MAINTENANCE OF STANDARDS IN BUILDING MATERIALS PRODUCTION AND UTILISATION

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INTRODUCTION

Before the advent of the white man, buildings were constructed using the locally available building materials and rudimentary technologies. Because of the organic base of most of the materials, the houses built with them were susceptible to inspect, vermin and fire attacks and therefore require frequent maintenance. These account for the attractiveness of cvonventional building materials like sandcreate blocks, aluminium/zinc roofing sheets, etc. although these materials are more expensive and respond less favourably to local climate.

The scarcity and prohibitive costs of conventional building materials, government dwindling resources for housing development and the low purchasing power of the average Nigerian have priced access to decent accommodation out of the reach of the average Nigerian. It is widely accepted now that a truly indigenous building materials production sector is capable of overcoming these constriants in addition to creating opportunities for improved skills and employment, income generation, affordable products and stimulation of other sectors of the economy.

In the past few decades, especially since the economic down turn of the early 80's, efforts have been generated towards the identification of suitable alternative building materials which are affordable and capable of bringing down the cost of housing development to the reach of the average citizen. Results show availability of a wide variety of local raw materials that can be harnessed for different building components. Also available are indigenous craftsmen capable of producing the needed technologies.

Despite the advantages of these indigenous building materials as mentioned earlier, their entrance into the building materials market has been rather slow and not encouraging. Some of the major reasons for this include lack of quality control in their production and utilization resulting in materials/products of variable quality or standard. The absence of formulated standards for them makes their inclusion in the nation's building codes and regulations difficult.

This paper discusses how acceptable quality and standard can be ensured in the various processes a building material/product goes through from the extraction of the raw materials through production and installation. It will focus on soil-based materials which are cheap and widely used especially in rural areas of the country. Besides, improved production and application techniques have been developed in the country.

STANDARDS FOR LOCAL BUILDING MATERIAL

The Longman Dictionary of Contemporary English defines standards as: "a level of quality that is considered proper or acceptable". The esence of standards is therefore to maintian acceptable quality. Standards and specifications have been identified as vital regulatory instruments for ensuring quality of products in the building industry, as they provide guidelines on basic processes, test procedures, equipment, etc. (ISO: 1978) over a long period of time. Standards can be useful in settling disputes arising due to quality of construction or behaviour of materials used. Standards ensure safe use of building materials, guaranteeing adequate protection for producers, users and the general public. Perhaps of utmost importance is the fact that availability of standards help in popularizing building materials as standards implies official certification.

Standards evolve from knowledge based on experience and experimentation over a long period of time. There are basically two methods for the formulation of standards as follows:

DESCRIPTIVE STANDARDISATION

This method is material-specific and suitable for materials whose suitability for particular applications have been proved over a long time. It gives specific details of materials/prodcuts necessary for ensuring accepable quality. It is not concerned with specific details but practical results. It can be considered as pragmatic.

SCIENTIFIC STANDARDISATION

Unlike the descriptive method, this method prescribes condition to be met by materials/products in order to be considered suitable for a particular application, although it gives room for a choice of materials, it requires extensive research and development in order to specify appropriate limits test methods and other measures to determine compliance with guidance. It also presumes a high level of professionalism in the souring, handling, processing and utilziation of building materials/prodcuts.

Considering the fact that most of the alternative building materials in the country are new and there is not sufficient experience in the procedures for their production and utilization, scientific standardization method will most probably be appropriate informulation of standards in the country. Besides, this will enhance international competitiveness of local resources as envisaged in the National Vistion 2010.

QUALITY CONTROL MEASURES IN THE PRODUCTION and UTILISATION OF LOCAL BUILDING MATERIALS

Local building materials are basically indigenous materials which can be harnessed for building construction. Ideally, they are not import-dependent in terms of raw materials sourcing, production and utilisation. Unlike conventional materials whose production technologies have built-in quality control mechanisms, production of local building materials tend to involve several uncontrolled manual operations which are influenced by a number of factors leading to variations in quality of products. It is therefore important to bear in mind that the quality and performance of local building materials, to a large extent will depend on the care exercised and the quality control measures taken during all the processes the material goes through.

SOIL-BASED BUILDING MATERIALS

Soil is one of the oldest materials used for building construction all over the world. The traditional method of using soil for building construction is predominantly manual and therefore prone to abuses of quality control. Thus, inspite of its high fire resistance, good thermal properties and low cost, its low mechanical strength, high shrinkage, high water absorption rate, low durability and unstable behaviour in the presence of water make it an unpopular choice in modern day construction.

Based on grain-size analysis, soils have been classified into six groups, (UNCHS:1987), given below:

TABLE 1

S/No.	GROUP	SIZE RANGE (mm)
1.	Clay	0.000 - 0.002
2.	Silt	0.002 - 0.020
3.	Fine sand	0.020 - 0.200
4.	Coarse sand	0.200 - 2.000
5.	Gravels	2.000 - 20.000
6.	Pebbles	20.000 - 200.000

The grain-size distribution of soils determine its plasticity or clay content, compactibility and cohesiveness which affect quality of soils used for building construction. Other factors which influence quality of soil bricks include water content of mix, degree and type of stabilisation, compaction pressure, brick size and shape.

SUN-DRIED BRICKS

The first step in assuring standard of building materials is the selection of the right raw matrials. Research has shown that soils for sun-dried bricks should not contain more than 1% of sulphates; excessive mica flakes; 50% iron oxides; and more than 15% of clay. Soils of compositions shown below have been recommended as acceptable. (Madedor & Asaolu (1989).

TABLE 2

S/No.	Constituent	Percentage (%)
1.	Sand	35 - 50
2.	Silt	40 - 45
3.	Clay	10 - 20

Adepegba (1975) has recommended an optimum water content equivalent to 17% of soil weight plus 0.6% of the weight of cement. This some how falls within the range of 11-16 recommended by Madedor & Asaolu (1989).

Laboratory tests for determining the suitability of soils for construction purposes include Atterberg Limits of Liquid; Plastic Limit; and Linear Shrinkage tests. As a guide, Madedor and Asaolu (1989), have recommended the following values for soil blocks:

LL <45%
PL <39%
LS <5%

There are however, simple test procedures which can be carried out in the field to determine characteristics of soils.

1. **Smell Test**: Immediately after collecting the soil sample, smell it. A musty smell is an indication of the presence of organic matters. If in doubt, addition of water or heating will make the odour more pronounced.

2. **Touch Test**: Remove any large grains and rub soil sample in the palm. Add some water and rub again. A predominantly sandy soil will feel rought in the palms and the grains will remain loose when moist. Silt will feel slightly rough and moderately cohesive when moist while clay will become plastic and sticky with the addition of water.

3. **Sedimentation Test**: fill a Jar up to one-third its capacity with soil sample, there-after, fill the jar with water and cover tight. Shake the jar vigorously and allow

to setle for 30-60 minutes. Measure the height of the different layers of sedimentaiton to determine grain size distribution of soil.

Stabilisation

The properties of soil can be improved through stabilisation. There are three types of stabilisation, namely:

1. **Physical Stabilisation**: This involves a controlled mixture of different grains size particles of soil to achieve desired grain size composition.

2. **Mechanical Stabilisation**: This invovles the introduction of external pressure or compaction effort which results in changes of the properties of the soil like its density, compressibility, permeability, porosity and mechanical properties of the soil. Ola (1988) has demonstrated that increasing compaction effort from 1N/mm² to 2N/mm² gave compressive strength rise of between 62.5% and 132%, while an increase of compaction effort from 5N/mm² to 6N/mm² gave a minimal compressive strength increase of 2.9-5.4%. He also noted that not much improvement in block characteristics is achieved when compaction pressure is beyond 8N/mm². Compaction pressure of 3-4N/mm² is recommended for compaction of soil bricks used for bungalows, (Ola: 1988; NBRRI: 1991). In this regard, the Nigerian Building and Road Research Institute has developed a brick making machine which exerts compressive effort of 3N/mm² and produces bricks with crushing strength of 1.68N/mm² at 4% cement stabilisation. Earlier studies by Ola. (1988) had shown that 1.4N/mm² crushing strength is adequate for bungalow construction.

3. **Chemical Stabilisation**: This method invovles the introduction of additives which change the physical properties of the soil via a combination of physical and chemical reactions. Common soil stabilisers include fibres, cement, lime and bitument.

Fibres in soil mixtures hinder cracking, accelerate drying, decrease density and improves insulating properties of the soil. Strength of bricks made from fibre stabilised soil depends on the quantity of the fibre used. A minimum of 4% of volume of soil is recommended, (UNCHS: 1987). The fibre should be cut into lengths of 4-6cm and soaked in water for about 4 hours before use, in order to reduce its brittleness. A variety of fibres available in the country like coconut, *rama*, sponge and palm fruit fibres can be used effectively.

For cement stabilisation, highest compressive strength is acheived when soils with high percentage of gravel or sand rather than silt or clay are used. 6-12% cement stabilsiation is often recommended for walling purposes. However, lower cement content can yield acceptable results if adequately compacted as reported earlier.

Lime stabilisation is similar to cement stabilisation. Either slacked or quick lime can be used to achieve acceptable quality. For bitumen stabilsiation on the other hand, bitumen emulsions which are fluid and mix easily with moist soil are preferred to bitumen cut back. Use of bitumen cut back requires elaborate preparation and is restricted to dry areas. It is also flammable and therefore not recommended for areas prone to fire attacks.

Water Content of Mix

As earlier mentioned, the greatest weakness of soil as a building material is its affinity to water. When the right soil has been selected, care must be taken to ensure that the soil mix has an optimum water content. If the water content is not enough, it will affect the homogenity and workability of the mix. if on the other hand the water content is in excess, it will produce a fluid mix which is prone to deformities and takes longer time to dry.

A simple field test to determine optimum water moulding content is to mould a portion of the soil into a ball. Squeeze the ball in the palm and release the fingers. If the prints of the finger appear distinctly on the ball without sticking on the figers, then the water content is alright. If however, the finger prints do not appear, then the water content is inadequate. If the soil sticks on the palm and finger,s this is an indication that the water content is in excess. Water content can be adjusted in either case to achieve required moisture content.

Moulding and Handling

Moulds should be firm. They should not be over laoded or under loaded. After extraciton, wet bricks should be left on pallets for at least 24 hours to firm-up before removal. Wet bricks should also be protected from direct sun-light and rain. It is recommended that an open curing shed be provided to allow bricks cure under controlled temperature. Curing should last a minimum of 7 days before the bricks are used. Therefter, cured bricks may be carefully stucked in the open covered with, nylon sheets for example.

A vital quality control measure is to undertake regular tests on sampels from each production batch. Tests should include those to determine bulk density; moisture content; water absorption rate; shrinkage cracking; compressive strength; and ability to withstand variations between wet and dry conditions. A high bulk density is an indication of high compressive strength. Water absorption rate should not exceed 25%. At the time of application of bricks, their moisture content should not exceed 4%.

Visual observation will reveal any cracks present. Generally, a good brick will show no signs of erosion or flaking after six circles of wetting and drying. Also, weight loss not exceeding 0.4% during the same period is acceptable.

FIRED BRICKS

The firing temperature, drying and firing procedures are important in the production of quality fired bricks. They are determined by the constituents of soil used in the production of the wet bricks. Generally, fired bricks have high clay content. While clay with kaolimite require high firing temperatures, clay with montmorillonite require very careful drying and firing procedures. Also, iron compounds in soil indicate that bricks are likely to get fused within a short time of attaining maximum temperature. On the average, soils with the following compositions are considered adequate for fired bricks production:

TABLE 3

S/No.	Constituent	Percentage (%)
1.	Clay	20-30
2.	Clay and silt	40-65
3.	Sand	Remainder

Apart from the sedimentation and smell tests already discussed, other preliminary field tests to determine soil choice include chloride test, carbonate test and observation of sample moulds. For the preparation of sample moulds, a soil sample is freed of hard stones, plant roots, etc. and ground finely. The soil is mixed with water. Thereafter, balls of approximately 6cm diameter are moulded and allowed to sun dry. A suitable soil will show no signs of cracks or deformations. Chrloride test involves dissolving small quantity of the soil in water and adding a solution of silver nitrate mixed with nitric acid. White precipitates indicate the presence of chlorides. Presence of carbonates is indicated by the appearance of intense effervescence when dilute hydrochloric acid is added to the soil sample.

The field tests may not be conclusive. Thus, there may be need for more elaborate and conclusive tests in the laboratories before production of fired bricks commence. The UNCHS (1987) identified some of those tests to include:

i. analysis to determine percentage of chemicals like carbonates, magnesium oxide, silica, allumina, organic matter, etc. present in the soil.

ii. determination of cat ion exchange capacity (T). This is the maximum quantity of all types of cat ions that a soil is capable of retaining expressed in milli equivalents (meq) per 100 grams of soil. Soils with a T value higher than 80 meq are generally not suitable for construction.

iii. x-ray diffraction test carried out to determine the presence of clay minerals such as kaolimite, montmorillite, illite, mica minerals and iron minerals.

iv. differential thermal analysis (DTA) to determine clay mineral content and presence of organic matter, sulphides and carbonates.

Soils for fired bricks production should not contain organic matter, chlorides and carbonates. Presence of limestone particles cause lime bursting, flaking, softening and swelling when bricks come in contact with water. To remedy this situation, grind soil finely and sieve with a 0.63mm sieve before moulding. Also, add sodium chloride (to the tune of 0.50-0.75% of weight of soil) to the soil during pugging of soil. This will reduce the occurrence of efflorescence. In addition, docking of freshly baked bricks by soaking of in water will dehydrate any lime particles in the bricks without any expansion in the volume of bricks.

The quality control measures to be taken during the production processes of fired bricks are smilar to those taken for stabilised bricks. In the same vein, the regular tests on brick samples recommended for stabilised bricks are also essential for ensuring that acceptable quality of fired bricks is maintained. However, a simple test peculier to fired bricks is the "ringing" test. This simply invovles hitting two fired bricks against each other. A good ringing sound indicates good bricks quality. Also, bricks should be randomly selected and observed for cracks, deformations, colour, weight, shape and strength, as these also indicate the quality of bricks

APPLICATION OF SOIL BASED BUILDING MATERIALS IN CONSTRUCTION

Soil-based materials are usually used for walling purposes. Mud based walls have certain limitations which the architect and builder must bear in mind.

i. They have low compressive strength;

ii. They are prone to damages via erosion and moisture attacks;

iii. They experience larger seasonal dimensional changes; and

iv. When used as bricks, they have smaller dimensional sizes than conventional materials.

The weakest points in earth cnstruction are the foot of the wall; top of the wall; reveals of openings; parapets; gargoyles, junctions; and bonds between different materials. There is need therefore to exercise extra care especially at these points.

Workmanship: Care is the watch word for achieving acceptable quality in bricklaying. Workmanship has considerable influence on the strength of masonry.

Poor workmanship can reduce strength of brick work by as much as 60% (Rai & Jaisingh: 1988). Because of the small dimensions of bricks, mistakes and inaccuracies are often not easily detected until after several brick courses have been laid. It is therefore very important for bricklayers to use their construction gadgets like spirit levels and plumb lines. At NBRRI, non-conventional construction gadgets which enhance productivity and quality have been developed and are available to the public. These tools aim at reducing time consuming operations like spirit levelling and string adjustments as well as mortar application during construction. They include end-frames, string holders, mortar guide boards, triangular trowels and corner finishing tools. Using these gadgets, improved productivity to the tune of 46-52% for blocklaying and 30-37% for plastering have been achieved (Bereoia & Mebude: 1988). More importantly, use of these tools will result in uniform thickness of mortar joints and higher strength.

Mortars: Choice of mortar is also very important. Ideally, the mortar should be of the same material and strength as the bricks. If the mortar is too strong, it will crack and cause the bricks to separate from the mortar. If it is too weak, the bond will be equally weakened as the mortar flakes off when dried and becomes more vulnerable to erosion and infilteration.

Bonding: Proper bonding of bricks is essential for structural stability. Bonding should ensure good toothing and adequate overlap in order to avoid cracks at the perpends. Common bonds include the Flemish, English, stretcher and Header bonds. In construction, cutting of bricks is inevitable. Cut ends should not be exposed as their affinity to water is higher. It is also good practice to wet the bricks before they are laid. Also Bricks under construction should be watered twice daily for enhanced bonding and strength.

Strengthening walls: Earth based walls though high in compressive strength are weak in tension. Thus where it is expected that walls will be subjected to stresses other than compressive stress, it is necessary to reinforce walls to be able to withstand such stresses.

Corners are very important parts of walls as their stability determine the stability of the building as a whole. As a result, appropriate bond type must be used. Use of off-cuts should be avoided at corners. Corners may be strengthened by use of stone, burnt brick with lime or cement mortars. These are included in the outer corners exposed to erosion.

Openings: Openings create points of structural weakness on the masonry. If not properly protected, they expose the wall to water penetration. An architectural design which recesses openings will prolong the service life of the building. Openings should be spanned by lintels of at least same thickness as the walls. Openings should incorporate impermeable flashings, drips under lintels and sills on the outer walls, while avoiding unstable projections on lintels and jambs. The UNCHS (1986) provides basic guidelines for the design of openings:

i. the ratio of apertures to solid sections in any one wall should not be greater than 1:3 and should be as eventy distributed as posisble. Avoid concentrations of apertures or excessively large openings.

ii. The total length of the openings should not be more than 35% of the length of the wall.

iii. Conventional spans should not exceed 1.2m.

iv. The minimum distance between an opening and a corner is 1m.

v. The width of a pier should not be less than the thickness of the wall with a minimum of 65cm. Piers less than 1m wide cannot bear loads.

vi. The ratio of the height of the breast-walling under sills and above lintels to the width of the bay should be adequate.

Services: Plumbing and electrical works are the main services required in buildings. They can however pose serious problems if poorly installed especially in earth buildings.

Plumbing work should be centrally located. Surface pipe network should be used instead of conduit system so that faults can be easily noticed, examined and rectified. Joints should also be water-tight to prevent leakage. Waste water must be carried outside the house away from foudnations. Similarly, gutters and manholes mut be carefully lcoated and maintained. Fittings should be installed to stand away from walls. Walls around fittings must be protected from splashings by ventilated water proof coatings, facings and plinths. Location of pipes and ducts should be planned in advance and wooden blocks used to secure such openings.

For electricity, conduit system should be avoided. If supply is coming directly from overhead wires, anchoring of mains supply brackets directly to the walls is not advised. This is because the wires are heavy and induce vibrations and tensile stress when taut. Supply should be connected to parts of the house that can resist tensile stress like vertical and horizontal ties.

Protective measures: In flood prone areas, damp proof courses made of impermeable materials are necessary. Base courses should be made of concrete or sandcrete blocks. If made of bricks, however, it should be of double courses and the walls protected with impermeable materials to prevent capillary action. Wind erosion can also be mitigated by introduction of courtyards and other wind-breakers.

RECOMMENDATIONS AND CONCLUSIONS

There is no construction material without strengths and weaknesses. What is important is understanding such characteristics in order to make the best of the material. Therefore, alternative building materials should be given a fair chance. Vulnerability of alternative materials to abuses of quality controlled can be curtailed by a variety of actions some of which are commended below:

i. Relevant research and development findings should be made available to potential end users.

ii. Practical training for professionals, technicians and craftsmen in the building industry should be organised periodically or as the need arise.

iii. There is need to introduce into coruse syllabi of relevant professionals, technicians and craftsmen courses on various aspects of local building materials.

iv. Local display and demonstration centres will help in popularising relevant skills required for widespread use of local materials.

v. Field manuals presented in ways which effectively convey desired information are necessary.

vi. Follow up visits, monitoring and evaluation are very important in effective introduction of new techologies and materials like local building materials.

vii. Adequate supervision is a vital tool of quality control and must be encouraged.

viii. Formulation of standards and code of practice for local building materials is very essential for maintenance of acceptable quality in the sourcing, production and application of local building materials.