

6. Conclusions

at pump system is highly effective when used to produce low temperature hot water in the range of 55 to 70 degrees C, by removing from the chilled water return of an air conditioning water chiller. This heat removal contributes to a reduction in the cost of operating the chiller.

Using the energy and cost figures from the graphs and using the values of the KWH equivalent savings at the air conditioning chiller using the conversion factors, the following Tables show the savings of this heat pump system.

1. gas savings (Fig.3) = 5000 Therms x .1055 GJ/Therm = 527.5 GJ
2. elec. savings (Chiller) = 25,733 KWH x .0036 GJ/KWH = 92.6 GJ
3. elec. usage (Heat Pump) = 42,000 KWH x .0036 GJ/KWH = 151.2 GJ

4 ----Energy Savings-----

Reduction in gas usage (from fig. 3) ----- + 527.5 GJ/mo.*
Reduction in Chiller KW ----- + 92.6 GJ/mo.

Increase due to Heat Pump (from fig. 2) - 151.2 GJ/mo.

Total Energy Savings ----- 468.9 GJ/mo.
or 468.9GJ/mo. x 12 mo./yr ----- 5,626.8 GJ/year

5. ----Cost Savings -----

Reduction in the cost of gas (from fig. 4) - + \$7,300/mo.*
Reduction in the cost of chiller operation
25,733KWH/mo. x .087 \$/KWH (Ave. cost) -- + \$2,239/mo.

Increase due to Heat Pump (from Fig. 4) - \$3,200/mo.

Total \$ Savings (Comparative) ----- \$6,339/mo.
or \$x,xxx/mo. x 12 mo./yr. ----- \$76,068/year

* Difference: Total Gas Bill minus Laundry (Sub-meter)

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BUILDING CONCEPT FOR HOT CLIMATES: "A CASE STUDY OF NIGERIAN SITUATION"

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1.0

INTRODUCTION

The traditional building concepts in most hot climates, and especially in the third world countries have always been to achieve privacy, the integration of the extended family system with strong interaction between communities, security and ventilation. The latter is still being achieved by trial and error. Most of the early building designs were in terms of environmental conformity, economic and climatic considerations, using local materials and techniques for any particular environment.

The present day building concepts in Nigeria is an integration of pre-colonial, colonial and post-colonial eras. The indigenous architecture which existed before the influence of foreign concept was developed in response to the climatic and socio-cultural settings dating back to many centuries.

Building concepts in any area could be as a result of a highly complex set of design criteria which incorporates differences in ways of life, rituals, culture and social organizations as well as climates and landscapes, materials and available technology.

- (1) Climate remains a fundamental and one of the most important ingredients determining the essential character of a building. Building technology is largely dictated by the nature of available materials. The way in which these materials are prepared for construction depends upon how labour is distributed and this, in turn, depends upon the organization of the community. In most cases, there is a close affinity between the preparation of building components and the production of local handicrafts such as pottery, in hot, dry regions where earth is the basic material, and mat weaving in humid area where bountiful rain facilitates lush vegetation, providing a rich source of organic materials.

The growing concern in Nigeria today is that our building concepts and architecture have succumbed to foreign design concepts which are not only alien to our geo-climatic, historical and socio-cultural settings, but turned out to be an economic disaster for a developing country whose foreign earnings is petroleum oil based. The huge earnings from oil exposed our excessive reliance on imported building materials and heightened our irresistible tastes for anything foreign as status symbol. The Federal Government of Nigeria (F.G.N.) has

squandered millions of Naira, with sometimes the best of intentions, on houses which people dislike intensely, because they couldn't relate to them and so often refused to live in them.

3.0 Climatic Zones

In order to develop efficient and economical design concepts, the climatic variations in Nigeria will be analysed. The country is situated between latitudes 4 and 14 degrees East of the G.M.T. It is bounded in the north by Niger Republic and south by the Atlantic ocean. The estimated population of its inhabitants is 100 million, making it the largest populated country in black Africa. The southern part of Nigeria along the sea coast is warm and humid whereas the northern part is hot and dry.

The climate in the country is a transitional one, lying between the dryness of the desert of the north and high humidity of the Atlantic Coast in the south, hence the country enjoys a tropical climate with marked wet and dry seasons. The intensity of the wet season decreases as one moves away from the coast while the marked seasons are associated with the prevalence of the moist Maritime South Westerly Monsoon from the Atlantic ocean and the dry continental North Easterly wind from the Sahara desert. The point of convergence of the two air masses marks the Inter Tropical Convergence Zone, generally known as the ITCZ. The fluctuating positioning of this zone marks the sequence of weather types found in Nigeria. Broadly, the country can be divided into two climatic zones, hot-dry and warm-humid, for building design concepts but the boundaries of each zone will overlap, substantiating the reasons for the overlap in design concepts in the two zones.

3.0 Analysis of Building Concepts

3.1 Pre-Colonial Era

Indigenous building concepts are dictated by the need for privacy, security, socio-cultural political settings and climate. Climatically, human and physical geography made necessary the development of curvilinear conical and mud roofed structures in the northern parts of the country and the rectilinear thatch roof mud houses in the south while timber piled buildings are common features in some parts of the riverine areas where lateritic soils are unavailable in reasonable quantities (2).

3.2 Hot - Dry Zone

Two outstanding features characterise the buildings in this zone. The first is the use of massive heavy weight materials

with high heat storage capacity which possess a valuable stabilizing influence on the micro-climate within the buildings. Such walls could be battered, with varying thicknesses of 400mm and 300 mm at the foundation and the roof levels respectively; or reinforced with straws, locally known as "AZARA". The second feature is that of open and semi-open spaces such as court-yards which offer important living spaces beyond enclosed rooms, ensuring adequate air movements and which are integral part of a typical dwelling. Court-yards are used for domestic works, serve as sleeping spaces during the hot season, help to distribute various family groups and different sexes, a concourse for sharing joys and sorrows with relations and sometimes, a space for rituals (3).

3.2.1 Forms of Construction

The curvilinear/pyramidal and the rectilinear are the two predominant plan-forms of construction, exposing minimum surface area to the prevailing winds from trans-sahara regions during the dry seasons. The 1.6 - 2.2 m high walls made of mud are often "reinforced" or mixed with chopped grass, leaves, corn stalk, horse or cow dung and other locally available materials. Water is added to the mud before being mixed into a paste by hand or feet stamping to ensure plasticity. The plastic material would be hand moulded into conical balls, locally called "TOBALI" in some parts of Northern Nigeria, which are in turn moulded into rectangular or circular blocks, depending upon the plan form and sun-dried.

3.2.1.1 Roof Types:- Two forms of roofs are commonly used namely mud and thatch. Mud roofs are of two types, flat type and dome type.

3.2.1.1.1 Mud Roof:- (i) Flat Type (For Rectilinear Plan Form) Azaras are arranged diagonally in layers to reduce span and then covered with grass mats, locally known as "ZANNA", before being covered with mud mortar. A final layer of loose grass may be added. In some areas, split palm trunks or other trees of various thickness and sizes are arranged at close intervals on top of the walls, overlaid with grass mats or weaved mats/grass to carry the mud roof distributed over "structural members" such as beams, lintels arches and columns made of Azara.

3.2.1.1.2 Mud Roof - (ii) These are used for Rectangular, Pyramidal and circular plan forms. Azaras are embodied in the walls to form arches which are later covered with grass mats and mud mortar. The top surface is water-proofed with bean or local herb based water proof solution for protection against

rain and thermal effects.

3.2.1.2.1 Thatched Roof - The design is commonly used for rectangular, pyramidal and circular plan forms. Such roofs are first covered with palm leave branches before the final addition of grass in various forms. Hard woods having high resistance against termite and other attacks are used for beams and purlins. The assembly and construction of circular and conical roofs often takes place on the ground before being lifted into position on the walls. Some of the roofing and wall construction are depicted by Figures 1 - 3 inclusive.

3.2.2. Openings - Minimum volume of openings in the direction of the court yard are provided for security, day lighting, thermal comfort/ventilation and religious considerations. In extreme cases, buildings are devoid of window openings while the low and narrow doorway would necessitate bending before gaining access into such buildings.

3.2.3. Thermal Comfort - The thick mud wall (minimum openings) with high heat storage capacity plus the choice of roofing materials, building orientation, close grouping of houses to ensure adequate shading effects and the compact design concept ensure adequate thermal comfort within the building. Roof tops are sometimes used for sleeping at the early hours of the night. Indigenous mud houses have the major advantages of being very cool during the dry season and warmer in the harmattan due to the heat storage capacity of the materials and wall thickness.

3.3 Warm-Humid Zone

Two major design concepts, the court yard and the compound systems, generally referred to as "AGBOLE" in Yoruba areas or "UFOK" in Calabar characterised the pre-colonial era. A typical Yoruba compound is depicted in figure 4. For centuries the heart of the Nigerian family community has been compound. A wise planner should recognise this and accept it as the cornerstone of newly planned communities, whether these are located in villages, towns or cities. Everything happens in the compound, being the play-room, kitchen, dining room, living room, garden, patio - all together in one flexible space - the family social centre.

3.3.1 Plan forms - Rectilinear or rectangular plan forms are predominant in the warm humid zone as depicted by figure 5 and the buildings are designed with verandahs which open into the courtyard or compound. Another design is that in which row of rooms of a bungalow open into a common corridor. Toilets Kitchens and storage areas are located outside the main buildings.

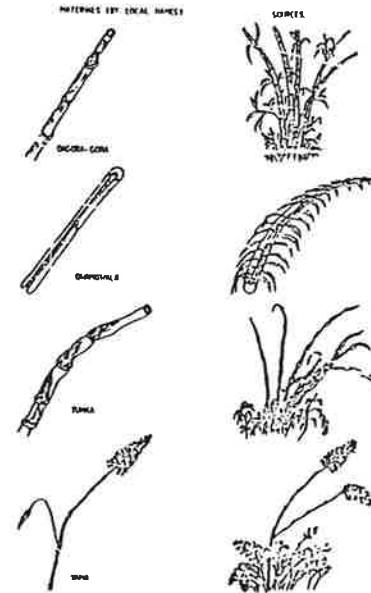


FIGURE 1: Sources of Vegetable Materials for Construction

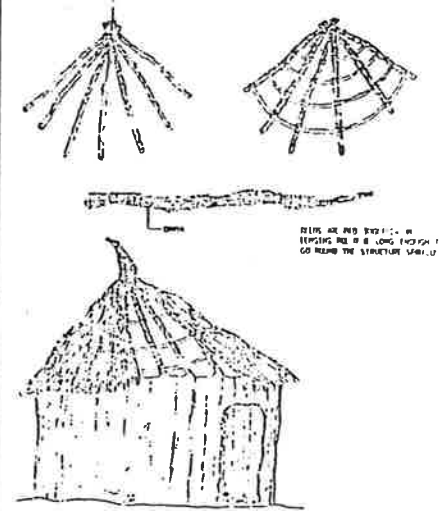


FIGURE 2: Basic Roof Construction

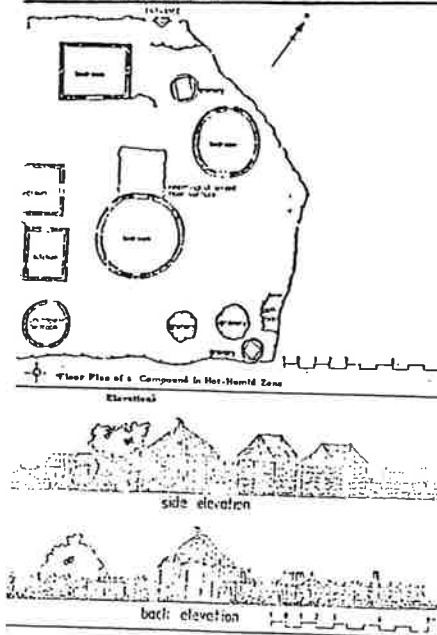


Figure 3

Source: Institute of Architects Journal June, 1986.

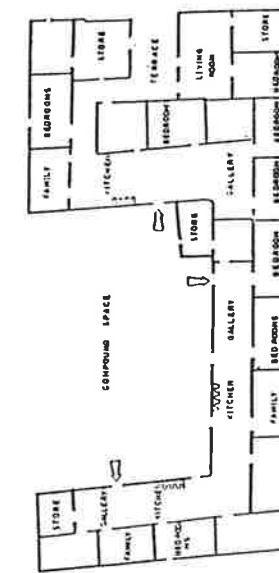


Figure 4:

Plan of a Yoruba compound

The number of houses constituting a compound is dependent on the family size, the degree of success as a farmer or fisherman or the livestock rancher or trading. Light weight materials are used because of the warm weather.

3.3.1.2. Construction/Materials:- The thin walls were either made of wattle and clays laterite consisting of two rows of sticks dug into the ground around which thin branches were laced as in filling panels to form a grid to receive the clay or made of timber or mud similar to the adopted systems in the hot dry zone. These thin walls are only required for privacy and security, and small openings are provided since they hardly stay indoors at day time. Some of these buildings are inadequately ventilated and poorly lit. Pitched roofs with large over-hang eaves protect the mud walls against rain, provide necessary shade for the verandah and maximize rain water collection. The roof members could be tree branches, bamboos, raffia or palm fronds covered with thatch could either be grass or raffia mats mown from palm leaves, piled on frame and lashed down. The average life span of an untreated thatch roof is five years.

3.3.1.3 Thermal Comfort - Thermal comfort is hardly achieved within the building during the day despite the choice of light weight building materials and the court-yard/compound design concepts.

4.0 COLONIAL ERA

This era could be regarded as the period of transition between the old and new concepts and it was marked with significant changes. The Islamic religion had tremendous impact on the form, scale, proportion and aesthetic quality of the local architecture in the north to such an extent that the simple rectilinear or curvilinear form gave way to the Islamic tradition of ingeniously combining the rectangle or square with the circle in domed, characteristic of Middle East concepts/culture. The European colonialists brought with them new life styles, building materials and construction techniques which brought about a chain of change in the building concepts of the South. This wave of change was followed by the introduction of the Brazilian building concepts by the returning freed slaves who have acquired new skills from Brazil. It may suffice to classify them as the "Euro - Brazilian and the Islamic eras." Odumosu (3). argued that these "colonialists" set out to distort and obliterate the very foundation on which the culture of our people was based, namely, the polygamous life which gave rise to the compound system, was frowned at and the courtyard began to lose its value and importance. The concept of compound design was being gradually eroded in favour of the western concept without full recognition of the socio-cultural needs of the people and its long term effects. The destruction of the connective

spaces between family units dealt a stunch blow to the traditional scheme, while they, in turn, introduced the Government Reserved Areas (G.R.A.) based on colonial concepts. Though the concepts and materials were foreign, the idea of cross ventilation and tree planting to enhance better air movement were born in the country and had since remained as part of the basic design concepts.

4.1 Construction Materials:- Concrete, burnt bricks and timber were used for wall construction while galvanized corrugated iron, Aluminium and Asbestos sheets (which reflect a high percentage of solar radiations when they are new) plus false ceiling became the main roofing materials throughout the country. In most cities, bricks and blocks were replacing the traditional materials like mud, which has a high heat storage capacity but could be slowly washed away by rain, making the building vulnerable during the rainy season. Mud walls were also being plastered for the same reasons. In order to maintain the required comfort-level, thick walls with small windows and compact design still characterised the design concepts in the north while thin walls with large window areas were introduced in the south. The first storey building was built in Badagry in 1942.

5.0 POST COLONIAL ERA AND FUTURE TRENDS

5.1 Independence Period (1960 - 1970):- The period witnessed the partial integration of the pre-colonial era, especially in the principal cities where the traditional bungalows were replaced with multi-storey/framed buildings in line with the newly acquired status. The general concepts in the rural areas, which constitute over eighty per cent of the population, were least influenced. Some principal cities, including Kano, recognize the need for community integration, resisted the destruction of their commonly community and fought to protect old Kano from modernisation.

5.2 Oil Boom Period (1970 - 1977):- This period witnessed a sudden departure from and a total disregard for our building concepts. The construction industry grew rapidly due to urbanization and industrialization and because of the rehabilitation programme after the civil war. There was a marked change from traditional to modern construction methods such as the use of steel and reinforced concrete frame buildings and fabricated houses. The country was blind to their unsuitability for hot climate because of heat transfer unless insulation or air-conditioning were used. Such structures were totally unsuited to Nigerian culture and socio-economic implications. Our design concepts succumbed to foreign dominance which was alien to our geo-climatic, historical and socio-cultural

settings. The design vogue was such that one could design anything anywhere and it would function while our foreign architects, designers and contractors involved in our major projects such as Abuja, exported and imported models without due regard for our level of technology. Since mechanical means were relied upon for thermal comfort, it became apparent that the inhabitants would be subjected to prolonged thermal discomfort whenever the regular power failure occurred.

- 5.3 Economic Recession and Future Trends:- Most of the building programmes were abandoned during the economic recession (1977 - 1983) when it became apparent that the depression in world economy had brought our oil based economy to a halt and the country was no longer credit worthy. The government emphasis shifted to the use of local materials and the need for new source of and the conservation of energy. The use of mud, stabilized laterite, red bricks, sandcrete, soilcrete blocks, treated bamboos, stabilized soils and others are now being advocated by the Federal Government. The need for energy consciousness in design has become the theme of the day. Various design concepts are being developed along this line in the two principal zones of the country. 279 mm, 330 mm, and up to 100 mm thick cavity walls are being introduced in the hot - dry zones in order to achieve the much desired thermal comfort, and the planners are becoming more conscious of the environment being designed for.

CONCLUSION

Eventhough the building concepts in the country had witnessed three major phases, the main design concepts had remained the same, viz privacy, security, socio-cultural-political settings and climate, the latter being the dominant single factor. An attempt to import foreign concepts without regard for the culture and climate of the people and the reliance on mechanical ventilation has proved a failure since the masses who were supposed to dwell in them neither have the financial resources to purchase the sophisticated gadgets nor the technological "know-how" to maintain them. In general, there is a need for designers to place emphasis on natural ventilation and other passive control systems and the use of local materials. In order to achieve a construction technology suited for local conditions, imported ultra-modern technology should be used cautiously with careful adaptation to embrace the local appropriate technology and to relate to our culture and climate. As mud and thatch go out of favour in the cities, the new local materials and modern technologies should be harnessed to serve fine traditions.

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