneous development such as advent of permanent site of distance learning programme by Obafemi Awolowo University as well as corresponding increase of commercial activities. House-form pattern commonly featured at Origbo community are typical courtyard housed and vernacular dwelling built from local materials. Many of those houses are still in their normal natural form while some of them have been plastered with cement, either total plastering or lower part of the building, the roofing element is corrugated sheet, indigenous thatched system of roofing has been substituted with corrugated due to technological innovation and improvement over the thatch.

Figure. 1 Showing the map location

Source: Google earth map 2015

RESEARCH METHODOLOGY

This paper concerned with an investigation of the material compatibility in conservation of traditional buildings especially external wall at Origbo communities in Osun state of Nigeria. A preliminary study involving the professionals in the construction industry identified problems and defects associated with the external building fabrics of traditional building with the use of wrong conservation material. The study used focus group to engaged rural dwellers in guided interview and discussion at the study area (Krueger,1994). The participants are experienced local house developers from rural dwellers, the focus groups were led by research fellows, who are aided by a discussion guide developed through prior interview with, experts in building local earth houses. The focus groups are a form quantitative researches in which purposely-selected participants in the field of study are interviewed in a group setting. Such

ISSN 2056 - 5771(Print), ISSN 2056 - 578X(Online

setting increases the efficiency of interviewing and interaction among the group members, it leads to more insightful response than attained through individual interviews. Such a pattern suggests the probability of a generalized view within the population being studied. Focus group also carried out structural failure investigation, by collecting soil samples used for earth conservation by local builders. This was done to determine the relative quantities of soil fractions in the soil samples aimed at identifying the intervention criteria, techniques used and evaluation of results, also to study the parameters related with the building itself as related to architectonic and construction characteristics of building and especially building techniques that compatible with effective conservation.

At the Origbo communities, earth buildings were rated according to conservation pathologies. 8,320 dwellings were identified; Primary data on the earth buildings were obtained through the stratification of the study area using stratified systematic sampling methods (Dixon and Leach, 1977).The focus groups generated the following pathological conservative category using 10% samples retrieved. 83% of material pathology and conservation compatibility with the character of earth building was also evaluated.

Data analysis and results

The data were analysed with SPSS, using frequency distribution and percentile method of analyses. The computed formula used is (f_i x 100)/n where f_i is the frequency of pathology categories; and n is the total number of represented sample. Further analysis was carried out using the Variance of (ANOVA) test to explain the linear relationship and determine the level of significance between earths building conservation status and identified material pathology. The result is established at both 0.01 and 0.05 probability.

The analysis and discussion of results are based on the assessment of focus groups identified from the study area. The results are presented as follows:

Material pathologies

Table 1 shows brief report from focus group it revealed that earth buildings from study area were 10-60 years old and above, from the report 689 of those building stock from stratified samples which amount to 83% were in a gradual dilapidation due to non-suitability of material composition for construction, environmental deterioration of earthen walls and lack of maintenance.

Table 1: Age range of the earth building

	10 – 20	*21 – 30*	*31 – 40*	*41 – 50*	*51 – 60*
Traditional Earth Building	59	103	285	226	123
Vernacular Earth dwelling	35	43	85	63	48
	73	96	173	187	161
				Σ = 690	

ISSN 2056 - 5771(Print), ISSN 2056 - 578X(Online

Table 2: Earthen wall deterioration

	Low level erosion	*High level erosion*	*Plastering disintegration*
Traditional Earth Building	530	518	520
Vernacular Earth dwelling	170	163	174
%	84.34	82.15	83.61

Mean value = 83.33%

The focus group strengthens further that 98.2% claimed ownership of their dwelling. 60% of those in this category inherited through their great grandfathers, 25% had their houses built by their grandfathers and while 15% had theirs built and transferred by their fathers. According to Jiboye (2010) in each of these cases, house ownership was by inheritance and significant proportion 60% of houses had been in use for over 60 years. This confirms the pattern of home ownership among Yoruba people where such is inherited through lineage (Adedokun, 1999).

Earth is made up of varying proportions of four types of constituents varying from, gravel, sand, salt and clay. The total porosity determines the behaviour of earth towards water and their vulnerability with respect to decay process. Thus the capillary rise and dry kinetics is indicative of the susceptibility of earth to moisture attack, earth behaves in a characteristic way so that when exposed to variation in humidity it become weak, some change in volume and others do not (Gernot, M. 2006,Mark, M.2004), According to focused group it was evident from table 2 that the earth usually employed for construction at the study area is direct moulding construction system, which comprises of high clay content in order to achieve sufficient strength, it contain particle distribution of 25% clay, 5% silt, 23% sand and 3% gravel, thus usually creates swelling and shrinking problem upon wetting and drying respectively. The analysis revealed that high percentage of traditional earth buildings was affected with high and low level earth erosion and peeling off cement plaster. This is as a result of wrong particle distribution of earth material used for construction, also poor compaction process that give way to loss of earthen material due to water erosion. Non-compatible of conservation material especially Portland cement, was confirmed by figure II and figure III, creating barrier for moisture passage that elongate damping period which bring about peeling of cement coat. Furthermore the addition of cement for conservation enhance fast wearing out of earth itself, which it could have been durable if either maintained or use conservation material that are compatible with earth that will not hastened deterioration process.Ordinarily earth structure breaths through the pores inside the structure that make the earthen walls durable, when such pores sealed off, it create situation of non-breathability that are injurious to earthen walls (Michael 2007).

Figure 1I showing the peeling-off of Portland Cement Coat on traditional earth building at the study area.

Source: Author fieldwork (2015)

Figure III showing the weakness of Portland Cement Coat on traditional earth building.

Source: Author fieldwork (2015)

Also further analysis of the result was carried out using the analysis of variance (ANOVA) test to explain the linear relationship and verify the level of significance between conservation of earth building and pathological variables. The result (F-value) of the test presented in table shows that no significant difference and that there is a linear relationship exists between building conservation and pathologies, material ($F = 1.874$; $p<0.05$, Age ($F = 2.429$: $P<0.01$), Moisture ($F= 3.591$: $P<0.01$).

These results indicate that building pathologies, conservation techniques, material, lack of maintenance and moisture influences the dilapidation process of earth building.

Discussion of Findings

The analysis revealed the deterioration process of traditional earth building through the material pathology. The specific issues generated during the interview conducted by the focus group are being developed into categories that could help to identify deterioration process affecting the earth building. The following issues were generated:

ISSN 2056 - 5771(Print), ISSN 2056 - 578X(Online

(a) **Age of those building**

The findings show that most of the tradition buildings sampled have been constructed centuries ago. 85% of those house-hold heads living in the existing houses in the study area were well over 70 years old and above, many of them have been occupying their houses for over 50 - 60 years. The traditional building ownership has been through inheritance, (Jiboye, 2010). Most rural dwellers are only responsible for mainly the provisions of earth structure without giving adequate attention to effective management of such structures. With the extensive damage this attitude has done, shift and orientation emphases are very necessary. If a satisfactory service is to be provided for the rural housing in comparism with the important role housing play in the lives of the rural area, maintenance practice must be given a top priority. Although, large programme of new house building may continued for many years with the adequate knowledge of earth as building material. It should still be appreciated if good maintenance measures in the existing housing stock are administered. Available housing should be utilized in the best possible manner to achieve the greatest possible satisfaction of the various housing needs. Furthermore, in order to achieve the objective of improving the performance of indigenous earth dwellings, education and re-orientation of rural dwellers in the most efficient manner on the adequate of holistic knowledge about earth and maintenance culture must be embraced (Akinkunmi, 2014)

(b) **Attack of earth building at low and high level erosion**

The focus group frequently emphasize the base of the wall just above the ground level is highly vulnerable to low level earth erosion. This is as a result of dripping rain water from the roof levels on the ground surfaces and splashing into the lower parts of the earth structures, this weaken the earth. This resulted in decay and deterioration of the affected lower part(s), this often leads to partial or total collapse of the building. The focus group also reported on the increase earth erosion of the surface of the wall at high level showed that roof eaves overhang is inadequate. Thus weaken the earth, resulting in decay and deterioration of the building fabric (David, 2007, Doat, et al, 1991, Norton, 1997).

(c) **Damaging effects of Portland cement on traditional earth building**

Portland cement is not designed for use on traditional earth building, which does not require its specific qualities on earth as building material, but it suffers its defects and side effects on traditional earth material. Its disadvantages are as follows:

(i) The use of cement is not reversible, its damages the traditional earth building cannot then be recycled.

(ii) Cement is too strong in compression, adhesion and tension, which is not compatible with the weak material of traditional buildings. It is a paradox that such weak materials have the greatest durability.

(iii) Because of its high strength, it lacks elasticity and plasticity when compared with earth, thus throwing greater mechanical stress on earth and hastening their decay.

(iv) Cement is impermeable and has low porosity, so it traps vapour as well as water and prevent evaporation. Consequently, it is no good for curing damp earth walls.

ISSN 2056 - 5771(Print), ISSN 2056 - 578X(Online

(v) Cement shrinks on setting, leaving cracks for water to enter and because it is impermeable, such water has difficulty in getting out. Therefore, it increases defects caused by moisture.

(vi) Cement produce soluble salts on setting which may dissolve and damage porous materials and valuable decoration (Leroy, 1996, Bernard, 2003, Giorgio, T. 2009).

Conservation structure as related to material compatibility

Several cases have shown in which the use of material non-compatible with original material used in conservation of traditional building structures result in damage to the original earthen materials, these led to conservation practice that use materials and techniques identical, if possible, to the original ones. This is based on a principle of homogeneity. Conservation should be guided by a principle of compatibility stating that the materials used in conservation should be compatible in properties with the original ones, i.e., it should cause no further damage to earth structure while contributing to their conservation (Michael, 2007, Bernard, 2003). In other words, the original materials and those added in conservation should form a composite structure that shows a satisfactory behaviour under the stress created by the environment factors. This is intended that the inevitable onset of new deterioration process should be delayed as long as possible (Barbara, S. 2007).

Compatibility problems are better analysed according to the type of deterioration process that is involved:

(a) Physical compatibility

(i) Materials microstructure

This is a determinative factor concerning moisture transfer kinetics, one of the main parameters of microstructure is the porosity of earth equal to the ratio of the earth empty space V_b versus the material total volume V_s (Giorgio, T. 2009).

$$E_0 = 1 - \frac{V_b}{Vs} = 1 - \underline{P_b/P_s}$$

WhereP_b, P_s are the bulk and the true density of the earth.

Pore structure, meaning pore shape, size, distribution and networking of pore: The low porosity of cement in earth creates problems by hindering the passage of water vapour as already mentioned (Matthew, et al. 2013).

(ii) Thermal expansion coefficient

All building materials expand when heated and contract again when cooled, this expansion and contraction being called thermal movement which is a major cause of decay in building. The extent of thermal movement depends upon the temperature range resulting from the heat impact and modified by thermal capacity of the structure, the thickness, conductivity and co-efficient of expansion of the material. Thermal expansion co-efficient of cement is frequently 50% to 80% larger than that of earth. The possible contrasts due to thermal cycles result in damage to

ISSN 2056 - 5771(Print), ISSN 2056 - 578X(Online

weaker material especially the earth, which cause deep cracks on the structure (Giorgio, 2009, Bernard, 2003).

(iii) Modulus of elasticity

Bernard (2003) confirmed that the modulus of elasticity of cement mix by far exceeds that of most traditional building materials if both are included in a conservation of structure subject to stain (deformation), all of it will be discharged onto the weaker material. Theresult is that the weaker material undergoes damage larger than the damage it would have suffered if left alone or if connected to a more deformable material with lower modulus. The reliable process to follow in conservation is that if a new material is to be rigidly connected to an old one, it is desirable that their strength and modulus be suitably matched together (Matthew, et al. 2013).

(b) Chemical compatibility

Building materials other than traditional building materials in the course of setting reaction produce soluble salts which will migrate into the adjoining porous materials and cause efflorescence, sub-efflorescence. Therefore, in this case, earth structure with abundant capillary pores and scarcity of large ones will undergo deterioration because salt crystallization inside the pore of earth structure creates damaging effects on the earth structure. Materials that ischemically compatible with earth structure that will not produce soluble salt in the course of setting such as lime should be preferred (Giorgio, 2009, Bernard, 2003).

CONCLUSION AND RECOMMENDATION

Compatibility of materials in conservation of earth building is vital;choosing an incompatible material for conservation can result not only in the failure of conservation process, but accelerate deterioration of the adjacent materials. Properties such as material composition, nature of capillarity, water absorption and vapour permeability, dry shrinkage, thermal expansion, coefficient and modulus of elasticity are the vital process to assessing this compatibility.The following essential factors are vital in promoting materials compatibility:

(i) Composition of earth as construction material

The first concern will be to determine whether a given soil is suitable for construction or conservation. Earth is made up of varying proportions of four types of constituents varying from, gravel, sand, salt and clay. Each behaves in a characteristic way so that when exposed to variation in humidity, some change in volume and others do not.

Gravel:This is made up of pieces of rock of varying hardness and size of which ranges between approximately 5 and 100mm. It is one of the stable constituents of soil. Its mechanical properties undergo no perceptible modification when exposed to water.

Sand: This made up of grains of minerals the size of which ranges approximately between 0.080mm and 5mm. Also, very stable constituent of the soil, it lacks cohesion when dry, but has high degree of internal friction force, it also has very great mechanical ability when in contact to resist movement. When slightly moist however, it gives the

ISSN 2056 - 5771(Print), ISSN 2056 - 578X(Online

appearance of cohesion as a result of the surface tension of the water occupying the space between particles.

Silt: This is made up of particles ranging between 0.002 and 0.080mm which has no cohesion when dry. Its frictional force is generally lower than that of sand. When wet, it displays good cohesion, under varying degrees of humidity; it undergoes perceptible change in volume, both swelling and shrinking and therefore cannot be used on its own as a material for making the constituent parts of a building (Vasco, et al. 2014).

Clay: According to Reeves, (2006) Clay makes the finest constituent part of soil; has quite different characteristics to those of the other particle types. Clay particles are coated with a film of absorbed water which holds tightly to the surfaces. It links the micro-particles of the soil together, which gives it its cohesion and unites its mechanical strength. Clay acts as binding agent between the coarser elements that constitute its skeleton. Clay is unstable and will change when exposed to different degrees of humidity; it has great affinity for water and equally shrinks when dry; it leads to cracks. With high water content, clay liquefies and loses its cohesion (Giorgio, 2009).

The available soil can sometimes display characteristics which it is possible to improve by increasing or decreasing the overall particle size, it can overcome for instance too great or too small a proportion of fine or gravel. Too plastic a soil can thus be improved by adding sand and insufficiently plastic soil by adding fine particles. Having good earth or making one by amending the particle mix are the two key points for the successful outcome of any construction/conservation in processed earth. If they are well-thought out and correctly implemented, they ensure that an optimum quality material is obtained, intended to guarantee that the properties endure over can be of benefit. According to Gernot (2006), the earth usually employed in direct moulding construction regime, has high clay content in order to achieve sufficient strength, it contain particle distribution of 25% clay, 5% silt, 23% sand and 3% gravel, thus usually creates swelling and shrinking problem upon wetting and drying respectively. The learner sand distribution of 14% clay, 20% silt, 62% sand and 2% gravel shows no cracks after drying. The surface of external earthen wall can be consolidated especially against rain and wind erosion by rubbing flat but light convex stone across the surface of the wall with force. This is adequate if the surface appears shiny and no pores or cracks are visible, it has high degree of weather resistance.

Soil materials are defined as follows:

Unified earth classification

Name of fraction	Grain size
Gravel	75 - 2mm
Sand (very coarse)	2 - 1
Sand (coarse)	1 - 0.5
Sand (medium)	0.5 - 0.25
Sand (fine)	0.25 - 0.125
Sand (very fine)	0.125 - 0.075
Silt	0.075 - 0.004
Clay	< 0.04

Source: (Matthew, et al. 2013).

ISSN 2056 - 5771(Print), ISSN 2056 - 578X(Online

(ii) **Water vapour permeability**: The relative high vapour permeability of building materials allow moisture to move through it. The absorption and evaporation of moisture from material keep regulating humidity within the building and diffuse penetrating water, subsequently protecting the structure from moisture consolidated damage (Matthew, et al. 2013).

(iii) **Flexibility**: According to Poul, B. And Robert, B. (2004), The elastic nature of the building materials used in conservation enables it to absorb minor structural movement associated with the expansion and contraction stress that building undergoes due to changes in temperature and humidity. This will make it less vulnerable to cracking than many cement based materials.

(iv) **Ecological and friendly**: Earth using for conservation contain no volatile organic compounds that course contamination. It allows water vapour to be dissipated, preventing the build-up of condensation. These contribute to healthier internal environment (Bjorn, 2001).

(v) **Capillary water absorption of un-stabilized earth**

The surface of most architectural materials especially earth is rich in group of atoms, such as the hydroxyl group ($^{-}O\text{-}H^{+}$) which carry electric charges are able to attract water molecules.

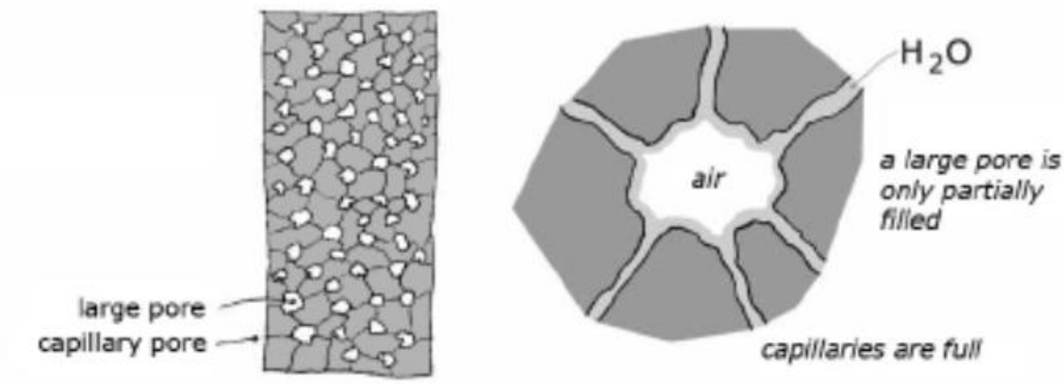
When the wall of earth building is laid on ground, the capillary rise is easily observed because the wet surface is darker than the dry wall. Water rises inside the pure system until an equilibrium is established when the amount evaporated from the surfaces which keeps increasing and the wet surfaces are extended, balances the water uptake from the soil. The inclusion of cement stabilizer prevents the evaporation of water, theprolonged dampness causes the earth to be weakened and cement plaster coat gradually separated and peel off.

The pores in porous earth building materials have variable dimensions and shapes (Figure, IV). This normally represented in a simplified model assumed to be cylindrical tube whose diameter roughly designated as large pores of larger than 10μm or capillary pores of diameter between 1 and 0.1μm (Matthew, et al. 2013).

The total porosity determines the behaviour of earth towards water and their vulnerability with respect to decay process. Thus the capillary rise and dry kinetics is indicative of the susceptibility of earth to moisture decay (Giorgio, 2009).

Figure: IV Showing the pore of the earth structure

ISSN 2056 - 5771(Print), ISSN 2056 - 578X(Online



Source: (Giorgio, 2009).

(vi) **Drying shrinkage**

An increase in water content tends to result in expansion of clay. The amplitude of the swelling depends on the amount and types of clay. After drying, clay shrinkage can create shrinkage cracks. These cracks facilitate water access into the earth material during cycles of wetting and drying (Matthew, et al. 2013).

REFERENCES

Adedokun, A. (1999) *Perspectives of African Traditional Architecture and Planning*.SEDEC Publishers, Lagos, Nigeria.
Akinkunmi, J. O. (2012)*Role of informal housing provision and reliance on indigenous resources for low income urban group*. Structural survey of Osogbo in Osun State.Blackwell Education. Nigeria
Akinkunmi, J. O. (2014)*Improving the quality of roofing system of traditional building in rural area of Nigeria.*Elixir publishers. Poland.
Barbara, H. Stuart, (2007) Analytical techniques in material conservation, John Wiley and sons Ltd. England.
Bascom, B. M. (1955): "Urbanization among the Yoruba". American Journal of Sociology, March 1955, 60(5):446-454.
Bernard, M. F. (2003) Conservation of Historic Building. Architectural Press, London - New York.
Bjorn Berge, (2001) The Ecology of building materials, Architectural press Oxford.
David S. W (2007) Building Pathology, Principles and Practice, Blackwell Publishing, USA.
Dixon, C.L. B. (1977)*Sampling methods for geographical research*.ATMoGGeogr.Abstra.17, 33-35 (University of East Anglia, Norwich).
Doat, P. et al (1991)Building with Earth: the Mud Society, New Delhi, India.
Gans, H. (1962)*The urban villagers' group and class in the life Italians*. Tree press, New York.
Gernot, M. (2006) Building with Earth Design and Technology of a Sustainable Architecture, Birkhäuser - Publishers for Architecture, Boston.
Giorgio, T. (2009) Lectures on Materials Science for Architectural Conservation, The Getty Conservation Institute, Los Angeles.

ISSN 2056 - 5771(Print), ISSN 2056 - 578X(Online

Jiboye, A. D. (2010)*Evaluating the pattern of residential quality in Nigeria*: The Case of Osogbo Township.Sci. J. factauniver.8(3), 307-316 (Architecture and Civil Engineering.University of NIS. Serbia).

Krueger, R. A. (1994. *Forms group*: A practical guide for applied research. Fond on sage publications.

Leray, E. etal (1996) Survey of damage to historic building, GCI Scientific program report, Getty conservation institute Los Angeles.

Mark Miller, etal (2014) Complete building construction, Wiley publishing, Inc.

Matthew R. H. et al eds. (2013) Modern earth buildings, woodhead Publishing Limited .Materials, engineering, construction and applications.

Michael Forsyth, ed. (2007) Understanding historic building conservation, Blackwell publishing.

Michael, F. (2008) Materials and Skills for historic building conservation, Blackwell Publishing, USA.

Mileto, C. et al.eds. (2012): Rammed earth conservation. CRC Press, London New York.

Moncmanova, A. (2007) Environmental Deterioration of Materials, WIT Press, Spain.

Norton, J (1997) Handbook on Building with Earth. Intermediate Technology publication Ltd. London.

Poul Beckmann and Robert Boweles, (2004) Structural aspects of building conservation, Elsevier butterworth Heinemann, U.K.

Osasona (2007) From Traditional Residential Architecture to the Vernacular: The Nigerian Experience.

Raven, J. (1967)*Sociological Evidence on Housing.*The Home Environment. Archit. Rev. 161(142), 236-245.

Reeves, I, et al, eds (2006) Clay materials used in construction. Geological Society, London.

Vasco Peixoto, de Freitas, etal (2014) Building pathology and Rehabilitation, springer Heidelberg. London.

ISSN 2056 - 5771(Print), ISSN 2056 - 578X(Online