



**NIGERIAN BUILDING & ROAD  
RESEARCH INSTITUTE**

*Commemorative*  
**10TH YEAR ANNIVERSARY**  
*Magazine*



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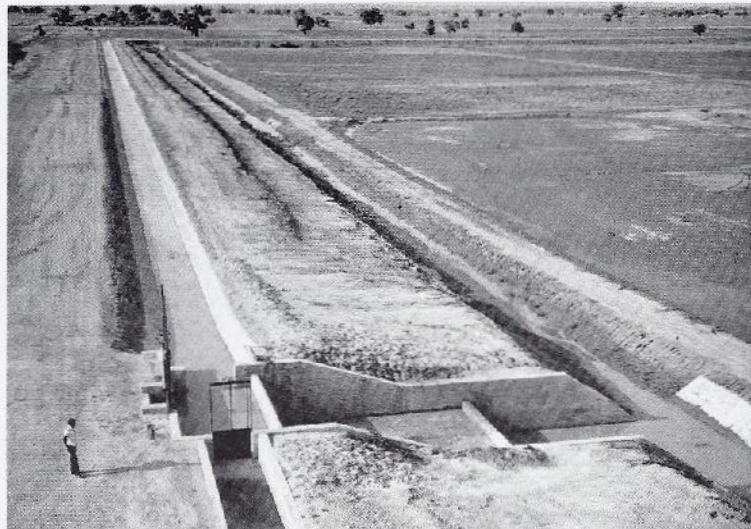
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*PROF. E. U. EMOVON, fcs  
Hon. Minister of Science and Technology.*

# Minister's Goodwill Message

The provision of shelter to the generality of the population at affordable prices and the construction of an extensive network of good and durable road system without undue reliance on external resources are two important goals of all nations at every stage of their development.

This fact informed the establishment of the Nigerian Building and Road Research Institute ten years ago. Expressly, the Institute was mandated to research into the use of local materials and resources in the building and road construction sectors of the economy as well as develop the necessary technology and equipment for their use.

I am pleased to note that in carrying out its functions, the Institute has indeed undertaken a number of projects which have immediate relevance to the nation's current housing and road construction problems. Of practical significance, for example, is the development by the Institute of building materials from clay soils using simple manually operated brick-making machine. Similarly, effective roofing materials have been developed from cement and coconut fibre. These noteworthy achievements are undergoing practical field test in Kano State where they are currently being used to implement a rural housing development scheme. In the area of road construction, it has been possible, through the efforts of the Institute, to locate sources of aggregates and other road construction materials in difficult locations by means of remote sensing techniques thereby easing the problem of road construction in these regions with problematic soil conditions.

All in all, I am satisfied that since the establishment of the Nigerian Building and Road Research Institute ten years ago, its management and staff have shown a commendable measure of dedication to their assigned roles and functions through the application of science and technology. I, therefore, congratulate you on the occasion of the Institute's 10th Anniversary Celebrations and wish you continued success in the challenges of nation building.

**Prof. E. U. Emovon**

*Hon. Minister of Science and Technology.*



*MRS. A. I. OLUKEYA*  
*Permanent Secretary,*  
*Federal Ministry of Science and Technology.*



*DR. T. I. OBIAGA*  
*Director, Industrial Science and Energy Research,*  
*Federal Ministry of Science and Technology (FMST).*

# NBRRI Is Ten: Celebrate With Us

*Anthony Madedor*  
Director NBRRI

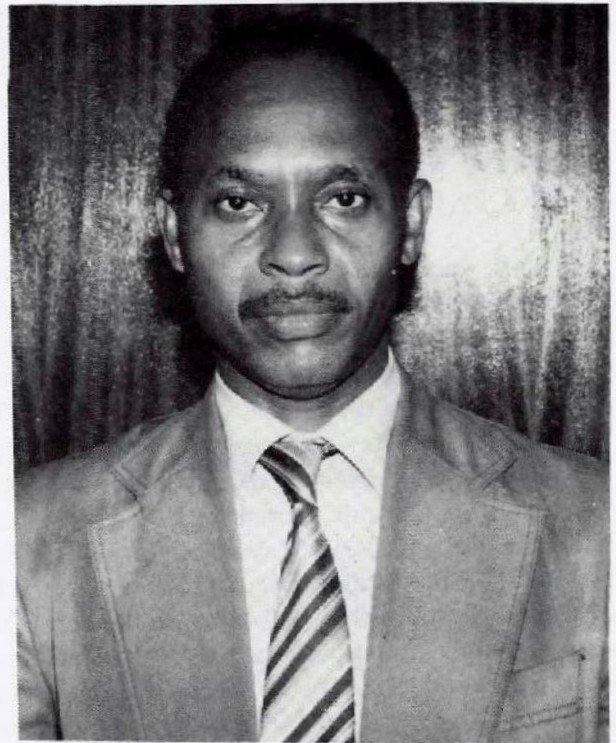
The Nigerian Building and Road Research Institute (NBRRI) is ten years old on 1 April, 1988. We invite you to celebrate with us.

We are not inviting you to the usual extravaganza of rare delicacies of food and wines. We are asking you to celebrate with us in a modest way for some very good reasons which will unfold as you read on. By having a copy of this magazine you are already celebrating with us because of your goodwill for us.

Under the normal course of events, NBRRI should have been established as far back as 1962 as an offshoot of the West African Building Research Institute (WABRI). This is because WABRI was a regional building research institute established to serve the British West African Region consisting of the Gambia, Sierra Leone, the Gold Coast, currently known as Ghana, and Nigeria. However, when Ghana gained independence in 1957, Ghana decided to pull out of WABRI with the fear that her progress would be delayed by the colonial status of the remaining three countries. In light of what subsequently happened, even in independent Nigeria, Ghana's decision now appears justified.

There was a sub-station of WABRI at Zaria situated near Ahmadu Bello University. The Zaria station was inherited by the Federal Ministry of Works and Housing. Notwithstanding this, the Zaria station failed to evolve as a national building research centre. This was mainly because the current programme at Zaria at that time did not appear to further Nigeria's national goals. When eventually the expatriate staff left in frustration there were no indigenous building research scientists to take over and develop Zaria into a national building research institute. It took various efforts of a checkered nature before eventually a national building research organisation was established.

Briefly the first effort was made when technical assistance was sought by the Federal Ministry of Works and Housing. It originated with the



participation of Mr. A. Ibrahim, of the Federal Ministry of Works and Housing at a Materials Conference in Moscow. As a result, Mr. I. Small, a former Director of WABRI, was sent by the United Nation Development Programme to Nigeria to prepare a report on the subject. This report would be the basis of the Nigerian Government's request to UNDP (Special Fund). Mr. Small recommended that the establishment of a construction and road research institute was desirable. Unfortunately, this project was not given a high enough priority and was not included in Nigeria's request to UNDP.

Alternative approaches were then considered. On behalf of FMWH, I paid a technical visit in 1970 to the Building Research Station, Garston and the Transport and Road Research Laboratory, Crowthorne, both of the United Kingdom. I prepared a report which provided a basis for the submission of a memorandum by the Federal Ministry of Works and Housing to the Federal Government urging the establishment of a building and road research institute. Surprisingly enough the request was turned down. This was quite contrary to all expectations.

No one could really explain this setback. Professionals in the construction industry speculated that perhaps the advocates of a highway authority might have at the last minutes developed cold feet, afraid that the materials engineers of the FMWH would be transferred to a new construction research institute to the disadvantage

of the proposed highway authority. As might have been expected by dispassionate observers, the highway authority was rejected. Its creation would have cost the Federal Government extra overheads to execute the same or similar highway programme which had been more than 90% executed by the highway division of the existing FMWH.

To the relief of the construction industry, the idea of establishing a building and road research institute was referred to the National Council of Science and Technology, which was established in 1970, to consider the matter further. The NCST duly completed its study under Professor I. O. Oladapo of the University of Lagos. Armed with the NCST report and recommendations from an NCST nationwide 1973 symposium which recommended the establishment of a road research institute, I submitted another report on the subject through the usual channels to management of the Federal Ministry of Works and Housing. However, there was no feedback for about nine months. I therefore requested Mr. M. T. Usman, the then Director Federal Public Works, to raise the matter with the Permanent Secretary, Mr. G. A. Ige. Immediately things started happening. The then Deputy Permanent Secretary, the indefatigable and hardworking Mr. J. E. Uduehi took hold of my report and converted it into a memorandum to the Federal Executive Council. To cut a long story short, the Council approved the establishment of the Nigerian Construction and Road Research Institute (NCRI) on 24 July, 1975 under the aegis of FMWH.

The rest is now history. NCST was replaced by the National Science and Technology Development Agency (NSTDA). Eventually NSTDA took over NCRI under NSTDA Decree 1977 Research Institute (Establishment) Order 1977, Supplement to Official Gazette No. 49 Vol. 64 13 October, 1977. Under this Decree, NCRI became known simply as the Nigerian Building and Road Research Institute (NBRRI) following the examples of Ghana and the Sudan. NSTDA swung into action and appointed the present writer as the first director on 1 April, 1978. This is the date we invite you to celebrate with us.

The regime of General Gowon was replaced on 29 July, 1975. Thus the decision to establish NBRRI on 24 July, 1975 was one of the last decisions taken under him as Head of State of Nigeria. Many professionals in the construction industry now consider this as an act of providence. If the favourable decision on the Institute was not taken on 24 July, 1975, it might have led to a delay of perhaps another two years before the

Institute would have been established.

There is no doubt that NBRRI has contributed significantly to the welfare of the Nigerian people notwithstanding its short existence. It is not my intention to list the Institute's achievement in this short article. Such an effort will not do justice to the Institute. All I would add is that some of the achievements of direct benefit to the layman are contained in the simple-to-follow articles in this magazine. You are requested to take your pick.

I wish to end on a note of appreciation and thanksgiving. In the old tradition of the civil service, which we inherited from the British system, the civil servant gives loyal, honest and faithful advice in the light of his professional and socio-economic and cultural knowledge. Thereafter he carries out whatever decision is arrived at by Government with complete loyalty. In the process only those who are closely associated with a decision can even hint at the roles played by anyone in the process that led to the decision. That is why on this occasion I wish to thank publicly all whom I suspect have helped in one way or another in the establishment of the Nigerian Building and Road Research Institute.

First I wish to express my gratitude to Mr. Femi Okunnu, the then Commissioner for Works and Housing and Mr. G. A. E. Longe, Permanent Secretary of FMWH, when the first memorandum on NBRRI was deferred and referred to NCST. I suspect that their quick presence of mind must have contributed to keeping alive the idea of a building research institute for Nigeria. In the next group, I wish to especially thank Mr. M. T. Usman for using his position as Director, Federal Public Works to push the presentation of the second memorandum on the Institute. We are also grateful to Messrs. G. A. Ige and J. E. Uduechi, Permanent Secretary and Deputy Permanent Secretary respectively at that time. Finally we note for posterity and with gratitude that the Decree establishing this Institute was under the leadership of General Yakubu Gowon. There are many others, whom we do not know, who had contributed towards the establishment of this Institute, we thank them with equal strength and fervour.

And you who are reading this, we thank you for celebrating with us. We only ask for an additional favour - your continuous goodwill and prayers for sustained growth of the Institute and greater achievement in the future.

# Functions of NBRRI

The Nigerian Building and Road Research Institute (NBRRI) was established to conduct integrated applied research and development in the diverse related fields of building and construction industries. In particular it conducts research on:

- (i) local building and construction materials to determine the most effective and economic methods of their utilisation;
- (ii) architectural design of buildings to suit Nigerian climatic conditions with respect to lighting, ventilation, thermal comfort and humidity;
- (iii) the design and performance of functional units in buildings including electrical installations, plumbing, painting, drainage, ventilation and air-conditioning systems;
- (iv) foundation and earth works for building and bridges especially on problem soils;
- (v) local construction and building operations, and methods to increase their effectiveness;
- (vi) the economic and social aspects of the building and construction industry;
- (vii) the design and construction of roads best suited to the Nigerian environment;
- (viii) road safety including the occurrence of accidents and methods of reducing the number of accidents;
- (ix) the economic and social aspects of road and transportation schemes, accident and safety measures;
- (x) structural designs of buildings and bridges and the development of design criteria, specifications and codes of practice;
- (xi) provision of consulting services and professional, technical and scientific data relating to buildings, roads and transport to the building and road construction industry and to Federal, State, and Local Governments; and
- (xii) any other related matters as may be determined from time to time.

# Research Innovations From NBRRI At A Glance

G. N. Omenge

Over the years, the Nigerian Building and Road Research Institute has achieved significant research results which can be considered modest in its ten years of existence. Quite a number of these research results have been translated into spectacular innovations which could assist tremendously in the building industry. Some of these innovations have undergone pilot testing and are available for patenting and mass production.

Among the research innovations are:

## 1. BRICKMAKING MACHINE:

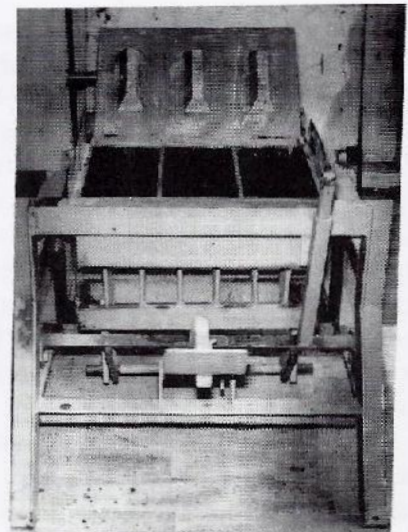
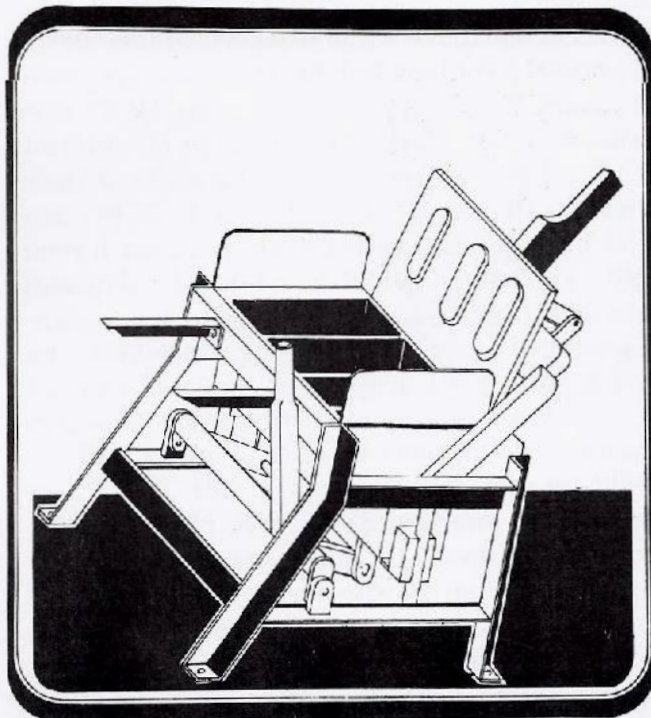
The brickmaking machine was designed and fabricated at the Nigerian Building and Road Research Institute. It can produce sun-dried, fired and cement-stabilized bricks and blocks from locally abundant clay deposits in Nigeria.

The machine has the basic advantage of imparting adequate compressive effort on the bricks to achieve suitable strengths for low cost

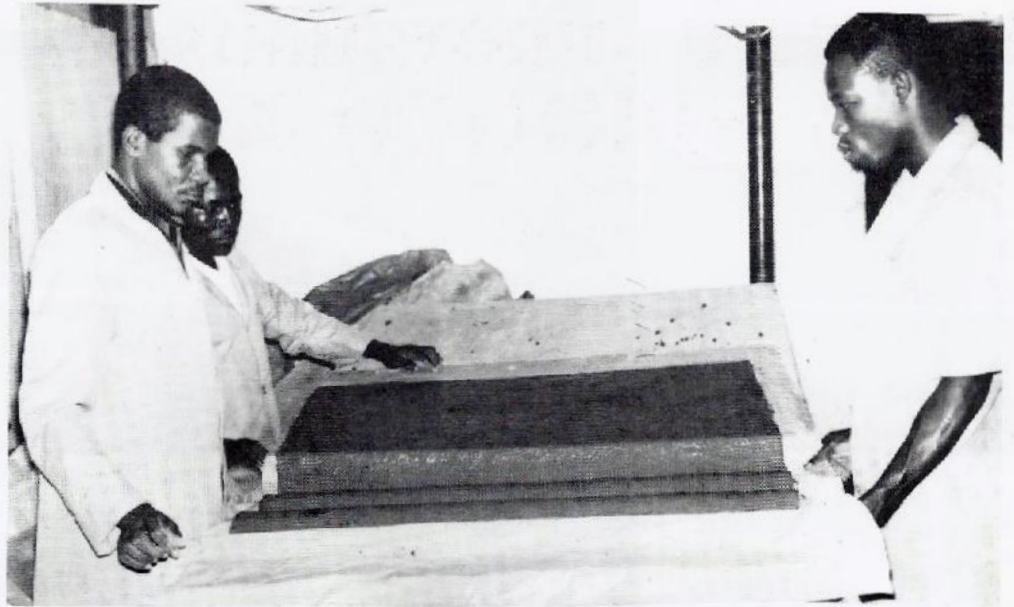
housing. The machine is light weight and can readily be transported and used at sight especially in rural areas. The operation is very simple and requires a three-man operational team. The production capacity is 800 - 900 bricks per an eight hour working day.

In the production of cement-stabilized bricks and blocks, great economy can be achieved because less cement content than would normally be required in sandcrete blocks are used. In the production of fired bricks and blocks, appropriate level of technology is applied in the construction of clamp kilns using unskilled and semi-skilled labour with the advantage of utilizing the communal self help spirit of the rural areas.

The technology has been used in pilot test programmes at the Yankatsari Village Resettlement Scheme in Kano State; construction of Porters Lodge at the premises of the Kano State Housing Corporation; and in erecting some 'test huts' at the present site of NBRRI. More importantly however, the Directorate of Food,



NBRRI Brickmaking Machine



Production of Coir Fibre Roofing Sheet in progress

Roads and Rural Infrastructure (DFRRI) has extensively used this machine and the relevant technology during a series of its workshops on training the trainers of Technical Extension Workers (TEW). This is in line with its mass rural housing programme for the twenty one states and Federal Capital Territory of the Federation.

This machine is presently available for patenting.

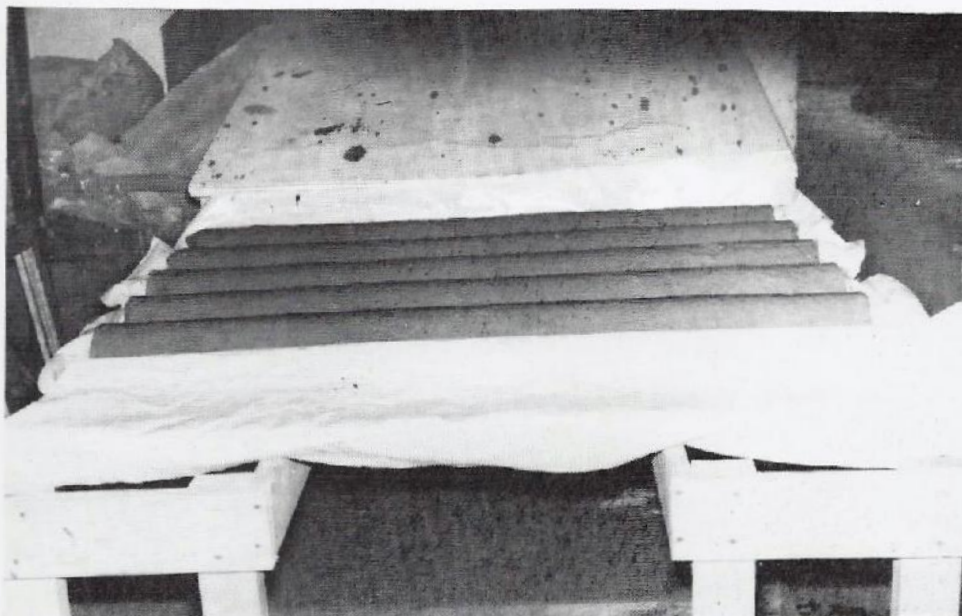
### 2. TILE MAKING MACHINE:

A tile making machine was also designed and fabricated at the NBRRI. The machine has also been extensively employed in all the pilot programmes mentioned above.

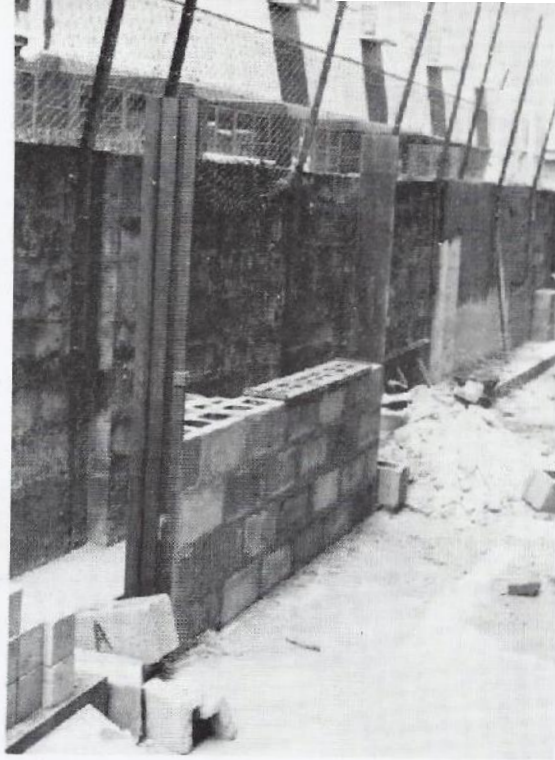
### 3. COIR FIBRE ROOFING SHEET:

An appropriate technology of producing durable and cheap roofing sheets at any required site was developed at the NBRRI. For this, a roofing sheet moulding table was designed and fabricated. The construction is simple and can be done even in rural areas and by rural communities.

The appropriate technology involves using coir fibre from coconut husk, cement and sharp sand in suitable combination. Indeed any type of fibre viz. palm kernel fibre, sisal fibre, sponge etc can be used in place of coir fibre. About nine roofing sheets can be made from one bag of cement and production requires a three-man team.



Coir Fibre Roofing Sheet: Finished product



*Block laying with End Frames, String Holders and Mortar Guide*

The fibre-based roofing sheet is cheap, durable, water and fire resistant and is a better alternative to the conventional galvanised iron and asbestos roofing sheets.

These sheets have also been extensively used in pilot programmes as indicated earlier.

#### 4. CEILING/PARTITION BOARDS:

Ceiling/partition boards were developed from appropriate combination of agro-wastes (i.e. sisal fibres, coir fibres, sponge etc), cement and sand. The excellent thermal and sound insulation properties as well as the attendant durability and low cost make these ceiling/partition boards preferable alternatives to conventional ceiling boards.

#### 5. EFFECTIVE AND INNOVATIVE CONSTRUCTION TOOLS:

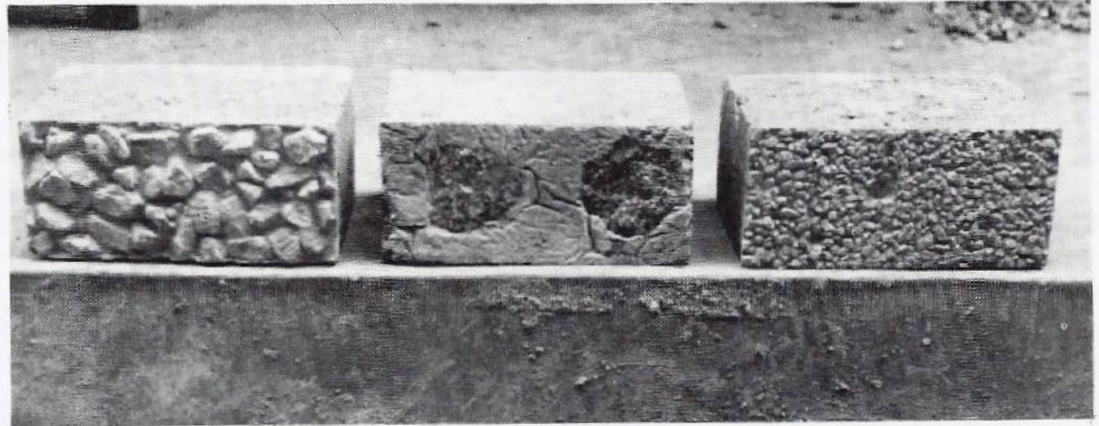
In order to enhance work output of building operations at construction sites, various simple construction equipment and tools were developed. These include:

##### a. TOOLS FOR BRICKLAYING:

Some of the tools developed were aimed at minimizing or eliminating non-productive operations of spirit levelling and string adjustments as well as mortar application during blocklaying by masons. Some of these gadgets include ENDFRAMES, STRING



*Construction gadgets: Corner finishing gadgets, Triangular trowel and String Holders.*



*Stone Masonry Block*

**HOLDERS and MORTAR GUIDE BOARDS.** These were developed locally with local materials and the technology is simple. A 40% increase in productivity over traditional method of blocklaying has been recorded.

**b. TOOLS FOR PLASTERING:**

A simple **TRIANGULAR TROWEL** was designed and fabricated at NBRRI. The advantage over conventional trowel is that more mortar can be handled with ease. Productivity of 30% over conventional trowels has been recorded.

**c. STONECRETE:**

For effective use of stones in walling in areas where rocks and stones are abundant, a simple technology for making stonecrete blocks was developed. This uses cement concrete mixes of 1:5:8 and stone pieces/boulders cast in battery moulds. Different surface textures

as required can be obtained.

**6. SOLAR WATER HEATERS:**

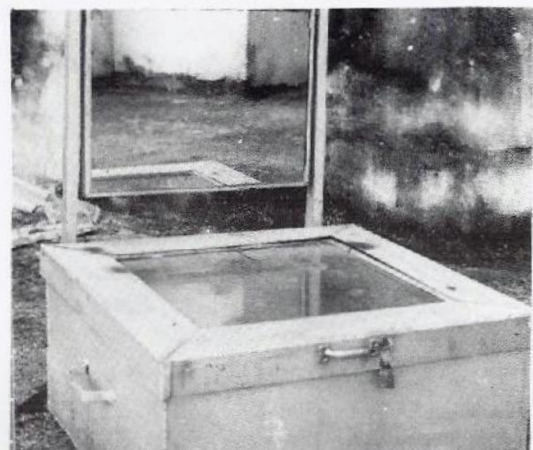
A consequence of the solar energy studies at NBRRI is the design and development of solar water heaters, from local materials. Two types of solar water heaters were developed viz. the natural convection solar water heater and an integral (built-in-storage) solar water heater. Temperatures of between 55°C and 70°C have been achieved for both heaters. If water is drawn at regular intervals during the day, the water temperature ranges between 40°C to 60°C. These heaters can easily be constructed in both urban and rural areas.

**7. SOLAR COOKERS:**

Two types of solar cookers were designed and fabricated from local sources. These are the box type solar cooker and the concentrating type solar cooker. These have been used to cook rice, yam and potatoes around noon hours.



*Solar water heater.*



*Solar Cooker*

# Research And Development In Housing

C. E. Nwachuku

## INTRODUCTION

### I. *Research and Development*

Research and development are inseparable twin processes for continually ensuring improvement in almost every field of man's endeavour, his manner, style and standard of living. By them our forebears empirically learnt to build mud and thatch houses, with or without stick and other reinforcements. By them also we even today turn agricultural and other wastes into useful materials for housing and other aspects of human living. They, indeed, permeate and pervade all spheres of human life and endeavour.

Dividing lines between research and development are very much blurred. Research on the one hand is the very first step that clarifies problems, assures that ideas, processes and machinery can work and most often ends in crude prototypes. Development on the other hand consists of the various interactions and modifications necessary to further refine workable ideas, processes or machinery to assure economic and financial feasibility and at the same time enhance smoothness of operation and general acceptability.

Research and development may assume very wide formats. They may range from unorganised informal personal explorations, operations to highly organised sophisticated operations of big corporate research and development departments, with clearly set-out project objectives/targets, budgets and deadlines, as well as concomitant rigorous administrative and monitoring processes. The latter tend to achieve more, better and quicker results.

#### i. *The House*

The house occupies a very unique position for just like food, it is a basic human necessity. The house is the homebase from which nearly every human being operates. The nature and performance of the house significantly affects moods and attitudes of occupiers whose

performance outside of the home are indirectly affected. Indeed, the home is the centre for a very wide range of often conflicting activities by people of different sexes, attitudes and widely different age-groups. For most people however, the home is by far the most expensive single non-commercial investment or consumer of income.

Research and Development in housing are therefore, most important. Performance, acceptability, suitability and cost are among many factors of continual and recurring interest for research and development and which make research and development so very important.

### II. *Strategies for Housing Research and Development:*

Three categories of strategy are predominant in housing research and development. These are the components, experimental houses and housing in service approaches.

#### i. *Components Approach:*

The house can be conceptualised to consist of components: foundations, walls, roof, windows, building materials tools, and efforts made to develop new, cheaper or better performing materials, proceedings and processes. Most of the work can be done in the laboratory or workshop, though some of the work may have to be done in the field. The latter, most often, involves validating and obtaining user acceptance of new schemes, materials and techniques/processes. Maturation time is relatively short.

Here at NBRRI the above approach has been most successfully used in developing low cost stabilised/burnt bricks, roofing sheets from coir fibre, ceiling boards from agricultural wastes, simple handtools for housing construction, simple brick-making machinery etc.

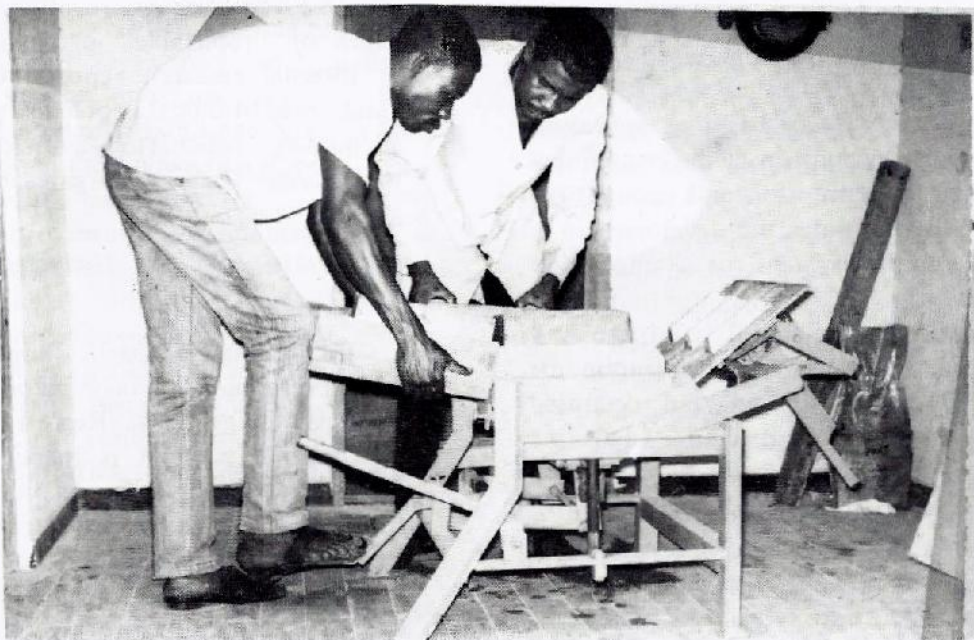
ii. *Experimental or simulated Houses Approach:*

Experimental houses or simulated houses may be very useful tools for specific studies of user requirements or determination of technique effectiveness. For example, foundation, floor systems, roof members may be observed, appropriate instrumentation read and occupants interviewed. Variability of habits of different occupants or of details of construction impose various degrees of limitations on the usefulness of conclusion to be drawn from such studies of limited number of cases. And this has to be duly recognised and considered. Even though houses may be located in widely differing climatic and foundation conditions, standardisation of components provides basic similarities in construction. Should occupants be generally in the same group, ethnic group and of similar economic status, differences in habits as reflected in house performance are more readily discernible.

With large groups of similar houses, failures or poor performance features that occur are normally repeated many times. This not only emphasises the problem but also helps to isolate the factors responsible. Though not built specifically for that purpose, housing stock of the various low cost housing schemes in different parts of the country could be powerful research vehicles.

Field investigations of many similar full-scale houses has additional benefits through improved contacts between researchers and practitioners. Researchers gain experience in practical construction problems while practitioners obtain a better understanding of applied science benefits. Complications arising from many uncontrolled or non-measurable variables in actual buildings may require large-scale laboratories or the instrumented "test hut" approach to many specific problem areas.

NBRRI has to date used a test hut built in 1983 to study, assess and project the durability of roofing sheets made from fibres, repair procedures for such roofing materials, roof overhang and verandahs for wall protection from driving rain, clay as mortar joints and the structural stability of unstabilised lateritic walls, stabilised as well as fired bricks. A model house at Yankatsari village near Kano is being used to study among other things, simplification of architectural patterns and construction procedures, spatial allocation to various activities and thermal comfort measurements. Feedback from the test hut and model house should lead to development of a better generation of roofing materials, walling materials, architectural patterns etc.



*Application of Indegenous Technology: Using NBRRI brick-making machine.*

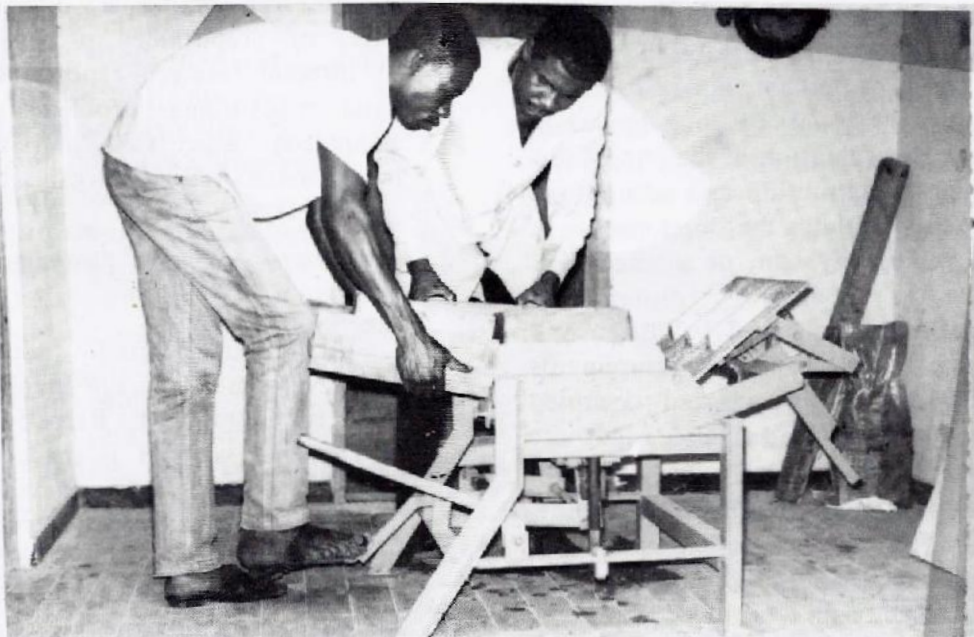
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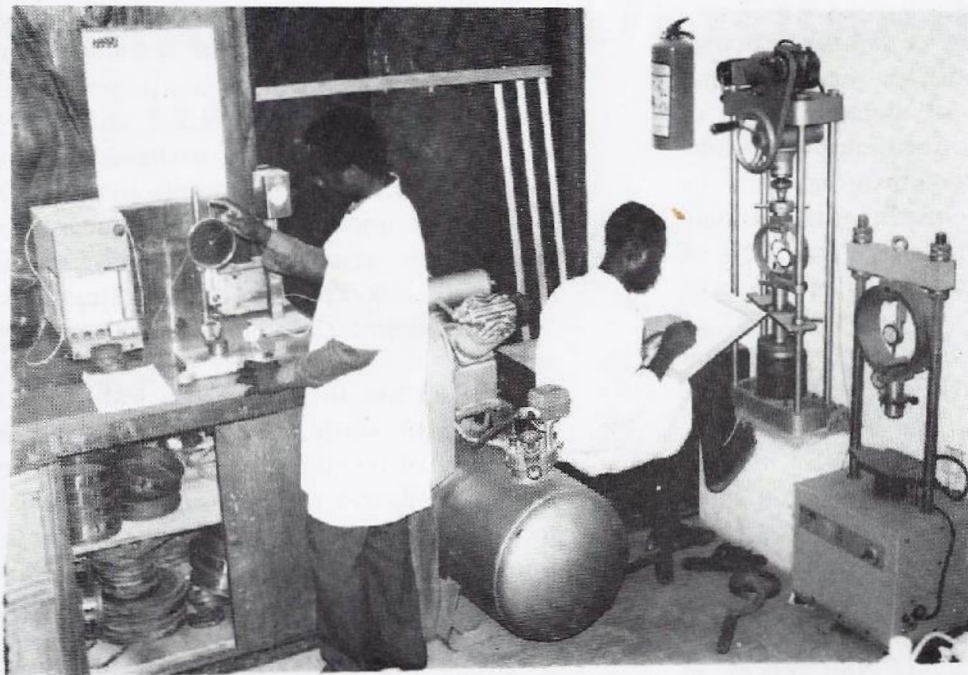
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*Application of Indegenous Technology: Using NBRRI brick-making machine.*



*Materials Laboratory in session.*

### *iii. Housing in Service Approach:*

Other problems experienced in housing that had been in service for a number of years and which come to attention suggest the broader study of housing in service. For example, collapse of buildings and wall cracks in parts of Lagos point in that direction. Also improved perception and measurements facilities encourage focus in that direction. Housing units should be chosen because of existence and accessibility of records of their planning, construction, maintenance and repairs and because of similarity in construction and occupancies. This organised approach towards performance assessment, generally referred to as building appraisals involves definite evaluation of the consequences of design, construction and occupation. This approach stimulates the development of a building appraisal system, or a "check-list" guide.

Investigation of collapsed buildings, wall failures in parts of Lagos and measurements of thermal comfort in selected occupied buildings in parts of Ibadan and Lagos are examples of this strategy being presently used by NBRRI in housing research.

### *III. Development and Utilization of Housing Research Results:*

Beside NBRRI, universities and similar research organisations, private individuals have

done significant work on various aspects of housing, and at different phases of the research and development process. Further research, development and utilisation of findings are hindered not by the present research structure per se, but by several operational factors, most prominent among which are:

#### *1. Limited communication between researchers/ research organisations and housing practitioners*

Research findings are often limited to the pages of "reputable" professional journals or internal research reports. On the other hand, practitioners problems are often not adequately articulated and communicated to researchers/research organisations.

#### *2. Inadequate level of financial support for R & D:*

Like housing itself, housing research and development usually involves substantial financial investment. Regretfully the level of financial support is inadequate and for the private sector it is miniscule. Substantial funds are necessary to attract and retain research staff as well as for the research itself.

To overcome above and other problems and effect more housing research and development (R & D), the following will be of great import:-

1. The establishment of a national directory of researchers on buildings, perhaps under the auspices of the Science and Technology Ministry, and readily available to housing researchers and practitioners. This should foster and encourage interaction between researchers, research institutions and housing practitioners and at the same time minimise duplication of research efforts.
2. Sponsorship of suitable workshops, seminars and orientation programmes in various aspects of housing by NBRRI, Association of Housing Corporations and such other corporations. A case in point is the most successful programme on housing materials and construction that has been run jointly by NBRRI and the Directorate of Food, Roads and Rural Infrastructure (DFRRI) for seven groups of state nominees since November 1986.
3. Enlarged communication of research result from strictly technical journals to feature articles in daily local newspapers, and non-professional magazines.
4. Mounting of appropriate exhibitions on various aspects of housing R & D results annually, or any more suitable intervals. This will acquaint practitioners and public of research results and researchers of housing problems.
5. Translation of political will into active support of research results by governments and their agencies actively using bricks, roofing sheets, ceiling boards and other research results in the construction of health clinics, schools and other public facilities. Even researchers themselves should put into practice their R & D findings by building houses in their villages with their newly-developed materials and techniques.
6. Vast improvement in literature stock so that researchers and practitioners can easily take advantage of findings, especially in developing countries with similar climates, geological formations, etc.
7. Co-operative research efforts with researchers and research organisations from other countries especially developing countries with similar climates, experiences etc.
8. Establishment of research institute governing board with strong practitioner and research representation on its membership.
9. Conditions conducive to the attraction and retention of high level research and development require the integrated efforts by high calibre staff of different professional backgrounds. More attractive working conditions are essential for the attraction and retention of such staff in housing research and development.
10. Greater expansion of research emphasis towards experimental houses and housing in service approaches, especially in light of problems arising from houses in use. Recent such problems include fires and collapse of houses in the Lagos area.
11. Vast improvement in level of research and development funding. Present housing research funding appears to be by way of government subvention which is inadequate for the range and scope of research and attendant development envisaged. Government subvention should be significantly increased. Practitioners and the private sector should come forward with strong general research and development funding, as well as funding tied to their various specific needs, problems and project areas.
12. Practitioners deliberately and consciously bringing to the attention of NBRRI and similar research organisations specific practical problems for assistance in effecting solutions. An admirable example of this was a recent request by the Kano State Housing Corporation for NBRRI to test the suitability of traditional "Rama" and "Kaba" fibres in producing durable, fire-resistant building materials. Preliminary results indicate that while "Rama" may be promising for roofing materials, "kaba" may well be suitable only for partition boards. Confirmatory tests are presently in progress. This is the sort of problem-oriented interaction between housing practitioners and research organisations that should be actively cultivated and carefully nurtured.
13. Better understanding of, and more active research into various traditional building technologies. Just as in most other aspects of life, Nigerian traditional housing technologies have evolved empirically to such a stage that there are skilled craftsmen and artisans in key areas of housing. For instance, skilled artisans and craftsmen in the making and use of roofing tiles are known to be present in Bida, Niger

State and Uzuakoli, Imo State. There must be many more instances of traditional craftsmen and artisans skilled in various other aspects of housing in many more parts of the country. These groups constituted a very special class from whom researchers can learn a lot.

Unfortunately, neither much extensive contact has been made with these traditional technologists, nor much study undertaken of their technologies. A significant step should be made both in contact and study. Site study of the technologies would be most useful. Even more useful would be laboratory and workshop studies, complemented by annual short-term research fellowship awards to enable deserving craftsmen/artisans visit housing research organisations. Visiting craftsmen could develop modern research skills while research organisation staff develop better appreciation of traditional technologies. Housing research and development, especially for rural communities, would benefit immensely. Building materials, construction methods, activity spatial allocation are all areas fertile for exploration.

#### IV. Conclusion

NBRRRI has used, and is continuing to use in

various degrees, the three strategies for housing research. The cost of the house shell as well as the lot on which it stands remains very high. Yet the monthly income within the country remains paltry! ₦93.65 to ₦172.72 rural, and ₦104 to ₦298.46 urban, for all the Southern States surveyed, and the pattern is likely to be the same for Northern States.

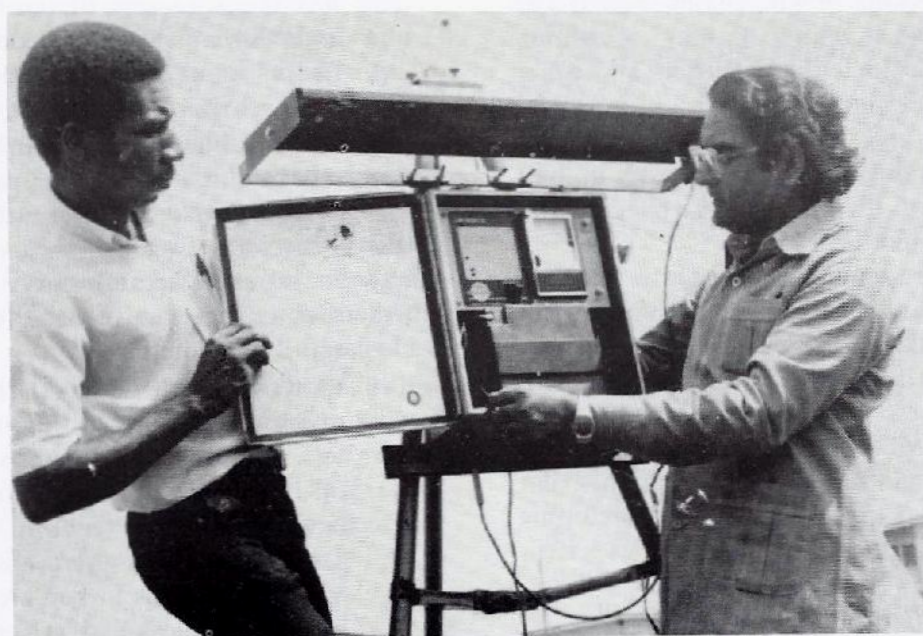
NBRRRI sample studies of the bill of quantities of single storey low-cost housing projects show the following cost breakdown for the various components. -

Element	Percentage of total cost
1. Foundation and plinth	9
2. Floor	10
3. Wall	17
4. Roof	15
5. Doors and Windows	9
6. Finishes	22
7. Services	
a. Internal	11
b. External	7
Total	100

Also labour costs are 45% of overall costs, as against 55% for material costs.

NBRRRI research has perfected the "Core Housing" concept for our local conditions. This involves initial construction of a clearly identified but smaller area for some key activities. Additions

*Continued on page 28*



*Solar meter for measuring solar radiation on horizontal surfaces. The data generated are used in solar energy applications in building.*



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# Development Of NBRRI Permanent Site

G. N. Omange.

At inception in 1978, the Nigerian Building and Road Research Institute occupied a two room office at the Federal Secretariat for a few months before moving to its present site at 15, Awolowo Road, Ikoyi. Due to the rapid expansion of the institute, it became apparent that the three floors occupied in the four-floor building was inadequate for the scope and functions expected of the NBRRI. Even though the present site houses six laboratories viz soil, concrete, brick and tile, chemistry, architectural physics and bitumen laboratories; demonstration areas e.g. building construction demonstration area, roofing sheet production area etc. and offices for both research and supporting staff, the space constraints are just too glaring.

In anticipation of this space constraints, the institute initiated at an early stage the machinery to acquire a large expanse of land in an area that will provide the conducive atmosphere

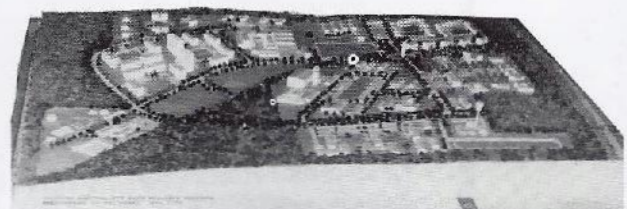
expected of a research institute. After a lot of bureaucratic bottlenecks, sixty hectares of land was acquired at Km 10 along Otta-Idiroko road.

The parcel of land has long been surveyed and architectural drawings for residential, office and laboratory complexes have been prepared based on a master plan that was previously developed. This year, the construction of the laboratory complex for both the Building and Road divisions are expected to commence. For this, a pre-qualification tender from contractors were invited in 1987 and these have been analysed.

It is envisaged that when the construction of the institute which is expected to be phased depending on funds availability is completed, the environment will not only be conducive for research activities but also provide enough space for pilot programme development of research results.



*NBRRI temporary site located at 15, Awolowo Road, Ikoyi*



*Layout of NBRRI permanent site.*

# Ten Years Of Technical Collaboration AT NBRRI

G. N. Omenge

In order to enhance, articulate and complement the research and development activities at NBRRI, the institute was actively involved in technical collaboration with some organisations both within and outside Nigeria:

## 1. *Technical Collaboration with Organisations in Nigeria:*

- a. NBRRI sponsored some research projects at the Departments of Civil Engineering in University of Benin and Ahmadu Bello University to complement its research activities.
- b. NBRRI has consistently provided technical advice and appropriate technology to the Directorate of Food, Roads and Rural Infrastructure (DFRRI) in its rural housing programme.
- c. NBRRI provided the technical advice and technological know-how in the development and construction of building prototypes in the Yankatsari Rural Resettlement Scheme of Kano State Housing Corporation.

## 2. *Technical Collaboration with International Organisations*

- a. NBRRI is a member of the Directors of English Speaking Building Research Organisation (DESBRO) which is a forum for exchanging views, ideas and enhancing building research activities.
- b. NBRRI has been in close contact with such sister organisations like Building Research Establishment England; Transport and Road Research Laboratory, U.K. Building Research Institute in Egypt, Building and Road Research Institute in Ghana, Central Building Research Institute in India just to name a few.

- c. The collaboration between NBRRI and the Central Building Research Institute, Roorkee and Central Road Research Institute both in India has been very unique. Under a mutual agreement signed in 1982, twelve experienced research scientists were seconded to NBRRI for various periods subject to a maximum period of four years to assist in the initial development of the Institute.
- d. NBRRI was chosen in 1985 as the pivot centre for one of African Regional Research activities in "Local Raw Materials and Technology for house construction" sponsored by the Commonwealth Science Council. The project billed for execution in four phases is due for completion in 1990.
- e. In a similar vein, NBRRI is actively involved in the formulation of African Standards and Specifications for local raw materials by the African Regional Scientific Organisation (ARSO) with headquarters in Nairobi, Kenya.
- f. NBRRI has also just recently in 1988 entered into a three-year cooperative research programme on "Small Scale Brick Production in Nigeria" with the International Development Research Council (IDRC) based in Canada.

# Remote Sensing Technique As A Tool For Identifying And Locating Locally Sourced Materials

*S. I. Ohamobi*

## 1. INTRODUCTION

An inventory of soil and material resources is a pre-requisite for proper planning of roads and buildings. Nigeria as a developing nation needs large number of buildings and a large network of roads to boost her economic activity. In order to meet these needs at minimal costs, accurate inventory of soils base and building material resources is inevitable. Such an inventory makes local sourcing of aggregate materials (for roads) as well as clays and laterites (for house construction) possible. It also allows for the best possible choice of terrain for road alignment while avoiding problematic soils and other obstacles. Currently only a small fraction of material resources are being operated while many more suitable sources are still to be identified.

Identification and location of suitable construction materials and problematic terrains (such as peaty, clayey or black cotton soils) can be done most expeditiously by the application of remote sensing technique. This basically involves the interpretation of aerial photographs, SLAR and Landsat imageries; and culminates in the production of engineering geological maps which become invaluable aids to engineers and regional planners for building and construction materials sourcing, road route selection, regional planning etc even for inaccessible terrain.

## 2. REMOTE SENSING TECHNIQUE:

This technique as defined by Avery (1977) is the detection, identification and analysis of objects or features through the use of imaging devices (sensors) located at positions remote from the subjects of investigation. Remote sensing techniques involves the interpretation of aerial photographs, side looking air-borne radar (SLAR) and

Landsat imageries.

The basic systems and concepts involved in the acquisition and interpretation of remotely sensed data includes the source of illumination of a given terrain; type of energy emanating from the source; functions and effects of the energy as it passes through the atmosphere, interacts with surface objects and transmitted to a sensing device; the process of mapping this energy and the ultimate interpretation of the images.

For the purpose of clarification, the three remote sensing techniques are briefly described below:

### 2.1 AERIAL PHOTOGRAPHY:

Photographic remote sensing techniques is the oldest and well established. It is probably the most useful remote sensing system because it has the greatest number of applications in the field of agriculture, forestry, statistics, engineering etc. The conventional method of using the panchromatic (black and white) aerial photographs (23cm x 23cm) has continued to gain acceptance as a research and planning tool in Nigeria. This is mostly due to the large scale, (as large as 1:10,000) and ability to have a three dimensional view of the terrain due to overlapping photography. Although the system is passive and dependent upon the solar illumination, it provides the best source of qualitative data extraction for rapid soil survey.

### 2.2 SLAR (SIDE LOOKING AIRBORNE RADAR) IMAGERY:

This type of remote sensing is a particular application of the general radar principles. It is an active system which generates its own energy to illuminate the earth's surface with invisible microwave rays. For this reason, it

is an all-weather (day and night) system and has a unique capability to penetrate cloud cover, dense jungle vegetation and to map the structural fabric of the underlying terrain with considerable detail. Other advantages which SLAR Imagery has over aerial photographs include ability to cover a large area on a single photo, resulting in a higher work efficiency and a more synoptic presentation of the terrain. In addition, changes in aircraft altitude has no effect on mapping scale because it is a time-distance function of the electronically recorded pulsed energy. However, the lack of stereo coverage and the corresponding small scale are inherent problems associated with the interpretation of SLAR imagery (Anthony Levis, 1974).

### 2.3 LANDSAT IMAGERY:

The Landsat (earlier named ERTS i.e Earths Resources Technology Satellite) is the latest development in remote sensing. It was first launched in 1972 by the U.S. National Aeronautics and Space Administration (NASA), operated for over six years and the series has been maintained by subsequent satellites culminating in the Landsat 5 launched in 1984. The images cover an area approximately  $160\text{km}^2$  at a resolution of 80m, and are recorded in four different spectral bands enabling different physical aspects of the earths surface to be studied.

Landsat imagery is produced by means of a Multi-Spectral Scanning System (MSS). MSS is capable of producing imagery both in the visible and reflectance infrared, and the near-ultraviolet and thermal infrared portions of the EM Spectrum. Images can be produced as colour composites or in black and white. It has the special advantage of exploiting differences in tone-signature of terrain objects imaged in the various bands.

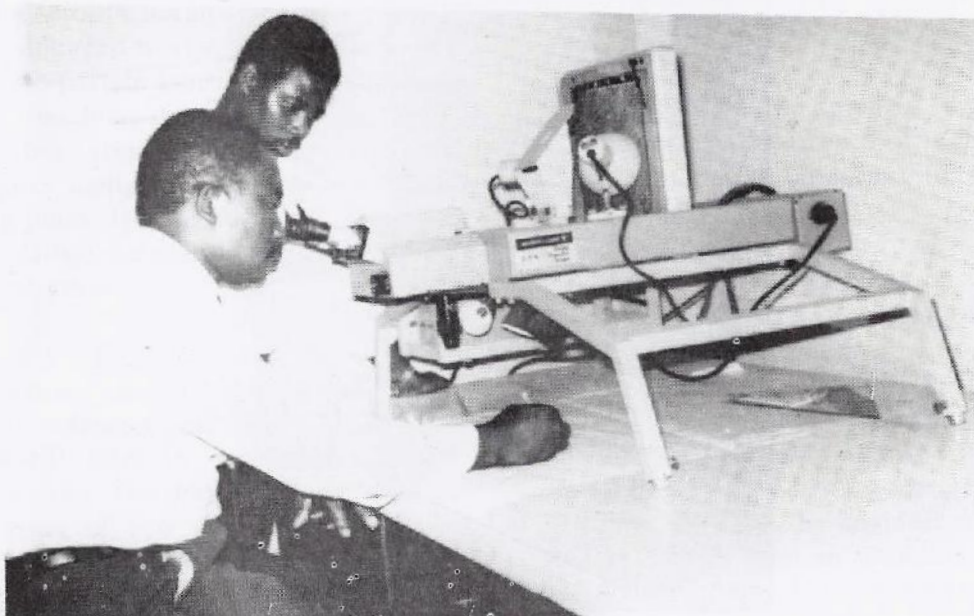
However, it is a passive system and dependent on solar energy; hence it does not penetrate the dense cloud cover of the Southern parts of Nigeria. In addition, no stereoscopic image can be studied and thus has poor potential for relating interpretation to relief.

### 3.0 IMAGE INTERPRETATION:

Image interpretation is an act of examining photographs and or images for the purposes of identifying objects or phenomena and judging their significance and effect on a particular problem. The interpretations are made using key patterns for the aerial photographs, SLAR and Landsat imageries.

#### 3.1.ELEMENT OF SOIL PATTERN FOR INTERPRETING THE AERIAL PHOTOGRAPHS:

The aerial photo, used as a record of surface conditions, is created by certain



*Aerial Photo Interpretation in progress*

spectral of light energy producing the photo image being reflected (or emitted) from the surface of objects. A panchromatic photograph records the surface only as tones of grey and variations of colours and provide a wealth of details in the form of a 3-dimensional model of the landscape.

The factors or elements to be evaluated from the photographs are:

- (i) Landform
- (ii) Drainage.
- (iii) Erosion.
- (iv) Soil photo tone.
- (v) Vegetation and Land use.

Each factor is viewed separately and in conjunction with others to identify and classify the soil. The soil delineated from this process must be verified by ground checking to confirm or adjust the original air-photo prediction.

### 3.2 IMAGE RECOGNITION AND IDENTIFICATION ON SLAR IMAGERY:

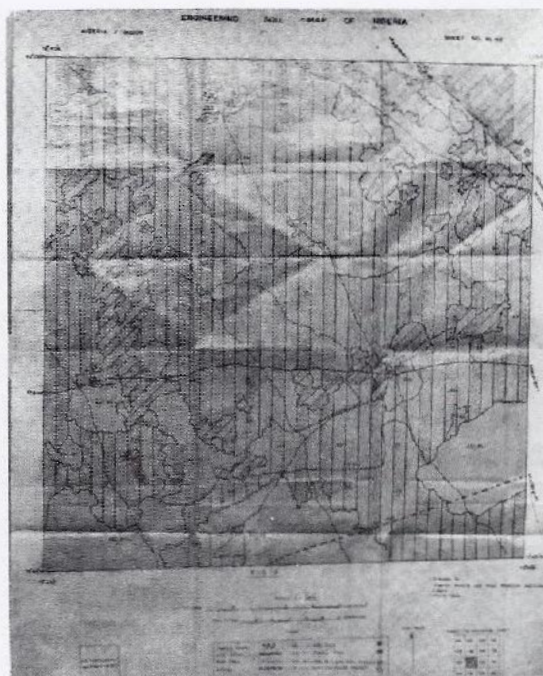
Radar reflection from land is generally more complex, because land is a composition of vegetation over soil, with neither the vegetation nor soil being homogeneous. The reflection properties are recorded on films as variations in grey scale (tone or image density), texture and shape.

Generally, the interpretation of SLAR imagery deals with the recognition and identification of features such as roads,

settlements, drainage patterns, regional linearments, soil tone and texture and topography, using identification keys. Schwaar (1970) compared that the image interpreter uses details of the image characteristics as a map reader uses conventional map symbols to interpret topographic map. From the knowledge of the area, certain features not interpretable from image characteristics are deduced. These characteristics include: tone, texture, shapes, sizes etc.

### 3.3 DEVELOPMENT OF INTERPRETATION KEY:

Interpretation of images is greatly facilitated by the construction of interpretation keys. Collateral informations, such as that derived from maps, aerial photographs, imagery, weather data and ground observations are usually considered for the construction of the keys. The keys help to evaluate the information presented on images in an organised manner and provide guidance about the correct identification of features or conditions on the images. The delineation of boundaries of soil types, mappable soil units and construction materials is normally based upon the recognition of diagnostic features such as image tone and texture relationship, relief, drainage and erosion patterns, vegetation and landuse aspect.



Typical engineering soil map of part of Nigeria derived from Remote Sensing Technique

#### 4.0 IDENTIFICATION AND CLASSIFICATION OF MAJOR ENGINEERING SOILS UNITS AND CONSTRUCTION MATERIALS:

A major factor in the classification of the different soil units is the identification and evaluation of a mappable terrain. Terrain evaluation involves the recognition of distinctive patterns of landscape, called land systems (Dowling 1968). The recognition of the characteristic features of each unit on the imagery is an important factor in the selection of a road alignment, sourcing and location of soil fills and construction materials as well as possible hazards due to the occurrence of heavy clay (black cotton soil) and migrating sand dunes.

#### 4.1 CONSTRUCTION MATERIALS:

**4.1.1 CALCRETE:** This construction material is predominantly found in sandy terrains, especially in the Northern part of Nigeria, where it is locally called Jigilin.

Calcareous gravels have been located in the aeolian sandy plain and sand dune terrain. Their locations are identified on the aerial photographs on the basis of absence of external drainage or water erosion, few and scattered bushes/vegetation, and presence of grey tone with whitish tinge.

**4.1.2 LATERITE:** Laterites are located on SLAR imagery by the recognition of a smooth texture and an unusually pronounced whitish grey patches. The photo-pattern consists of a characteristic medium/dark grey tone with whitish grey patches and a fairly higher topography than the surrounding plain. It is often characterised by sporadic grassland vegetation and cultivation.

**4.1.3 SAND:** Sands occur in dunes in the Northern part of Nigeria as a result of wind depositions. They appear as SW-NE lines in landsat and SLAR imageries. The drainage features consist of few continuous and discontinuous drainage lines. The tonal signature appears light grey in SLAR, and in aerial photographs there are

no grasses or bushes, with light grey tones.

#### 5. USES OF ENGINEERING SOIL MAPS:

The principal uses of the Engineering Geological Maps which are results of the various imageries interpretations are as follows:-

- i. The initial planning and reconnaissance for location and re-location of road alignments and preliminary planning of airports.
- ii. Locating sources of soil materials suitable for making fills.
- iii. Planning soil surveys for a specific project.
- iv. Highway design, keeping in view the optimum utilisation of locally available materials.
- v. Materials inventory map and record.
- vi. Ideal base map for pavement performance studies and other research activities on in-situ materials.
- vii. Assessing trafficability of soils for the movement of heavy defence equipment.
- viii. Identifying areas of low bearing capacity such as swamp soils and clays in areas of high water table. In addition, problematic soils like peat and black cotton soils can readily be located.
- ix. Predicting the potential physical erosion, occurrence of major flooding and natural landslides, likely to affect a road alignment.
- x. Determining the position of drainage channels and the size of their upstream catchment area in relation to road alignment.

These information which can be obtained from the Engineering maps without necessarily engaging in field work are important planning tools for the engineer and regional planner. The Nigerian Building and Road Research Institute has developed a number of such maps.

## 6. GENERAL COMMENTS AND CONCLUSION:

- i. The technique of Remote Sensing, particularly the use of aerial photographs (at 1:25,000) has great potential in surveying soil and material resources with considerable details, even if the region is inaccessible. Nevertheless, a certain amount of ground verification is desirable to avoid any discrepancy or anomaly.
- ii. SLAR imagery at 1:250,000 is of limited usefulness for a consistent and detailed mapping of soils and material resources in Nigeria, particularly in the interpretation of subsurface soils, due to lack of stereo-scopic view of the terrain. As a result of this, some areas of intense cultivation, bush burning and water bodies are not distinguishable on SLAR imagery. They are often mis-interpreted as silty clay or clay of high plasticity, because of their dark radar signature. Also in some cases, the variations between some soil types, such as SM and SM-SC and SC or CL and CH are not easily discernible to classify them separately because of their similar image characteristics. This sometimes lead to generalisation in the interpretation and classification. However, airphoto interpretation can eliminate these anomalies.
- iii. Though, SLAR imagery at 1:250,000 has a primary advantage of large areal cover on a single photograph, certain important landmarks and problematic soils, such as the locations of small towns and villages, small deposits of black cotton soil and thick accumulation of aeolian sands (up to 2km stretch) are not easily identified on the imagery, due to the inherent small scale. However, such small bodies are interpretable on large overlapping aerial photographs.
- iv. Some of the calcrete sites as depicted on some Engineering soil maps, are identified with respect to the roads appearing on the aerial photographs.

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### Research and Development in Housing *Continued from page*

are made to the "Core" area as increasing family size, increased income accumulation, and other relevant variables dictate or allow.

Furthermore, NBRRI research has developed appropriately simple technologies requiring low levels of operational skills for the local production and use of much cheaper durable materials for the housing shell. Some high cost components like finishes may be completely or at least greatly minimised. Both material and construction costs can therefore, be very significantly reduced.

From NBRRI research perspective, an effective new national policy for mass housing of the urban poor as well as rural dwellers should be firmly anchored on:-

1. Provision of serviced lots at low or nominal cost.
2. Use of easily available alternative cheap building materials.
3. Appropriate use of the "Core Housing" concept as may be dictated by conditions.
4. Encouragement of self and cooperative help through use of available low-level simple technologies.
5. Due cognisance of cultural and functional patterns in housing design and execution to assure acceptability.
6. More generous and active support of R & D, and effective utilization of R & D results.

# Technical Extension Services Offered Within The Past Decade

G. N. Omenge

NBRRI provided some technical extension services as a means of complementing its research and development activities. This involved conducting a series of short professional courses, seminars and offering consultancy services to some organisations.

## 1. SHORT PROFESSIONAL COURSES:

- a. Between March 30 and April 1981, NBRRI in collaboration with the Planning and Transport Research and Computation Ltd (PTRC) U.K., organised and conducted a two-week course on "Highway Design and Maintenance" for the benefit of practising engineers and related professionals. The course examined the latest procedures in Highway design and their applicability to the local engineering environment.
- b. NBRRI successfully conducted a one week course between 2 - 6 November 1981 on "Safety Design and Operational Practices for Streets and Highways." This course not only provided traffic engineering training to individuals with background in non-traffic areas but also upgraded the technical expertise of practising highway and traffic engineers. The crop of distinguished Nigerian lecturers were also joined by two highway and transportation experts from the Centre for International Transportation Exchange at the Michigan State University USA. So successful was the course that in response to popular demand, a similar short course on same theme was organised by NBRRI and co-sponsored by the World Bank between November 26 - 30, 1984.

## 2. SEMINARS:

In the past ten years, NBRRI successfully

organised and conducted three highly technical seminars.

- a. Sequel to the preparation of an 85-page "Report of the coordination of the installation of various services along Nigerian Roads" by Comprehensive Engineering Consultants on behalf of NBRRI, a two-day seminar on the coordination of the installation of various services along Nigerian roads was organised and conducted between November 11 and 12, 1981 for the benefit of such professional bodies like State Water Boards and Corporations, NITEL, Ministry of Communication, Federal and State Ministries of Works; Housing and Environment, Town Planning Departments, Consulting Civil Engineer and Contractors.
- b. Further to the significant trend in the results of some research activities at NBRRI and other related organisations such as Universities etc in the field of alternative building materials development, a seminar on the "use of clay bricks and blocks, for the provision of cheaper and durable housing" was successfully organised and conducted by NBRRI between October 14 and 15, 1985. Of direct relevance and significance is the publication of a 296-page proceedings containing 27 highly technical papers for the seminar. Participants were drawn from government and private sectors and included professionals from universities, polytechnics, housing cooperations, financial institutions, ministries of works and housing and the brick manufacturers.
- c. In response to the National Housing Policy which the Federal Government threw open to public debate, NBRRI successfully organised and conducted a

one-day seminar on "Research and Development in National Housing Policy" on November 9, 1987. A 14-paper document titled "National Housing Policy Debate - NBRRI position papers" was prepared for the seminar followed by a 67-page proceedings. A mini-exhibition of practical research achievements at NBRRI was simultaneously held with the seminar.

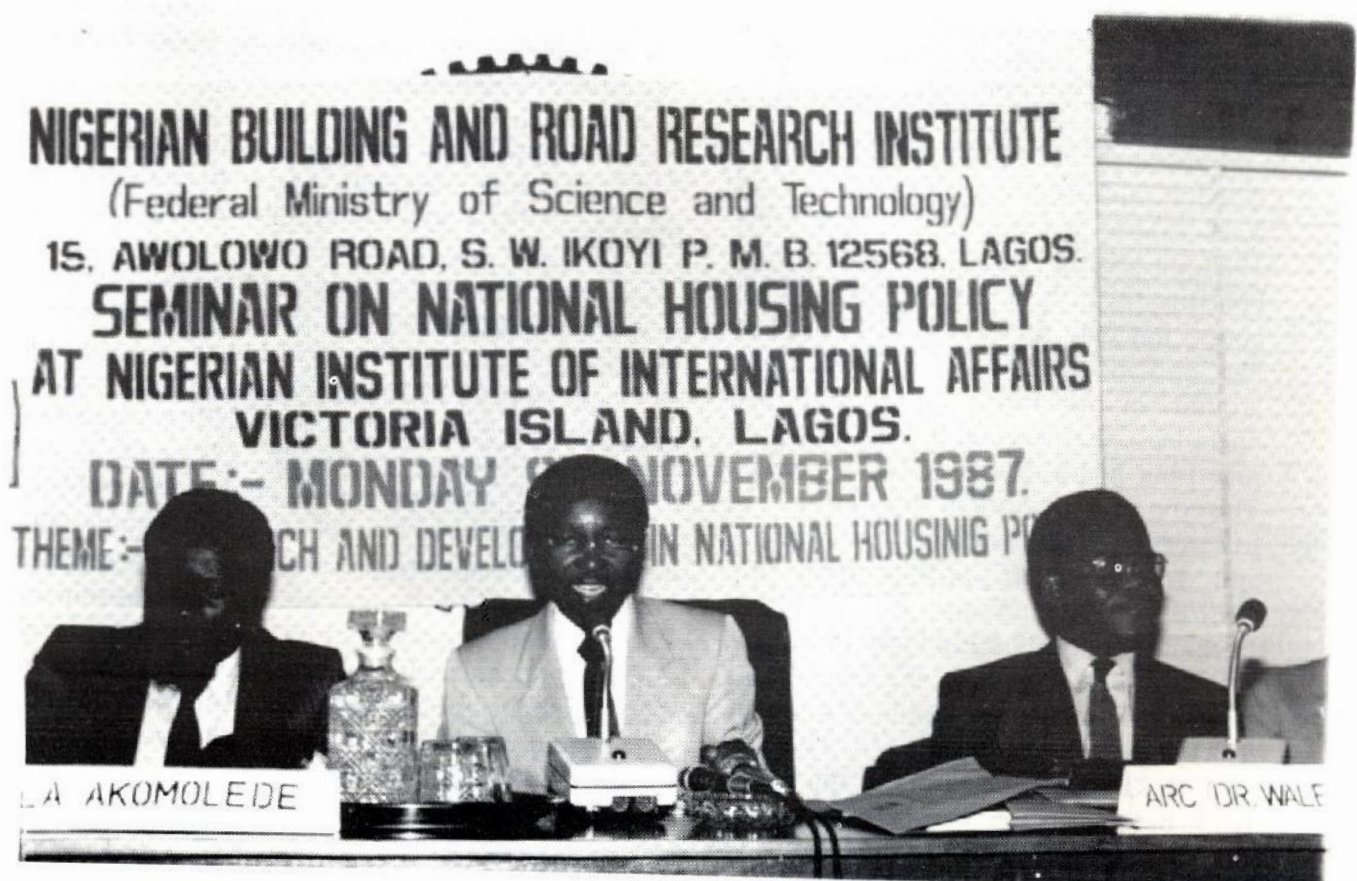
### 3. CONSULTANCY SERVICES:

Three consultancy services were offered for different organisations and these complemented the research activities of the institute.

- a. NBRRI successfully undertook a survey of road construction materials in Kano State using remote sensing technique for the Kano State Ministry of Works and

Housing in 1985; and thereby effected a lot of savings in foreign exchange which could otherwise have gone to an overseas organisation that was originally billed for the same job.

- b. NBRRI participated on a consultancy basis with a working group of specialists to fashion out a "manual for the design and construction of rural roads" for the Federal Agricultural Coordinating Unit (FACU) of the Federal Ministry of Agriculture, Water Resources and Rural Development.
- c. In 1985, NBRRI provided limited consultancy in the area of soil investigations, pavement and drainage rehabilitation on a section of the old Shagamu-Lagos road to West African Portland Cement Company (WAPCCO), Shagamu.



*Seminar on Research and Development in National Housing Policy organised by NBRRI.*

# Use Of Alternative Building Materials In Rural Housing -NBRRI Demonstration Project In Yankatsari Village, Kano

A. P. Opoko (Mrs.)

## INTRODUCTION:

Building materials used in Nigeria can be broadly divided into two groups namely modern and traditional building materials. The modern or conventional building materials which include such materials as concrete, steel, glass, zinc and asbestos roofing sheets are often imported or require high use of imported raw materials and technology for their production. Due to their high quality performance, aesthetics and status symbol which they convey, they are in high demand not only in the urban areas and among the elites but also in the rural areas, despite their exorbitant costs and scarcity. Traditional building materials on the other hand, are readily available materials usually produced from rudimentary and crude technology. However, they are despised even amongst the rural dwellers due to their low quality performance and the mad craze for imported building materials.

As a result of the dwindling economic fortunes of Nigeria in recent times coupled with the clarion call to look inwards, there has been a loud clamour for the widespread use of locally available building materials. To ensure that cheap, durable and sociologically acceptable building materials are produced from local sources, NBRRI embarked on a series of research and development activities to improve on available traditional technology and develop new and appropriate ones. Significant results of some of these research efforts have led to the production of stabilized bricks (for walling) and coconut fibre cement roofing sheets. These materials were effectively and successfully used in a demonstration programme in the Yankatsari model village, Kano.

## YANKATSARI MODEL VILLAGE DEMONSTRATION SCHEME

### OBJECTIVES:

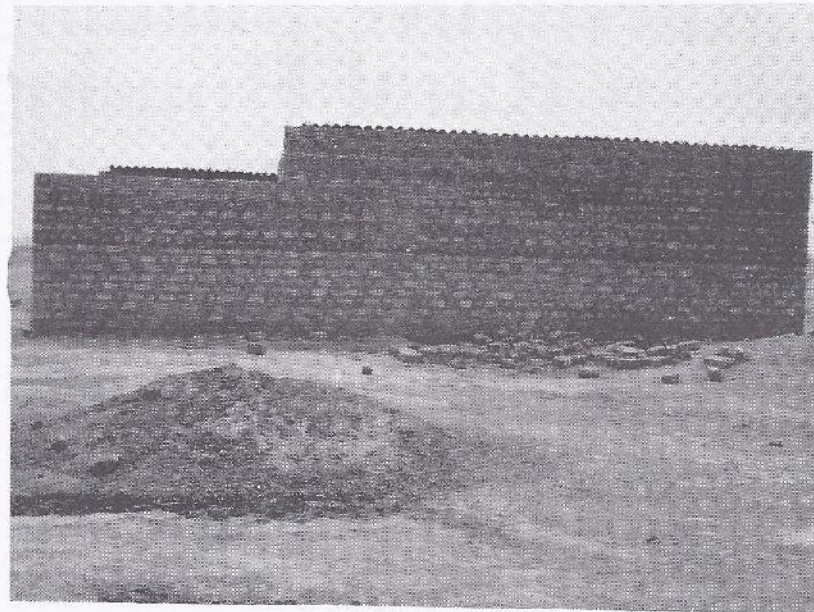
Yankatsari village is located in Dawakin Kudu Local Government Area of Kano State. It was chosen by the Kano State Government as a regrouping centre for the surrounding scattered rural settlements. Based on the previous research works carried out at the Nigerian Building and Road Research Institute, Lagos, the institute was approached by the Kano State Housing Corporation for the design and construction of prototype rural dwellings with the following objectives:

- (i) To design appropriate houses to reflect the living pattern of the affected rural dwellers.
- (ii) To provide a more permanent landscape by the use of improved local building materials.
- (iii) To introduce a building management system designed to harness the self help spirit of the people.

A living pattern survey of the rural people was jointly carried out by the Kano State Housing Corporation, Kano and the Nigerian Building and Road Research Institute, Lagos to determine among other things the peoples' preferences, the average household size and composition, household activities and their mode and place of performance. The analysis of the survey results revealed the following living pattern characteristics;

- \* Large family size
- \* Restriction of entrance into compound
- \* Outdoor and indoor activities
- \* Interaction with neighbours
- \* Privacy, especially for the females
- \* Disorderly planning and waste
- \* Unorganised growth.

The influence of the above characteristics on the quality of spaces and house design, and other means of ensuring affordability and durability were investigated and analysed. Based on this analysis, three design prototypes were evolved



*Building prototype constructed by NBRRI at Yankatsari Model Village near Kano using local resources, technology and communal labour.*

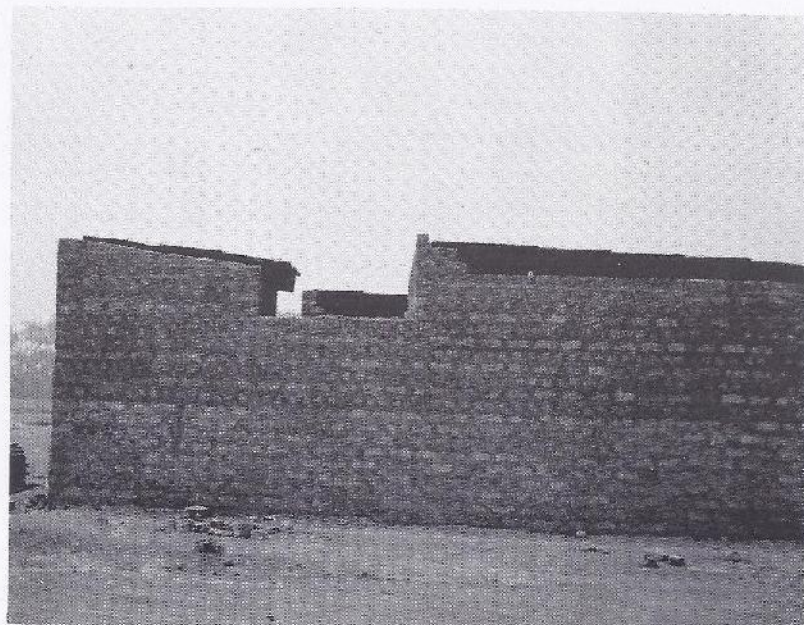
with the following basic features:

- Incorporation of living pattern needs
- Regulated entrance to inner core of houses
- Orderliness in planning and growth
- Optimum space utilization
- Open planning
- Possibility of stage construction.

One of the prototype house designs was chosen for construction. The use of fired bricks produced from local clay type was investigated. The low compressive strength of fired bricks arising from the nature of the locally available

clay type as well as the lack of firewood made the use of an alternative walling material imperative.

Stabilized mud bricks produced with NBRRI brickmaking machines were eventually used. The bricks, produced in 290mm x 140mm x 100mm. moulds, have a compressive strength of 1.68N/mm<sup>2</sup> and high aesthetic and durability qualities, far above those of the traditional "adobe." Similarly, NBRRI innovative coconut fibre cement roofing sheets, produced from materials in the ratio of 6kg sand: 6kg cement: 300g fibre were used in place of the traditional 'azara' flat roof to minimise maintenance cost. The sheets which have tested breaking load of 107kg/m<sup>2</sup> are produced



*A closer view of the building prototype constructed by NBRRI at Yankatsari Model Village near Kano.*

in 1m<sup>2</sup> sheets using manually operated machines designed at NBRRI. They satisfy not only the essential requirement for durability and low cost but also that of aesthetics which convey status symbol with it.

#### CONSTRUCTION STRATEGY:

Supervision of the construction was done by NBRRI members of staff. The bulk of the labour force ranging from carpenters to masons however came from the rural dwellers. This ensured a quick and effective transfer of the required skill in production and handling of the innovative materials and technology developed at NBRRI and used in the demonstration project.

#### FEEDBACK FROM THE COMPLETED DEMONSTRATION PROJECT:

The building has been completed. Feedback studies conducted reveal that the rural dwellers are impressed by the performance of the materials used and are infact willing to use them in building their own houses. Also based on the feedback studies, the designs have been reviewed with the following amendments and additions effected:

- \* Segregation of human and animal traffic.

- \* Simplification of design to facilitate quick construction, phasing and cost reduction.
- \* Reduction of built up area to further reduce cost.
- \* Introduction of Ventilated Improved Pit (VIP) Latrines.

#### CONCLUSION:

The performance of the demonstration house built at the Yankatsari model village shows that the materials and technology developed at NBRRI and utilized in the project are indeed appropriate for rural housing in Nigeria. The prototype house constructed is a model to be adopted by the rural communities in Yankatsari village in their housing programmes. Similar technology can be extended to other rural communities in Nigeria, but this has to be preceded by the production of appropriate building plans based on the living patterns of the communities.

The brickmaking machine, obtainable at NBRRI is simple and can be easily operated by a three-man team. Similarly, the roofing sheet technology is simple and can be readily effected even in rural areas.

## NBRRI PIONEER STAFF



*NBRRI Pioneer Staff: Sitting from left to right, Mr. M.N. Ugoma (Accounts), Mr. G.N. Omange (Research), Mr. L. K. Komolafe (Research), Dr. A. O. Madedor (Director), Mr. N. A. Jagunmodu (Administration) and Mr. A. I. Oke (Audit).*

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**DR. C. E. NWACHUKU**  
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# Making Buildings Comfortable Without Airconditioners.

L. K. Komolafe

## INTRODUCTION:

Nigeria lies within the tropics which is characterised by intense heat with high or low relative humidity in various parts of the country. To make buildings comfortable for habitation under these conditions without resorting to cooling systems such as air-conditioners which are expensive both to purchase and maintain, it is necessary to apply some scientific measures. Such measures, discussed below, aim at avoiding excessive heat input into buildings while providing high ventilation rates to combat the high relative humidity - thereby ensuring thermal comfort to the building.

### 1. PROPER ORIENTATION:

At the design stage, buildings must be properly oriented to face North-South direction. This means the longer side of buildings with the windows must face North-South direction. Figs. 1, 2 and 3. The side facing East -West direction should be made as short as possible and windows should be avoided in this direction. Buildings which face North-South direction have less thermal load compared with any other. To shade windows, for instance, in a single storey house a roof overhang about 76cm long would be ideal. (see Fig. 9).

### 2. LOCATION AND SIZE OF WINDOWS:

Windows should be well distributed on the windward wall. The outlet openings on the leeward side should be diagonally opposite to the inlet openings. In case of rooms with only one wall exposed to the outside, provision of two windows on that wall is preferred to that of a single window. Fig. 6. Windows of living rooms should open directly to an open space. In places where building sites are restricted, open space may have to be created in the building by providing adequate courtyards. As the distribution of wind speeds and flow patterns indoors is mainly

governed by the location of inlet openings, it is desirable that inlet openings (windows) be located at a low level with a window height of about 1.1m, Figs 7a - 7c. The maximum window or glass area should not exceed 30 - 40 percent of floor area. Internal screens like curtains or venetian blinds may be necessary to protect windows and other glass areas from direct solar radiation. Verandahs should be provided as these enhance air motion inside.

## 3. BUILDING MATERIALS:

### 3.1 WALLS

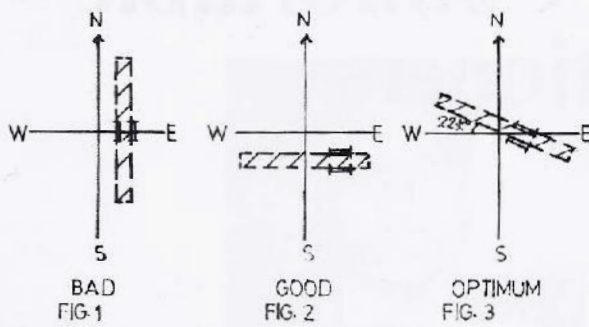
Use of clay bricks is preferred for wall construction because of their low thermal conductivity. Solid clay bricks are ideal for load-bearing walls while perforated clay bricks are preferred for non-load bearing walls. The perforation enhances ventilation inside the building and helps the thermal insulation of the wall elements.

### 3.2 ROOFS

Use of fibre cement tiles with a false ceiling made from local fibres, if available, is recommended. Asbestos cement roofing boards may also be used. For heavy-weight roofs such as concrete roofs, additional insulation may be very desirable so as to limit both solar heat gains and thermal movements of the roof

## 4. LANDSCAPING:

Landscape design elements such as trees, flowers hedges, earth mounds and other similar features have a pronounced effect on the flow of wind around them. Fig. 8. Their layout in relation to the building has an important bearing on air movement indoors. Air motion in a house may be



FIGS. 1-3 BUILDING ORIENTATION WITH RESPECT TO THERMAL AND VENTILATION CONSIDERATION.

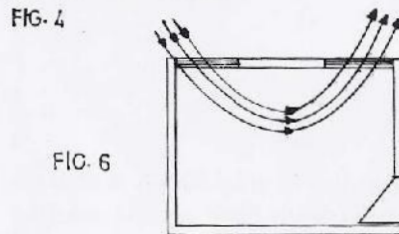
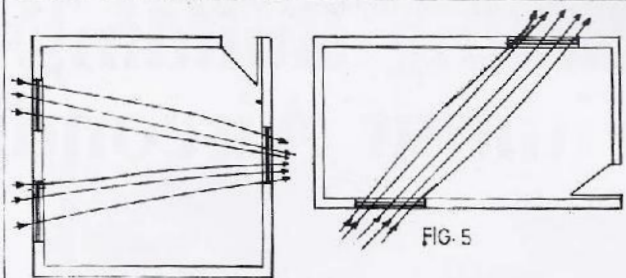
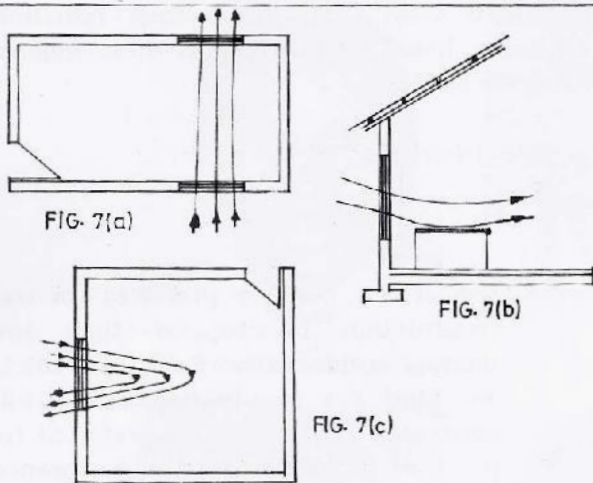


FIG-4 INLET OPENINGS LOCATED ON THE WINDWARD WALL.  
FIG-5 WINDOWS LOCATED DIAGONALLY OPPOSITE TO EACH OTHER INDUCE BETTER VENTILATION.  
FIG-6 AT LEAST TWO WINDOWS ON THE ONLY EXPOSED WALL



FIGS. 7(a-c) NEED FOR PROPER PLACEMENT OF WINDOWS TO INDUCE VENTILATION AT OCCUPANCY LEVEL.

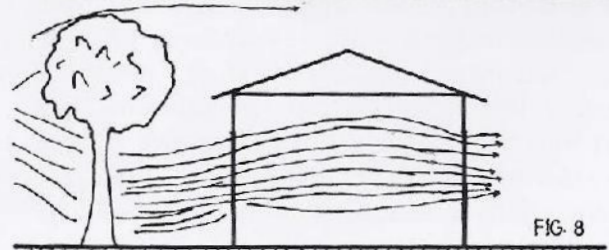


FIG-8 TREES HELP IN AUGMENTING AIR MOTION IN THE INTERIOR OF BUILDING.

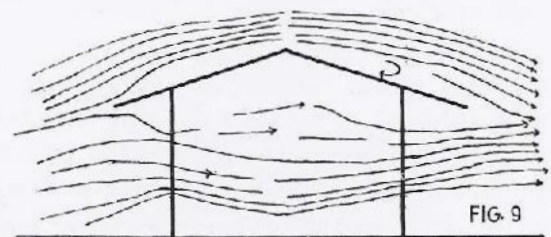


FIG-9 ROOF OVER-HANG ENHANCES AIR MOTION IN THE LIVING ZONE INDOORS.

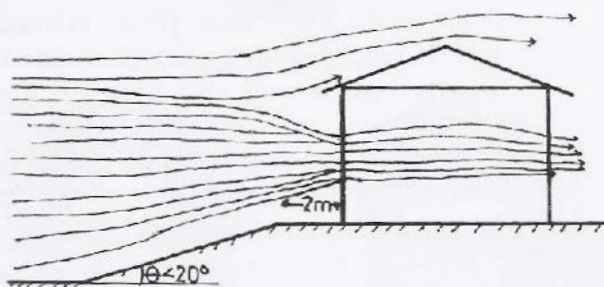


FIG-10 BUILDING LOCATED ON AN EARTH MOUND HAS ENHANCED AIR MOTION INDOORS.

enhanced or decreased depending on the height of landscape elements used and their distance from the building. Care should, therefore, be taken in the planting of hedges as they, sometimes, could retard air motion indoors.

Hedges planted in the windward side of the building should be at a distance of about 20 times the hedge height. However, air motion in the leeward part may be enhanced by planting a low hedge at a distance of about 2 meters from the building. Buildings located at the edge of a mound with slopes less than  $20^\circ$  have their air motion indoors enhanced. Fig. 10. Air movement indoors can be further increased with increase in height of the mound.

Continued on page 54

# The Problem Of Road Maintenance In A Developing Country.

G. N. Umange

In order to achieve the maximum economic and non-economic benefits from any road network whether rural, urban or federal - over its design life, emphasis must not only be placed on proper and adequate design and construction of the road, but also on the post-construction maintenance. While it has now been established that roads start to deteriorate from the moment it is put into use, the rate of deterioration depends on a number of factors which include the type of road (whether paved or unpaved), extent of overloading on the pavement, type and periodicity of maintenance etc.

About three quarters of the road network in most developing countries are unpaved. Since the rate of deterioration on unpaved roads (whose surfaces are directly exposed to damaging effects of water) is faster than on paved roads; and since the rate of road deterioration is greater than the rate of road construction in most developing countries due to dwindling economy, the need to evolve effective road maintenance system is very compelling and in most cases imperative. This will not only lead to great deal of economic returns on the road but also users' comfort and convenience.

However in most developing countries, there is always the lack of political priority for road maintenance. This is due to a number of reasons. It has often been erroneously believed that a newly constructed asphalt/bituminous paved road such as a Federal Highway does not require maintenance for a long time, and governments in developing countries tend not to pay the desired attention to road maintenance until the deterioration reaches a critical stage when poor riding quality becomes apparent. Similar attitudes are held for unpaved roads. Consequently by the time funds are forced by deplorable road condition to be made available for reconstruction, the road is costing more than it would have if regular maintenance programmes were in effect over the same period of time.

## CAUSES OF ROAD DISTRESSES:

Extensive road distresses and damages prevalent in most developing countries are due essentially to four main reasons:

- i. **Overloading:** Overloading of road pavement by heavily laden transport vehicles far beyond the design limits is a regular feature in developing countries. It has been shown by studies that concentrated loading by one vehicle beyond the design limits has greater damaging effects than if same loading were carried by two or three vehicles. It has been estimated that a load twice its design value would be equivalent to about twenty trucks of design load. Closely related to the overloading of the pavement is the utilization of inadequate traffic forecasts in the design of the pavement. This leads to under-designing for the ultimate traffic load and volume.
- ii. **Climatic Influence:** The combined influences of high temperature, high precipitation (rainfall) and thick vegetation prevalent in tropical areas grossly accelerates deterioration by weathering of pavement materials. The singular parameter which causes and rapidly enhances deterioration is water which promotes leaching, erosion etc. of pavement materials. It is therefore essential that adequate provision of drainage channels free from blockage should be made.
- iii. **Insufficient Funding:** In developing countries, insufficient road maintenance funding could be due to economic misfortunes or limited budgetary resources. The lack of awareness of the long term economy achieved in properly maintained roads often culminates in limited or no budgetary allocations being made for maintenance. Thus roads are often allowed to deteriorate to such an extent that total rehabilitation/reconstruction would be needed to make the road serviceable. The

irony however is that more funds are eventually expended.

- iv. *Others:* Road distresses could be a consequence of under-design due to insufficient data or construction blunders committed during construction operations.

#### TYPE OF ROAD MAINTENANCE OPERATIONS:

There are two broad types of maintenance and these are:

a. *Routine/Preventive/Short-term Maintenance:*

This involves safe-guarding the design life of pavements. It requires conducting regular maintenance schemes with less investment on a continuous basis, and is independent on the amount of traffic. Some of the maintenance operational schemes include cutting roadside grasses, clearing drainage channels, filling pot holes, sealing surface cracks etc. These activities are usually conducted two to four times annually. Due to the unprotected surface, unpaved roads require more regular maintenance than paved roads.

b. *Periodic/Constructive/Long-term Maintenance*

This essentially involves strengthening and resurfacing the road pavement. It is usually required at longer intervals of time say once in every 4 - 6 years; and often involves relatively higher investment. Such maintenance could vary from regravelling of unpaved gravel roads to surface dressing for paved roads.

- c. *Emergency Maintenance:* This normally involves remedial maintenance measures to emergency situations such as after-effect of flooding or a fallen tree along a road.

Delays in effecting routine maintenance at the appropriate time could lead to incurring extra expenses. For example, the World Bank reports that a one year delay in the award of contracts for rehabilitating a West African Road some years ago resulted in an increase of 30% in costs due to the deterioration that has gone so bad to required total reconstruction.

#### BENEFITS OF A PROPERLY MAINTAINED ROAD:

- It is essential to ensure cost effectiveness in

road maintenance so as to provide safe and free flow transportation at low costs.

- On the long run, a well maintained road is cheaper than an unmaintained road of same length. Since the unmaintained road has to undergo reconstruction after about 4 - 5 years of design life thereby incurring higher investment, then the internal rate of return of a well maintained road is higher. This could be termed direct savings.
- For a well maintained road, a lot of savings is achieved in vehicle operating costs (VOC). This could be seen as savings accruable directly to vehicle owners and yet indirectly to governmental authorities. For example, the high VOC for an unmaintained road has direct relevance to vehicle spare parts most of which have to be imported with hard currency. A beneficial approach therefore is that adequate budgetary allocations should be made for proper road maintenance and forestall high VOC such that less foreign exchange is spent on vehicle spare parts importation.
- A well maintained road would provide good comfort and high riding quality to users.
- It also postpones for at least several years the need for rehabilitation or overlays, thereby saving on expenditure.

#### MANAGEMENT OF ROAD MAINTENANCE:

As a result of the enormous road network requiring maintenance, the limited funds that are often made available for road maintenance and the fact that the rate of road deterioration far exceeds the rate of road construction in developing countries, there is the need for effective pavement maintenance management system. Such system prioritizes the roads out of a multitude that require and could be maintained at the appropriate time, with the correct equipment, gang etc. within the limited resources. Several types of pavement management systems are being developed all over the world to achieve great economy and well organised and properly articulated maintenance operations. All the operations have similar principles of evolving machinery that will monitor a country's road network, codify the defects and utilize the appropriate maintenance scheme on a priority basis.

*Continued on page 54*

# Designing Affordable Rural Houses — A Simple Guide

Opako A. P. (Mrs.)

## INTRODUCTION

Shelter is regarded as one of the basic needs of human living, being ranked next to food and good health. Buildings provide a means of creating an atmosphere that meets the physical, mental and spiritual needs of man. Hence, house-ownership is one of the most cherished acquisitions of man. Unfortunately, the desire to own a decent shelter has hitherto eluded many people. Some of the many reasons for this include poverty, high cost of construction materials etc.

Good practice requires that the design and construction of every building should be co-ordinated under a qualified architect. But the rural poor (about 80% of Nigerian population) cannot afford such professional services. This article aims therefore at highlighting the various considerations that need to be made in order to arrive at a cost effective design i.e. a house design that will be able to provide basic comforts along with reasonable durability and still be within the reach of the rural dweller.

## SITE CONSIDERATIONS:

Cost of dwellings can be broadly divided into two namely, cost of land and cost of construction. Land is a basic component of house construction. It is needed for a variety of uses which may be both conflicting and competing. Land value depends largely on the demand and competition for it. However, land cost poses little problem in the rural areas as most families have family plots of land on which buildings could be erected.

Attention should however be focussed on other parameters for choosing a particular plot. As much as possible, a plot that has easy access to road and required public services like water and electricity should be chosen as this reduces greatly the cost of transportation and installing these services. Plots of land that are swampy and unstable or which are full of burrow pits or 'prone' to 'erosion' should be avoided as special

and more expensive foundations will be required. Features of adjacent environment such as rocks, overhead cables, railway lines if any, and other public utility etc will greatly influence the siting and orientation of the proposed building.

## CLIMATIC CONSIDERATIONS:

All aspects of weather are relevant for any good building design and therefore must be considered carefully; temperature, wind, sunshine radiation and humidity are important because they determine how hot or cold our buildings will be; rain and humidity because they destroy our building materials especially the finishes.

Aspects of climate that affect human comfort should be specifically considered during the design of a building. This may require such specific issues as the proper orientation of the building as well as the choice of building materials. In doing this it should be remembered that Nigeria is in the tropics and can be broadly divided into two main climatic zones namely:

- a. Hot dry zone in the North, characterised by excessive heat from the sun, dryness, dust laden wind, scanty vegetation, open land, little rainfall.
- b. Hot-humid zone in the South characterised by heavy rainfall, driving wind, heat from the sun and thick vegetation.

In the North therefore, the main problems for the designer are the excessive heat and dust-laden wind while in the South the main problems are heavy rainfall accompanied by driving wind and heat. Problems of inclement weather can be tackled by judicious choice of materials and careful planning.

## CULTURAL CONSIDERATIONS:

An area that is often over-looked in building design but which determines to a large extent how suitable a design is to the needs of a prospective house-owner/user is the living pattern

**FIG.1 CORRELATIONSHIP OF BODY MEASUREMENTS**

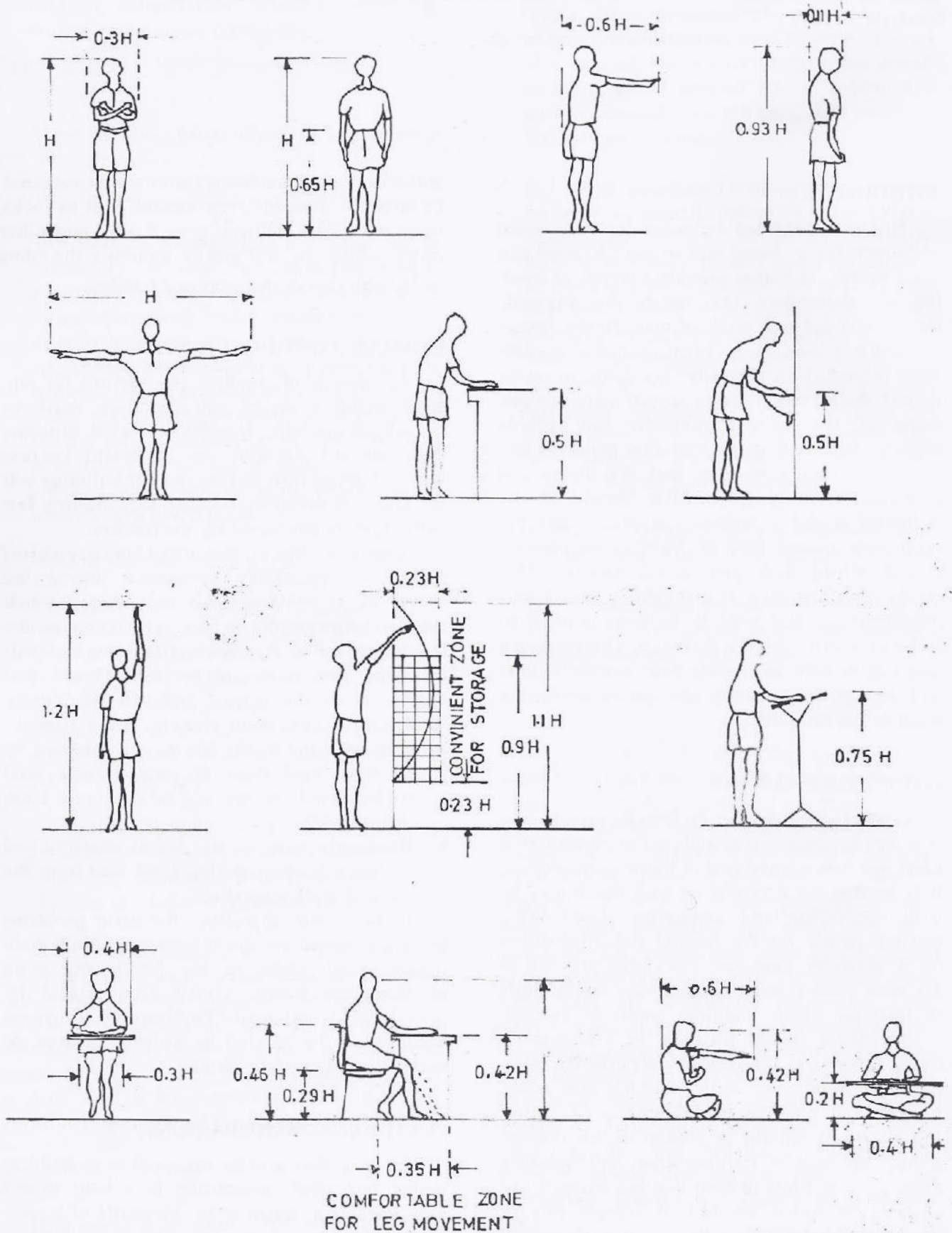
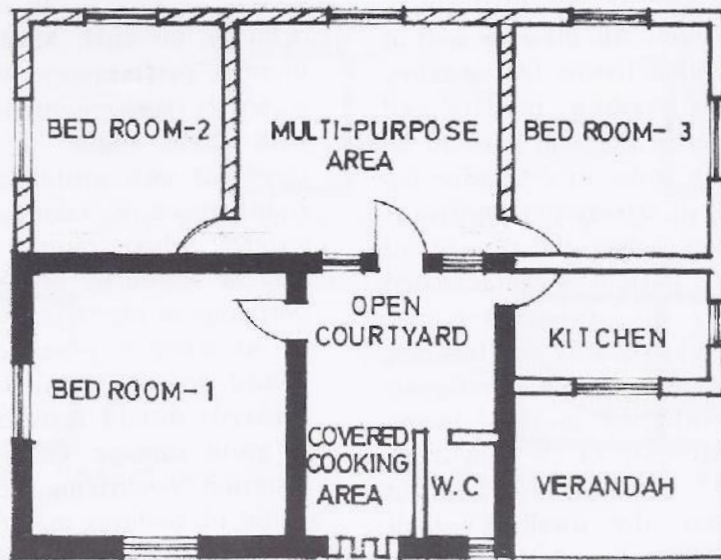


FIG. 2 STAGE COMPLETION




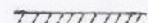
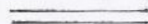
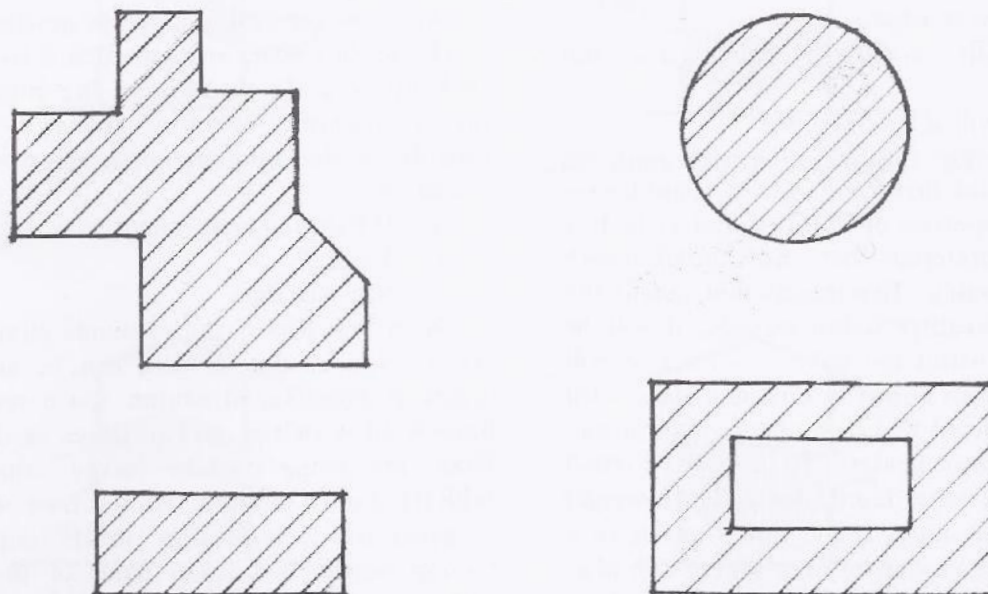
	STAGE 1	CONSTRUCTION
	STAGE 2	»
	STAGE 3	»

FIG. 3 BUILDING SHAPES



(a) and (b) are complicated expensive and difficult to build while (c) and (d) are simple and cheap to build

which is influenced by his socio-cultural background. Such issues include the family size of the occupant in terms of the number of wives, children and relatives living with him. Where visitors are received and the relationship and level of interaction between visitors and members of the household is important. All these as well as where and how household activities like cooking, eating, sleeping, bathing, washing, relaxing and a host of others are performed will have to be adequately considered in order to determine the space required and plan it effectively. Studies at the NBRRI have however shown that on a broad level, the Nigerian living pattern is characterised mainly by large family size, extended family system; need for privacy especially for females, outdoor and indoor household activities; religious cultural and social dominance in daily living. When the life style and taste of an individual/family are taken into consideration both in design and construction, the dwelling which emerges is better suited to their requirements.

#### CHOICE OF BUILDING MATERIALS:

The main function of any shelter is to protect the inhabitants from unfavourable weather conditions. This has to be reflected in the choice of building materials. Today, there is a wide variety of materials available in the market; however the choice of any material should be based on the following:

- (i) The effectiveness of the material minimizing the influence of adverse weather.
- (ii) The durability, availability and cost of the material.
- (iii) How often will it need repairs?
- (iv) Can the average rural dweller build with it?

It is important therefore to have some knowledge of the properties of building materials. For example, light materials like most metal absorb and lose heat easily. This means that during the day when the weather is hot outside, it will be hot inside and when the outside is cold, it will be cold inside. This is not economical since a lot of money may need to be spent on airconditioning units fans and heaters to achieve thermal comfort. On the other hand, dense, heavy-weight materials such as mud, brick, and stone have a high heat-storage capacity. They take a considerable time to heat up and once heated take a long time to cool again. Shiny and polished surfaces reflect heat rays while dark and rough surfaces absorb heat more easily.

It is very important to choose materials that

are easily available because they are cheaper and construction work will not be unnecessarily delayed due to shortage. In Africa, earth has been widely used in traditional buildings and is the most widely used building material in Nigeria. This is because it can easily be got anywhere at little or no cost. Mud buildings have superior thermal performance when compared to other materials like cement blocks. It is easy to build with earth either in form of burnt bricks, stabilised and unstabilised earth. Little or no maintenance is required in places with little rainfall. Where rainfall is heavy, this problem may be solved by protecting the wall with huge overhangs or plastering with lime.

As much as possible, durability of materials should not be sacrificed for cost or availability. Materials should therefore be properly seasoned to avoid damage during and shortly after construction. Weathering is the chief cause of deterioration of building materials. When timber is not properly seasoned for instance, it may shrink, warp or crack and be washed away especially when exposed to rain. The problem of maintenance is however present in every building project, though its solution will lie a great deal in a thoughtful design.

#### PLANNING CONSIDERATIONS:

The planning approach chosen should aim at:

- i. providing comfortable and suitable indoor climate and
- ii. reducing cost as much as possible.

To reduce cost, one approach is to reduce the built up area. To understand the impact of cost due to planning, dwelling elements have been roughly divided into three main groups with cost as follows:

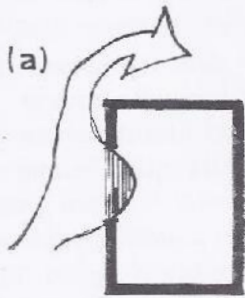
- |                         |   |     |
|-------------------------|---|-----|
| a. Horizontal component | — | 35% |
| b. Vertical             | ” | 45% |
| c. Non-variable         | ” | 20% |

With the above, the probable change in cost for a given change in area can be assessed. As much as possible, minimum space required for household activities and postures as determined from the living pattern survey conducted at NBRRI should be used. Studies have shown that a geometric relationship exists between the human height and other parts of the body at different postures. Fig. 1.

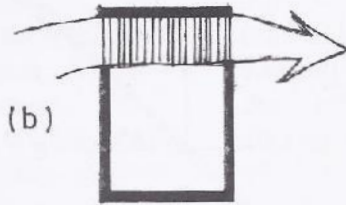
The designer should be able to differentiate between the prospective house-owners needs and wants as these are likely to vary greatly; the needs being analysed with respect to available money.

**FIG. 5 VENTILATION OF BUILDING**

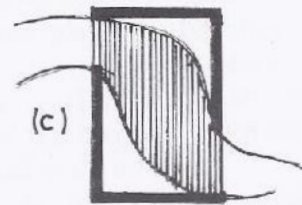
**A. LOCATION**



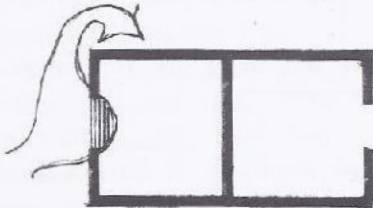
No cross ventilation



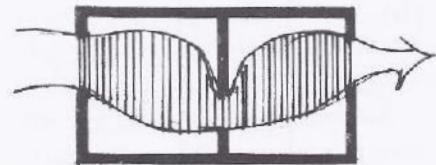
Only small area is ventilated



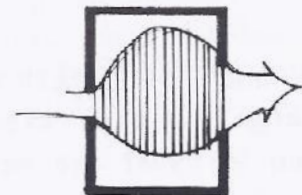
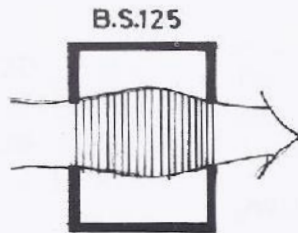
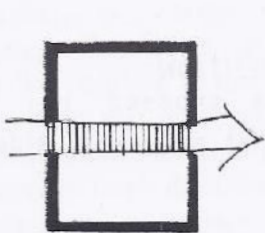
More space is ventilated



Partition obstructs flow of air



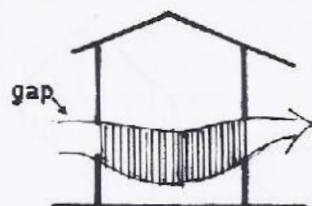
Both rooms are ventilated



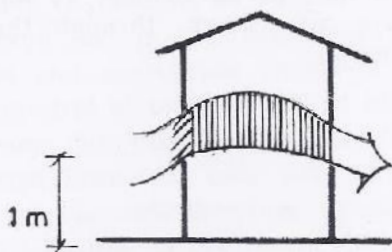
**C. CONTROL**



Air directed up



Air goes down because of gap

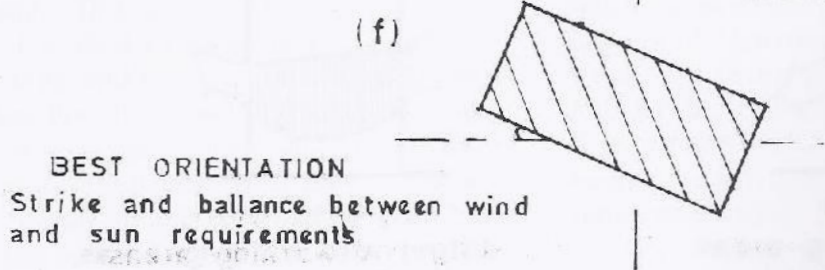
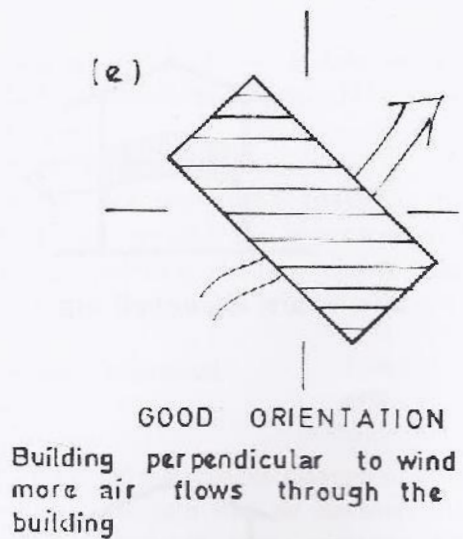
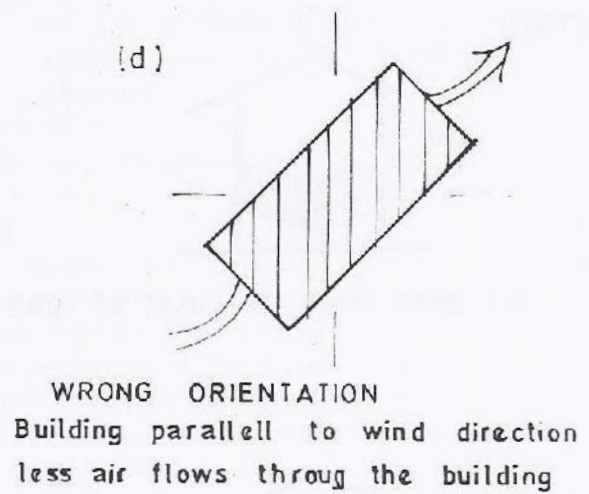
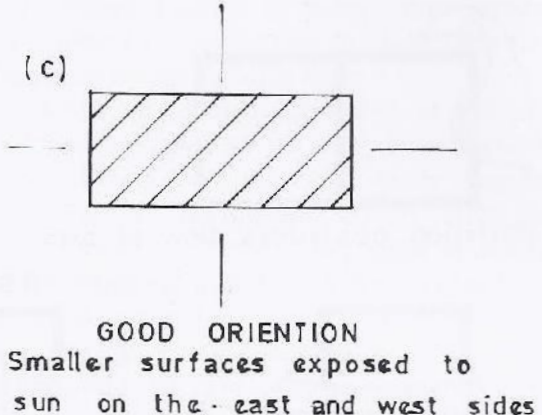
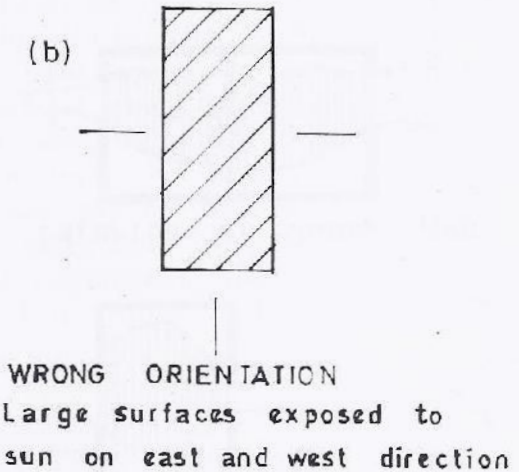
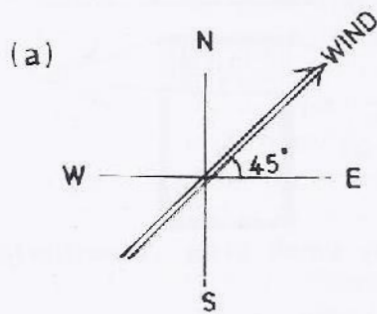


Air goes up  
sitting and working areas  
are not ventilated



Air goes down  
sitting and working areas  
are ventilated

FIG. 4 BUILDING OPERATION



Design should be flexible enough to meet the changing needs of the owner. It should allow for both horizontal and vertical growth, that is to say, the owner need not build everything now. The owner should build only what he needs and can immediately afford. As the family size and income increase, more rooms can be added. Fig. 2 The design should be as simple as possible, the shape being determined by the function. Curved and complicated shapes are difficult and expensive to build. Simple rectangular shapes are easier to build and cost less. Fig. 3.

Protection of walls and roofs from adverse weather will not only make the interior to be comfortable but also help to preserve the materials used in building. Building orientation is one major facet of site planning. It is determined by the path of the sun and wind direction. If a building is rectangular in shape, placing it along the North-South axis exposes a greater part of the building to sun, while placing it along the East-West axis will expose less of the building to sun. It should be remembered that although the sun rises from the East and sets in the West, the heat of the rising sun does not give as much discomfort as the heat of the setting sun. Bedrooms should therefore be placed either in the North or South; living rooms that are not usually used till afternoon/evening period in the East; toilets and bath that are not always in use in the West.

For Nigerian climate, the wind direction is in the North-East direction. Thus, for any building to get maximum benefit from wind, the longer side has to be perpendicular to the wind direction. However, considering the requirements of sun and wind, the best building orientation for Nigeria is as shown in Fig. 4. This provides considerable thermal comfort.

Rooms should be designed in such a way that proper ventilation is ensured. This can be achieved by proper orientation as discussed above and appropriate choice of position, size and control of openings. When inlet and outlet openings are placed very high, the air passing through them may only serve to cool the roof. For effectiveness therefore, openings should be placed as low as practicable (about one meter high). In the North where the dust laden wind is not desirable, openings should be small, while in the South they should be bigger. Fig. 5.

Open or partially covered courtyard is a very useful feature in buildings. It is an extension of the house, adding to the total space available

with very little additional cost. It acts as a barrier against noise, dust and wind. At night, cool air is formed at the ground level and seeps gradually into the surrounding rooms making them cooler. Courtyards are safe play area for children under adequate supervision by their mothers while the mother are performing their household chores. It is used for relaxing, sleeping, cooking etc. when the weather permits.

Roof overhangs, balconies, verandahs, canopies and pergolas are other effective ways of protecting the building from harsh weather. They are not only functional but also add beauty to the design. If a building is properly oriented and has wide eaves, it will be able to protect the walls from the effects of rain and sun.

Planting trees, flowers and grasses around a building is a very cheap way of keeping the inside of our building cool. Unfortunately, many people think that plants are only for rich people. Plants absorb direct sun rays, reduce reflected glare and speed of dust laden wind. They also provide shade and beautify the environment.

#### CONCLUSION:

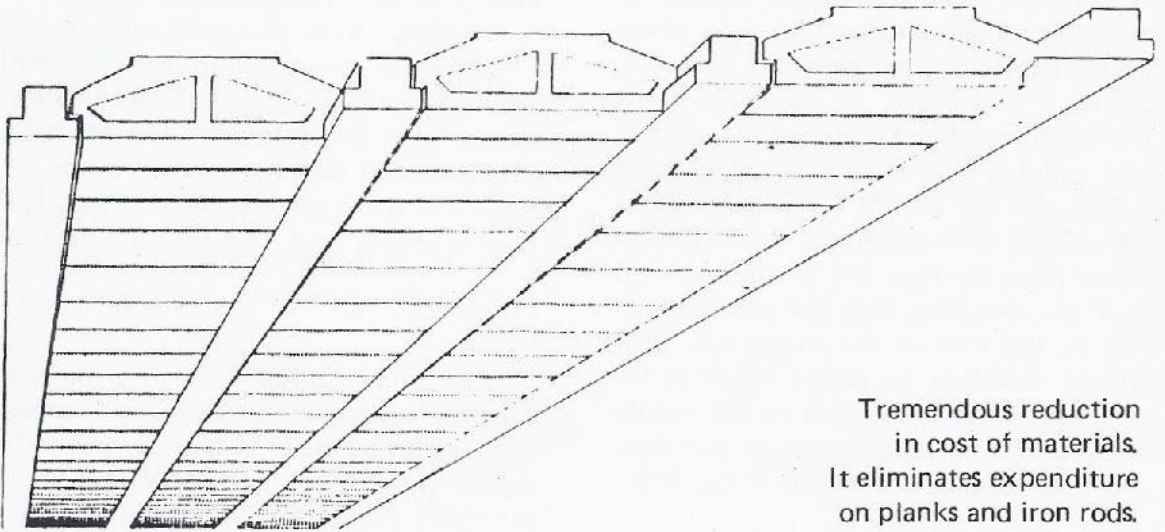
Functional building design is indeed a very complex operation. All the above considerations will have to be made in order to arrive at a building design which is not only within the reach of the rural dweller but also comfortable, suitable and reasonably cheap.

The provision of this design information should not be construed to mean that no outside professional assistance with design and supervision is necessary. Rather, it is hoped that the information given here will enlighten the prospective house-owner.



VORI INDUSTRIES  
(NIG.) LIMITED

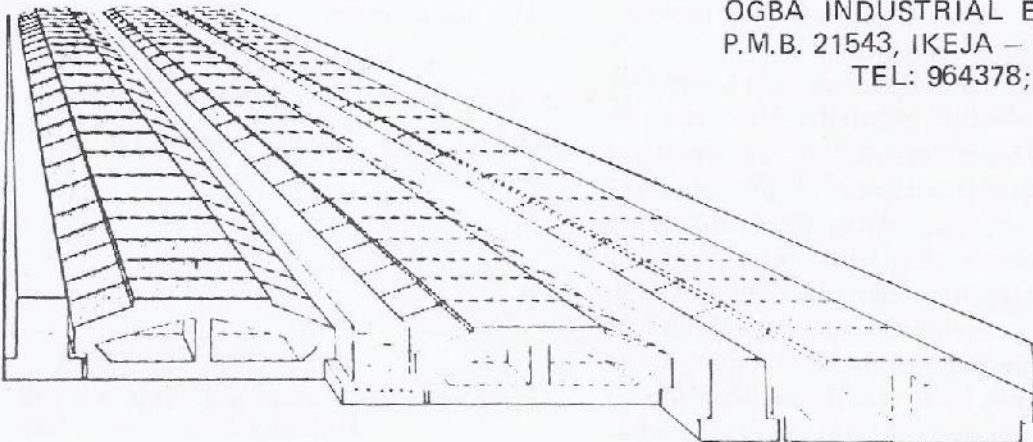
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**FLOORING AND ROOFING SYSTEMS**

# Staff Training And Development Scheme At NBRRI

G. N. Omange

Right from its inception, NBRRI has recognised the need for and the benefits of training its crop of research and supporting staff to achieve high calibre performance and efficiency. As a demonstration of this commitment, NBRRI secured the secondment of some building and road research experts from the Central Building Research Institute and the Central Road Research Institute both in India to this institute between 1982 and 1986. The Nigerian research staff were specifically mandated to understudy these experts.

## Training Sponsored by NBRRI:

In the early eighties when the annual subvention from the Federal Ministry of Science and Technology was appreciable, NBRRI sponsored some of its staff to institutions of higher learning. The beneficiaries ranged from research officers to technical and administrative staff (Table 1).

## Training Sponsored by other Organisations.

As a result of the downward trend in the economic fortunes of Nigeria coupled with the scarce foreign exchange and the attendant diminishing government subvention to NBRRI in the middle eighties, it became increasingly difficult for the institute to bear the financial burden of sponsoring courses especially outside

Nigeria. To this end, other avenues of sponsorship especially from multilateral and aid agencies were explored. Quite a handful of the NBRRI research personnel has benefited or are still benefiting from such avenues (Table 2). Similarly some short courses were also undertaken.

## Short and Self-improvement Courses Sponsored by NBRRI:

Perhaps of particular importance is the NBRRI sponsorship of its staff members to short but relevant courses offered by different professional bodies. These courses range from management courses to training and manpower development programmes in relevant fields such as secretaryship, cooperative programmes etc (Table 3).

## Conclusion:

The staff training and development scheme at NBRRI has gone a long way to improve both the professional and managerial skill of its staff members. However, since continuous training and retraining is part of NBRRI policy and in the face of limited available funds, the present emphasis is on securing sponsorship not only from multilateral and aid agencies but also from entrepreneurs and other organisations especially on a technical collaborative understanding.

---

## NBRRI DESEASED STAFF

- Arc. Jude Onotu Makoju, 28, Senior Research Officer: died in a ghastly motor accident on the Isolo - Oshodi Expressway, Lagos on 5 June 1986. Until his death, he was an invaluable asset to the Architectural Section in particular and the Institute in general. He was buried in his home town, Okene in Kwara State on 7 June 1986.
- Mrs. Folasade Ojubanire, 32, Cleaner: died during childbirth at the Lagos Island Maternity Hospital on Friday 9 January, 1987; was buried according to muslim rites.
- Mr. A. R. Mebude, 30, Senior Technical Officer, Mr. D. O. Olausi, 23, Senior Technical Assistant and Mr. A. Dairo, 20, Driver: died in a ghastly motor accident on Bir - Maiduguri Road, Borno State on Monday 20th September 1982, during an official assignment. It is noteworthy to mention the assignment was in connection with the study of the engineering properties of the black cotton soils of North-Eastern Nigeria and which eventually culminated in NBRRI Research Paper No. 1.

TABLE 1: FORMAL AND FULL-TIME COURSES SPONSORED BY NBRR I

Beneficiary	Section	Course	Institution	Degree	Duration	Dates	Remarks
1. G. N. Omenge	Road Materials	Civil Engineering	University of Toronto Canada	M. Eng.	2 Years	1981/83	-Course completed -Resumed Duty
2. E. O. Olabiran	Building Materials	Spectroscopy and Physical Methods of Analysis	University of East Anglia Norwich, U. K.	M. Sc.	2 Years	1982/84	Ditto
3. G. Ajigbewu	Administration	Purchasing and Supply	West Bromwich College of Commerce and Tech. West Midlands, U.K.	Diploma and Professional Certificate	1 Year	1982/83	Ditto
4. O. A. Ayodeji	Road Materials	Civil Engineering	University of Maryland U. S. A.	M. Sc.	2½ Years	1983/86	-Course Completed
5. F. A. Adeniran	Road Materials	Computer Science	University of Lagos	Post-Graduate Diploma	1 Year	1986/87	Ditto -Resigned Appointment
6. A. Idung	Road Materials	Science Laboratory Technology	University of Ilorin	Laboratory Technology Proficiency Certificate	3 Years	1983/87	—
7. S. Orji	Administration	Science Laboratory Technology	University of Port- Harcourt	Laboratory Technology Proficiency Certificate	3 Years	1986/89	Still on course
8. A. T. Agabue	Building Materials	Science Laboratory Technology	University of Lagos	Intermediate Certificate	3 Years	1985/88	Completed

TABLE 2: COURSES SPONSORED BY MULTILATERAL AND AID AGENCIES

Beneficiary	Section	Course	Institution	Sponsorship Awarding Body	Degree	Duration	Date	Remarks
1. O. Olawale	Road Materials	Structural Engineering	University of Sheffield	Commonwealth	Ph. D.	3 Years	1985/88	Still on Course
2. J. O. Akinyede	Terrain Evaluation	Applied Geotechnical Survey	International Training Centre, Enschede, The Netherlands.	European Economic Community (EEC)	PGD. Diploma	11 Months	1985/86	Course Completed
		Ditto	Ditto	Ditto	Ph. D.	3 Years	1986/89	Still on Course
3. O. Oguntase	Building Physics	Building Services Engineering	Brunel University U.K.	E.E.C.	M.Sc.	1 Year	1986/87	-Course Completed Resumed Duty
4. H. C. Ezirim	Building Materials	Bitumen Technology	Heriot-Watt University Edinburgh, U.K.	British Council	M.Sc.	2 Years	1986/88	Still on Course
5. G. N. Omange	Road Materials	Techno - Economic Feasibility of Road Design, Construction and Maintenance in Developing Countries	The Highway Institute, Belgrade, Yugoslavia	World Bank, Government of Yugoslavia and the Netherlands	-	6 Weeks	1987	Completed
6. A. O. Dirisu	Building Materials	Alternative Building Materials Training Attachment	Central Building Research Institute, Roorkee, India	Commonwealth Science Council	-	3 Months	1988	Completed

TABLE 3: SHORT AND SELF-IMPROVEMENT COURSES SPONSORED BY NBRRI

Beneficiary	Section	Course	Institution or Organisation	Duration	Year/Date
1. R. M. Omaballa	Accounts	Effective Management of Accounting Depts.	Nigerian Institute of Management (NIM)	1 Week	1981
		Budgeting and Budgetary Control	Nigerian Institute of Management (NIM)	1 Week	1981
		Middle Level Management	N. I. M.	2 Week	1981
2. N. A. Jegunmola	Administration	General Management	Administrative Staff College of Nigeria (ASCON)	6 Weeks	1983
		General Management	N. I. M.	2 Weeks	1981
3. L. K. Komolafe	Building Physics	Project Planning and Control	N. I. M.	1 Week	1981
		Advanced Management	ASCON	6 Weeks	1984
		Middle Level Management	N. I. M.	2 Weeks	1981
4. E. O. Olabiran	Building Materials	Supervisory Management	N. I. M.	1 Week	1981
		Management Audit: Tools for Effective Control	N. I. M.	1 Week	1981
5. S. O. Sanni	Audit	Internal Auditing	N. I. M.	1 Week	1985
		Induction Course	ASCON	3 Weeks	1982
6. J. O. Ojodu	Building Physics	General Management	ASCON	6 Weeks	1986
		Middle Level Management	N. I. M.	2 Weeks	1984
7. G. N. Omange	Road Materials	Project Planning and Control	N. I. M.	1 Week	1984

Table 3 (Continued)

Beneficiary	Sectionn	Course	Institution or Organisations	Duration	Year/Date
8. M. N. Ugonna	Accounts	Financial Management	ASCON	6 Weeks	1985
9. A. I. Oke	Audit	Internal Auditing	N. I. M	1 Week	1985
10. A. O. Adeyanju	Accounts	Accounting Course for Accounts Clerks	Yaba College of Technology	2 Weeks	1980
11. S. Ononeme	Accounts	Accounting Course for Accounts Clerks	Yaba College of Technology	2 Weeks	1980
12. J. E. Aka	Administration	Office Supervision and Management	Yaba College of Technology	2 Weeks	1985
13. L. A. Nkwocha	Accounts	Accounting Course for Clerical Officers	Yaba College of Technology	2 Weeks	1986
14. W. O. Onyemere	Accounts	Accounting Course for Clerical Officers	Yaba College of Technology	2 Weeks	1986
15. R. C. Ajoku	Road Materials	Training in Materials Testing	Foundation Engineering Ltd.	3 Weeks	1980
16. A. Idung	Ditto	Ditto	Ditto	Ditto	Ditto
17. A. O. Lawal	Ditto	Ditto	Ditto	Ditto	Ditto
18. D. O. Olausi	Ditto	Ditto	Ditto	Ditto	Ditto
19. H. C. Ezirim	Building Materials	Bifumen Testing	Total (Nig.) Limited	2 Weeks	1983
20. C. C. Kamalu	Administration	Confidential Secretaryship (CS. IV)	Fed. Training Centre, Kaduna	20 Months	1983/1985
21. E. U. Akpan	Ditto	Ditto	Fed. Training Centre, Kaduna	20 Months	1986/1988
22. R. O. Olarewaju	Ditto	Confidential Secretaryship (CS. III)	Fed. Training Centre, Kaduna	10 Months	1987/1988
23. F. O. Aitsebaomo	Road Materials	Intensive Course in Computer Sciences	University of Lagos	3 Months	1987
24. S. O. Timothy	Administration	Personnel Management	ASCON	6 Weeks	1981
25. C. R. Etuka	Building Materials	Ceramic Technology Applied to Building Materials	PRODA, Emugu	3 Months	1987
26. E. O. Olabiran	Building Materials	Ditto	Ditto	Ditto	Ditto
27. S. S. Idowu	Terrain Evaluation	Aerial Photo Interpretation Course	Regional Centre for Training in Aerial Survey, Ile-Ife	6 Months	1988

# A Rational Approach To Rural Road Development Using Appropriate Technology

G. N. Omange

## INTRODUCTION

A properly coordinated and well articulated integrated rural development programme has been recognised to be a panacea to rapid growth and development of the rural areas which constitute a sizeable proportion of most developing countries. In Nigeria, the Directorate of Food Roads and Rural Infrastructure was established by the Federal Government as one of its vehicle of achieving even development and 'opening up' the rural areas.

While integrated rural development embodies various components such as provision of adequate and appropriate shelter, food and related infrastructure, the provision of a good network of rural roads is a vital key to the economic integration of rural communities. This is principally because rural roads serve as communication and transportation links between villages/hamlets which are important agricultural centres on the one hand and market centres/towns on the other. In addition, a good network of rural roads provides non-economic but social benefits to the rural communities and the country at large. Such benefits include the enhancement of political and administrative control; promotion of cultural unity and integration; national cohesion and industrial growth.

At the moment, about 80% of the population of Nigeria is estimated to live in the rural areas which comprise of several villages and hamlets embodied in the more than 900 rural communities. This will definitely require a dense network of rural roads. As a result of the colossal task, limited funds and dwindling economy, such rural roads have to be 'low cost' with reference to not only the initial construction costs but also to strengthening and maintenance costs. Achieving this status will involve a rational approach in the application of appropriate technology to rural road development.

## WHAT IS A RURAL ROAD?

At this juncture, it is important to mention that there is no universal definition of what a rural road is. What may be termed a rural road in a developed country could well be an urban road in a developing country. Infact, in developed countries, rural roads are classified as all types of roads that pass through rural and agricultural centres. For deveveloping countries like Nigeria, this definition may not particularly be applicable since Federal, State and Local highways pass through such rural communities with the primary aim of connecting cities and towns together. Even then, the remote villages and hamlets still have no access or have limited access to such highways. In effect, rural roads in the context of a developing country could be seen as roads with low speed and low traffic volumes in predominantly agricultural areas. Such rural roads can broadly be divided into two namely those rural roads connecting interior villages with low population levels (and having very low traffic volume and intensity) and those rural roads with a relatively higher traffic volume and intensity (such as those connecting big villages to market, growth and industrial centres).

As indicated earlier, great economy can be achieved in the construction and maintenance of rural roads by the application of appropriate technology. This should involve the input of professionals such as scientists and engineers, so as to ensure low cost and all-season rural roads. At the moment, most rural roads are seasonal as they are generally inaccessible for between 4-6 months of the year during the rainy season.

## NEED FOR APPROPRIATE TECHNOLOGY.

The general engineering practice for designing pavement thickness of roads normally involve the determination of the (a) subgrade strength i.e. CBR (California Bearing Ratio) values and (b) anticipated traffic load on the road. These

two parameters are combined and by reference to standard CBR curves which are developed on the basis of limiting road deformation and serviceability, the pavement thickness and composition can be designed.

The direct application of this standard design procedure to rural roads often leads to over-designing for the level of serviceability of such roads. This is because:

1. The traffic load in standard design procedure refers to only pneumatic-tyred heavy commercial vehicles. In typical rural roads, however, the prevalent vehicles are bicycles, motorcycles and just a few or no pneumatic tyred vehicles.
2. The CBR strength index test to establish the subgrade strength is generally cumbersome and time consuming with low repeatability. This may not be too appropriate in rural roads due to the reasons mentioned above as well as the attendant testing costs.
3. As a result of the low traffic load in rural roads, the level of serviceability is low. Thus, the standard CBR design curves developed on the basis of high level of road serviceability cannot be applicable in rural roads.

From the foregoing, it is clear that appropriate technology application to rural roads is imperative. This should necessitate setting up a concerted research machinery to study the existing rural roads in a bid to establish appropriate design criteria for rural roads so as to avoid over-design and thereby effect economy both in construction materials and costs. Such a research effort was conducted in India and the outcome yielded good dividends.

#### ALTERNATIVES TO RURAL ROAD PAVEMENT DESIGN

The traffic load was estimated by the traffic index which is a weighted average of the annual daily traffic of all types of vehicles plying rural roads such as animal-drawn, solid wheeled carts, pneumatic-tyred heavy commercial vehicles and other light pneumatic tyred vehicles (such as motorcycles and saloon cars).

The subgrade strength (CBR) was also estimated by the Strength Index. After an exhaustive study resulting into the correlation of CBR values with strength index, it was established that with a knowledge of the dry density and moisture content values of the subgrade soils, the strength index can be determined and this can be correlated to the CBR values under soaked and unsoaked conditions as shown in Table 1.

Table 1: STRENGTH INDEX ESTIMATION OF SUBGRADE SOILS

Field Dry Density (g/cm <sup>3</sup> )	Field Moisture Content %	Strength Index Values	Corresponding Unsoaked CBR Values
1.40 - 1.75	12 - 30	2 - 10	0 - 10
1.60 - 1.85	5 - 12	11 - 30	11 - 30
1.86 - 2.2	5 - 10	31 - 80	31 - 80

Lab. Proctor Dry density (g/cm <sup>3</sup> )	Optimum Moisture Content %	Soaked Strength Index	Corresponding Soaked CBR Values
1.40 - 1.70	15	1 - 5	1 - 5
1.70 - 1.85	12 - 15	6 - 10	6 - 10
1.86 - 2.2	7 - 13	11 - 30	11 - 30

In a similar vein, pavement thickness design curves for rural roads were developed on the basis of abundant data on traffic index, strength index pavement thickness and serviceability or deformation levels collected on many rural roads.

For rural roads, estimating the traffic and strength indices, and applying these to pavement thickness design curves developed, leads to thinner pavement requirement than would normally result from the standard CBR design curves. This is a more realistic approach as it yields significant economy in pavement materials and costs while achieving appropriate level of serviceability. Using the design criteria established, a 20 - 25% savings in construction costs and hence pavement material was recorded in India.

In the Nigerian situation, similar studies is imperative in order to establish criteria that will be appropriate to the Nigerian situation. The great economy that will be achieved will ensure the construction of more rural roads from the limited funds.

#### APPROPRIATE LOW COST RURAL ROAD CONSTRUCTION

Achieving low cost rural roads will depend on achieving considerable economy not only in the design stage but also in the construction and maintenance stages of the rural road over its design life.

Savings in construction costs normally accrue from materials (achieved by using thinner pavements which is scientifically determined) and labour costs. Low cost construction techniques

can also be judiciously applied to the utilization of locally available construction materials such as gravels, laterities, soft aggregates and by employing simple but effective stabilization techniques.

In rural road construction, labour intensive techniques are usually emphasised and utilized. While such labour may not necessarily be cheap, it provides significant employment opportunities to the rural communities.

Adequate drainage channels e.g. gutters, ditches, culverts should be provided to drain water. Lack of or inadequate attention to this will significantly reduce the life of the road.

#### MAINTENANCE MEASURES:

In order to ensure that the rural roads perform its intended function over its design life, adequate short and long term maintenance measures must be regularly and periodically applied to the rural roads. These measures will normally include regular cleaning up of road side drainage channels; filling pot holes with suitable materials and compacting with hand rammer; replacing earth materials washed away by erosion with suitable materials, respreading earth materials thrown to the road edges; cutting of roadside grasses; sealing and handpatching of bituminous surfaces, regravelling of gravel roads every 2 - 5 years, recoating of bituminous surfaces every 8 years, etc.

#### APPROPRIATE CONSTRUCTION AND MAINTENANCE TOOLS

All these measures should be carried out by organised gangmen using equipment and tools that can be locally fabricated. For example compaction of rural roads can be achieved by using animal or motorcycle drawn road roller made of hollow drums that can be filled with sand through suitable opening to provide required weight.

Similarly, moisture during compaction can be provided by a water browser consisting of about 5 drums interconnected by galvanised iron pipes. A perforated pipe is provided at the tail end to spray water. These and other devices can be readily fabricated and maintained at village level.

#### CONCLUSION:

To provide a durable and low cost rural network and thereby 'open up' the rural areas for accelerated development, there should be a rational approach to rural road development using appropriate technology. This will involve conducting an inventory of relevant data on existing rural roads and subjecting these to analysis in order to evolve simple guidelines. The ultimate benefit will be the provision of more all-season rural roads within the limits of available funds.

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*Continued from page 36*

#### CONCLUSION:

If all the foregoing are duly considered during the design and construction stages of a building, comfortability of buildings would be greatly enhanced. Nevertheless, in Southern Nigeria, the high humidity coupled with inadequate natural air motion and calm winds necessitates the need to use ceiling or table fans. With these, buildings can be made comfortable to inhabit without the use of air-conditioners.

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*Continued from page 38*

#### CONCLUSION:

A good road maintenance scheme is an important tool in ensuring that a road performs efficiently over its design life. The basic problems associated with road maintenance in developing countries has been identified as that of dwindling economic fortunes which does not encourage governments to make adequate budgetary allocation to road maintenance. The lack of awareness on the need for good road maintenance scheme compounds this situation.

As a result of the tremendous benefits from a well maintained road which include low vehicle operating costs, high riding quality, etc, it is recommended that greater attention and budgetary allocation should be given to road maintenance so as to ensure low cost and serviceable road network.

# Library Facility At NBRRI

O. O. Oshiba.

## INTRODUCTION

The Library, just like the Institute occupies a temporary space on the third floor of the 4-storey building. It was the last section of the institute to take-off and was started in 1982. The initial teething problems of limited facilities were overcome because of the total and unalloyed commitment of the Director to a well equipped and functional library.

Consultations were held with other established libraries as well as the research personnel at NBRRI on their needs and requirements which served as an important pivot for the effective take-off of the library. Today, the library is adequately stocked with books and is well patronized by NBRRI staff (both research officers and other supporting staff) as well as others especially from various universities, polytechnics, Directorate of Food, Roads and Rural Infrastructure (DFRRI) etc. In fact, the Library has firmly established its position as an important 'support' service to the research activities and aspirations of the institute with its varied stock of reading materials.

## MATERIALS

The Library is well stocked with reference materials like Encyclopaedias, Dictionaries, Handbooks; Maps and Atlases, Standards, Government documents, Gazettes, Statistics; Calendars, Newspapers, Magazines; slides and VHS video cassettes and relevant journals; reasearch papers and texts like workshops, seminars, and conference papers; United States National Technical Information Service books; reports from Universities, Polytechnics, Research Institutes (local and overseas) such as Building Research Establishment, England Transport and Road Research Laboratory, U.K; Central Building Research Institute, Roorkee and Central Road Research Institute in India.

The stock of available books covers a wide spectrum of subject areas such as foundation,

geotechnical and soils engineering, building construction and management techniques, building materials, sourcing and development; road materials development, transportation; solar energy, building physics, remote sensing; architecture, civil engineering, housing etc.

## ACQUISITION

As a policy of NBRRI, all officers officially sponsored to attend any conference, seminar or workshop submits a copy of the bound proceedings to the Librarian for the benefit of the whole Institute. This is a legal deposit policy similar to that of the National Library of Nigeria Act. It is one way by which the Library acquires its materials. Other methods include direct purchase of books recommended and approved by researchers, users and the Director. Reading materials are also acquired through publishers' notices, books in print, British National Bibliography, other Library's catalogues from local suppliers, bookshops, local publishers, overseas agents and publishers like John Wiley, A. A. Balkema, Elsevier, American Society of Civil Engineers, Gothard, Bergano, UN Industrial Development Organisation, Organisation for Economic Cooperation and Development and Thomas Telford.

The Institute was unable to secure foreign exchange as a consequence of the downward trend of Nigeria's economy, and this has curtailed NBRRI acquisition policy to only publishers and agents who accept UNESCO coupons. The coupon has helped tremendously in acquiring foreign published materials like Journals, the British Standards and the American Standards (ASTM).

## CATALOGUING AND CLASSIFICATION

The Library uses the Dewey Decimal Classification Scheme because it is the most popular, easy to understand and readily available schedule, for its classification. This is used along with the

Anglo-American Cataloguing rules and Sears List of Subject Headings. The Library has a catalogue which is an inventory of all the stock available. It has also a Media Catalogue for Slides, Video cassettes, atlases and calendars. Materials are arranged according to subjects, authors and formats in the catalogue.

Books are arranged in the Library from reference materials, to loans materials, followed by reports and annuals: a Journal display rack, new arrival area, newspaper files' area, pamphlet boxes for pamphlets and other documents on the wall-shelves.

### SERVICES

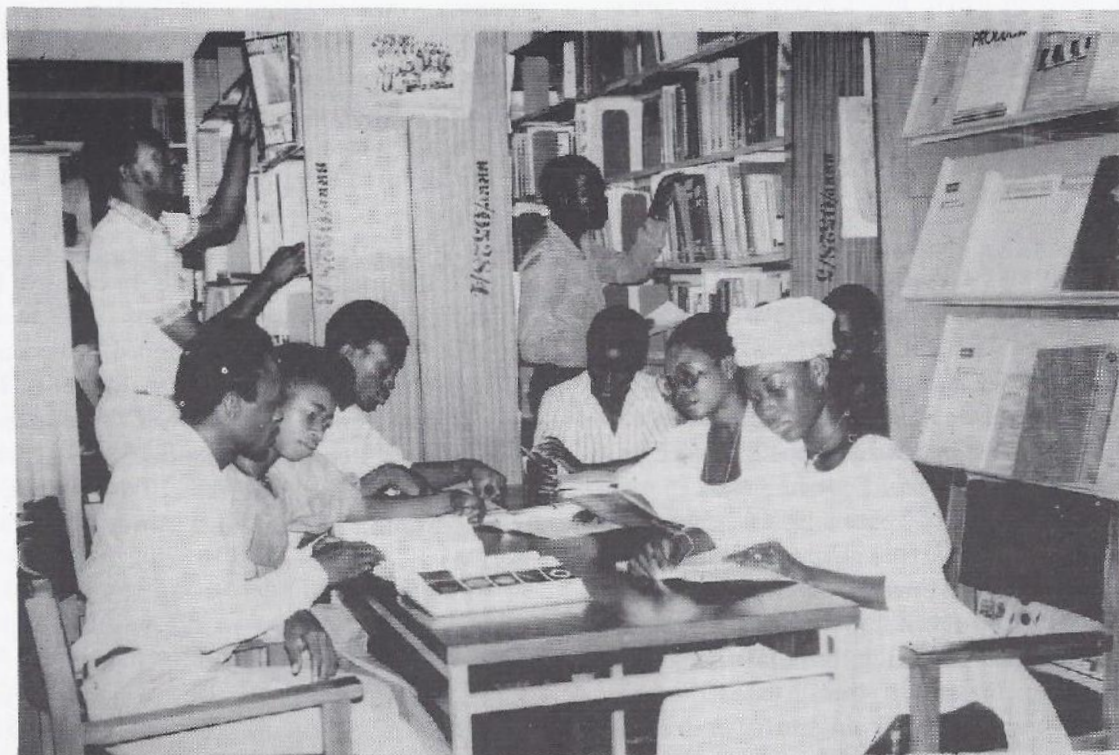
As a support service, the Library endeavours to support and back-up all current and future research programmes of the Institute and the Government through its acquisitions and loans policy.

The charging system is manual. Materials are borrowed through a modification of the Newark

charging system developed in the USA to save time and cost. A borrower writes and signs his name on the book card which is stamped for date-due. The card is filed in the borrower's record. The advantage here is that of precision, recall and control as the Librarian can know at any given time the particulars of materials borrowed by an individual, sends reminders or over-due notices, and manipulates records for other routines. Borrower's names are filed alphabetically (A-Z).

Inter-Library loans (borrowings from other Libraries), translations, gifts and exchange, reference and photostating services for external users and other services like newspapers and magazines loans; video and slide loans are also available on request.

The Library has a small seating capacity of 15 readers. It is fully air-conditioned, well illuminated and ventilated in case of power failures. In future, it is hoped that certain Library information may be documented into the computers which the Institute plans to set-up as a databank. At the moment, space constraint is a major problem militating against continuous expansion. It is hoped however that this situation will drastically improve when movement to the permanent site at Ota, Ogun State becomes a reality.



*NBRI Library in session*

# Do You Know That...?

Compiled by: G. N. Orange.

NBRRI LIBRARY

- \* The Nigerian Building and Road Research Institute (NBRRI) was established on April 1 1978 under National Science and Technology Development Agency (NSTDA) Bill 1977 Research Institute (Establishment) Order 1977, Supplement to official Gazette No. 49, 13 October 1977?
- \* NBRRI, at inception was under the auspices of the National Science and Technology Development Agency (NSTDA)?  
NBRRI came under the umbrella of Federal Ministry of Science and Technology which was created to replace NSTDA in October 1979?  
NBRRI at inception occupied a two room office at the Federal Secretariat until 1979 when it moved to its present temporary site at 15, Awolowo Road, S.W. Ikoyi, Lagos.  
NBRRI present temporary site contains such facilities as soil laboratory, brick and tile laboratory, chemistry laboratory, concrete laboratory, bitumen laboratory, acoustic laboratory, architectural physics laboratory, building construction demonstration site, offices for research personnel and supporting staff, library and store?  
NBRRI permanent site is located at Km 10 along the Ota-Idiroko road in Ogun State. Master plan for the permanent site has been drawn up and construction of the first phase is to start shortly?
- \* The Director of NBRRI is Engr. (Dr.) A. O. Madedor?
- \* NBRRI has developed, designed and fabricated a brickmaking machine?  
NBRRI has developed the technology and fabricated the machinery to produce durable and cheap roofing sheets from a combination of sand, cement and any fibre (coconut fibre, sisal fibre, palm fibre etc.)?
- \* NBRRI has developed, designed and fabricated some construction tools (endframes, string holders, mortar guide board, triangular trowels etc) to enhance productivity and efficiency of some construction operations?
- \* NBRRI has produced engineering soils map of parts of Nigeria using remote sensing technique to aid engineers, regional planners and related professionals in road route and construction materials location?
- \* NBRRI has produced subgrade soils map of some problematic soil areas in Nigeria to aid the relevant professionals in their practice?
- \* NBRRI has developed and constructed functional and domestic solar water heaters and solar cookers entirely from local resources?
- \* NBRRI has established varied and valuable criteria for ensuring thermal comfort for homes?
- \* NBRRI has developed valuable criteria for effective design of functional buildings in different parts of Nigeria with emphasis on living patterns, design detailing etc.?
- \* NBRRI is one of the twenty-three research institutes in Nigeria and is entrusted with the mandate of conducting research activities in the building and road construction industry?
- \* NBRRI provides consultancy service in various aspects of the building and road construction industry? Indeed NBRRI has successfully conducted consultancy service to Kano State Ministry of Works, West African Portland Cement Company, Shagamu and the Federal Agricultural Coordinating Unit (FACU).
- \* NBRRI conducts short courses to professionals and practitioners in the building industry?
- \* Twelve experienced research scientists from Central Building Research Institute, Roorkee and Central Road Research Institute, New Delhi both in India were seconded to NBRRI to assist in the development of the institute? Dr. S. K. Nnama, an Assistant Chief Research Officer in the Roads Section was transferred to take up appointment as the Deputy Director of the Nigerian Institute of Transport Technology, Zaria on 2nd March 1987?
- \* NBRRI engages in sub-soil investigation, soils and materials testing at reasonable fees?

NBRRI library has a good stock of reference books, textbooks, periodicals and journals? Research programmes are chosen within the National Scheme and Technology policy approved by the Federal Ministry of Science and Technology designed to achieve the goals of the National Development Plan?

NBRRI is capable of undertaking specific research projects for construction companies and private organisations?

NBRRI is a semi-autonomous corporate body mainly financed by the Federal Government of Nigeria?

NBRRI has two main divisions viz. Building and Road Divisions with supporting services provided by the Administrative, Accounts, Audit and Library Sections.



**IMO STATE HOUSING CORPORATION**

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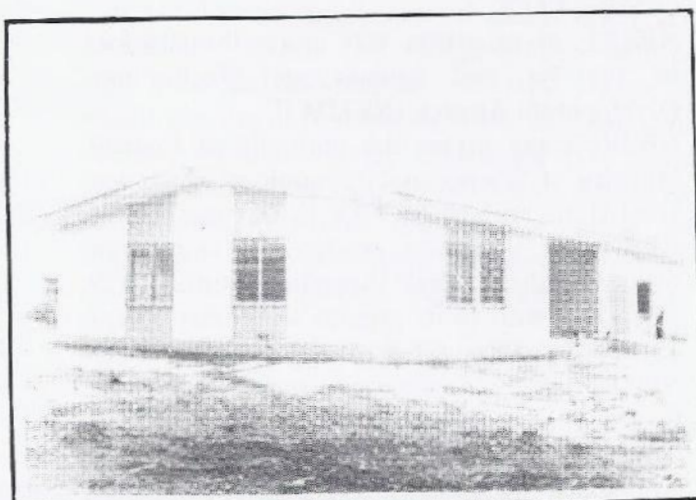
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49 Norman Williams St.  
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# CONSTRUCTION

The Journal of the Federation of Building & Civil Engineering Contractors in Nigeria

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IN NIGERIA



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## CONSTRUCTION

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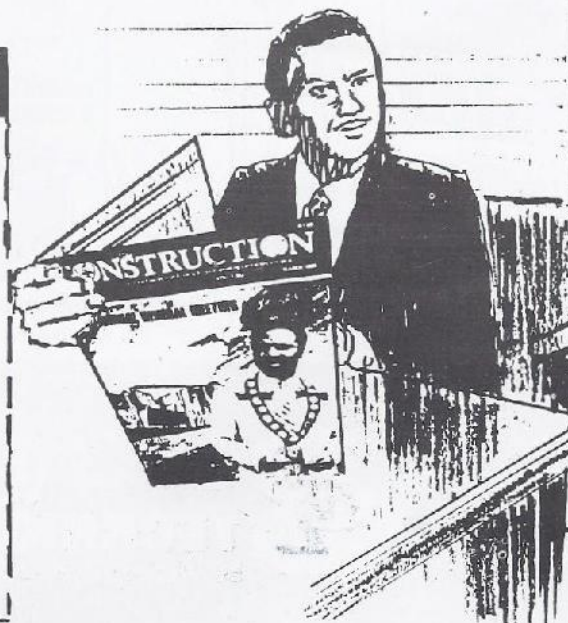
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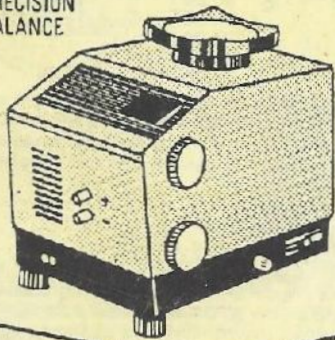
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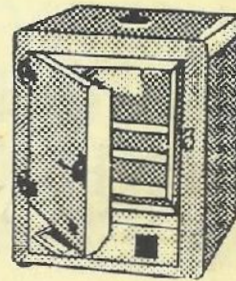
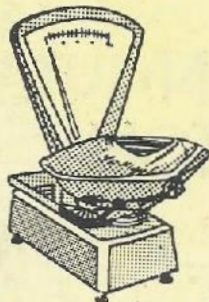


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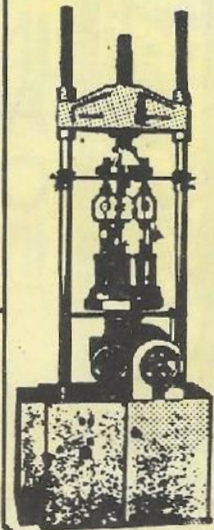
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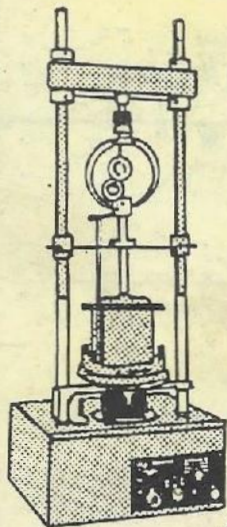
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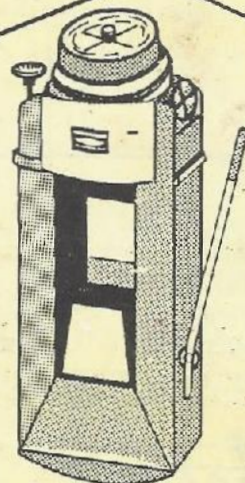
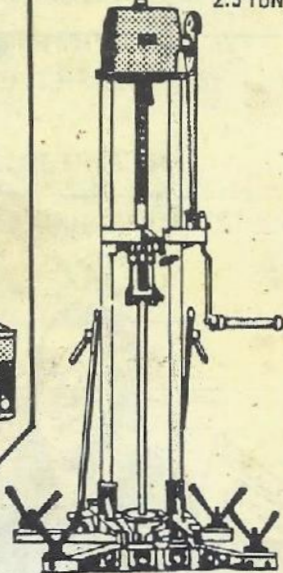


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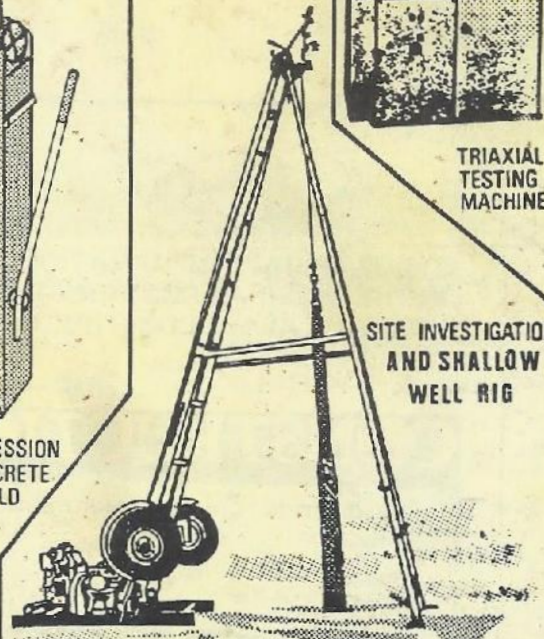


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