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This summary of the survey in 1976 sponsored by the Office of Housing of A.I.D. explores and synthesizes the work of organizations closely concerned with the research, project development, and use of materials in low-cost housing in sub-Sahara Africa. Countries visited include Tanzania, Kenya, Ghana, and the Ivory Coast. The main body of the report, arranged by country, lists institutions and organizations which are carrying out research in this field, and supplies detailed entries which describe the work being done by some groups in some of those countries. Each entry presents a general description of an institution's objectives and areas of interest, as well as a list of its current projects and a list of related publications, most of which are briefly described. Many of the projects described in these individual entries concentrate on the use of indigineous materials for building, such as timber, soil blocks, or clay bricks. Examples of the kind of projects being carried out include housing studies, restoration, resettlement, and designs for specific climates.

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Current Research In Building Materials And Low-Cost Housing In Sub-Sahara Africa

Office Of Housing

United States
Agency For International Development

CONTENTS

PREFACE

The Third African Conference on Housing, sponsored in April 1976 by the Office of Housing of the U.S. Agency for International Development, focused attention on research and project development in low-cost housing. It was noted that there is a need to facilitate information exchange among institutions involved in building material research and low-cost housing in Africa. The Office of Housing subsequently called for a survey of current research and project development being undertaken in the Sub-Saharan region of Africa. This report is the synthesis of the survey.

The intention has not been to produce a final document on research in Africa. The work is too dynamic and evolutionary. Rather the intention has been to provide a format which can be expanded and updated in accordance with the individual needs of the users. While it is a modest effort, I feel it provides a broad view of the character, scope, and depth of some of the research accomplished and on-going in the region. It is expected that by opening channels for exchange and dissemination of information, the report may help preclude overlapping and duplication of research efforts and identify areas requiring further investigation. In addition, it is hoped that by facilitating exchange of information and by fostering cooperative research, resources may be conserved and building materials development accelerated. Moreover, I feel that this survey will be useful to the Office of Housing in the development of projects undertaken in cooperation with African governments and their housing institutions.

Peter Kimm, Director
Office of Housing
Agency for International Development
Washington, D.C.

INTRODUCTION

The primary intentions of this project are to identify organizations closely concerned with materials utilization in low-cost housing in Sub-Sahara Africa through research, documentation, planning or implementation, and to provide information on their major activities, with an emphasis on materials research, development, and utilization.

Institutions were identified and queried by letter about their work. This report primarily records information provided by the responses to the letters of inquiry. In addition to material received in the responses, some information has been included from a modest search of relevant literature including material from the United Nations and other multilateral organizations. Some material was included from other recent surveys of different scope such as those of the Overseas Division of the Building Research Establishment of the United Kingdom and the Central Building Research Institute in Roorkee, India.

Four countries, Tanzania, Kenya, Ghana, and the Ivory Coast, were visited to survey their activities firsthand. The experience of the visits confirmed our expectation at the outset of this project--that the responses to our inquiries would not provide a fair indication of the breadth of the research and advances being made in the field. Much work is under way that has not been synthesized or documented, and demands on staff personnel prevent elaborate or complete responses to inquiries. The need for a continuing network in the region is obvious. A significant effort in this regard being undertaken by the United Nations Environmental Program in Nairobi, Kenya, to establish and activate a network is described in this report (Section KE/4).

The main body of this report is arranged by countries, with a listing of institutions and organizations followed by individual entries describing the activities of those for which detailed information was available. Following the country-by-country sections is an index of research subjects which allows cross referencing between subjects and institutions. The index lists code identification symbols for each institution which has related projects and/or publications. The identification symbol is found opposite the organization's name on the first page of a particular entry and on each succeeding page of that entry.

The individual detailed entries set forth a general description of aims, objectives, and areas of interest of the organization, and description of current projects and pertinent publications. Not all projects or publications of an organization are listed, but only those most pertinent to the aims of the survey. Publication lists are annotated whenever information was available.

The reader will note a great variety in the depth of treatment of the work of different organizations. This is in no way intended to express

any value judgment of the relative importance of the institutions or their research programs but is entirely a reflection of the information which was made available and the aims and scope of the report. The listing of institutions makes no claims as to completeness but may form a basis for a comprehensive inventory of such organizations. The flexible format of this report is intended to allow for future inclusion of additional organizations and information.

Large and significant contributions in the field have been made by non-African institutions such as the Building Research Establishment in the United Kingdom, the Centre Experimental de Recherches et D'Estudes du Batiment et des Travaux Publics in France, and many others. In addition, research is being pursued in many institutions on other continents which closely parallels work of African organizations. For example, the Indian Plywood Industries Research Institute is engaged in developing rice husk boards which are resistant to termites, decay, and fire, while similar experiments are underway in Ghana and Togo. It was decided, however, that constraints of time required limiting the scope of the report to work of organizations physically located in Sub-Sahara Africa.

COMMENTARY

A review of the report may suggest that certain areas of investigation such as soil stabilization dominate the attention of many organizations. While there is doubtlessly some duplication of effort, there is also often a felt need to verify the findings of others for particular local circumstances. At the same time, it may also appear that other areas, such as self-help building, are receiving less attention, while in reality there is a great deal of interest but the experiences are more difficult to record and less well documented than the testing of physical properties of materials.

In general, basic material testing is considerably diminished in importance in the current research programs of many institutions. A notable exception is research related to indigenous non-exported timbers. While some tree species are a major export of a number of countries, domestic use of other "secondary" species has been limited. Considerable basic research in timber protection and utilization is taking place, but demonstration projects of any scale are rare, at least in part because of user attitudes. Timber still has the stigma of being a "poor man's material" and also of not being durable and therefore not a "permanent" material.

In countries with serious foreign exchange problems rigorous experimentation is taking place in the use of indigenous materials as substitutes for imports. Considerable work is being done, for example, in the use of locally produced lime for soil stabilization to reduce the use of imported cement. In other countries, concrete block and corrugated galvanized steel and aluminum have almost the standing of "traditional materials".

Public non-acceptance of some materials is a severe impediment to continuing research into improving material quality and production and construction methods. In addition to timber, stabilized soil blocks and burnt clay bricks often meet considerable resistance from potential users. Julius Nyerere, President of the United Republic of Tanzania, speaking of public resistance to the utilization of indigenous materials, has said, "The present widespread addiction to cement and tin roofs is a kind of mental paralysis...people refuse to build a house of burnt bricks and tiles. They insist on waiting for a tin roof and 'European soil' [cement]." Evidently stabilized soil blocks and mud bricks do not, for the poor, represent a significant enough symbolic improvement over mud block walls of houses in villages left behind.

A further obstacle exists to acceptance of indigenous materials over imports when the imported product is less costly than the locally produced alternative. An example is the lower cost of corrugated metal roofing compared to burnt clay roof tiles. This unfavorable condition occurs not infrequently where transportation costs become significant as well as loss through breakage. The availability of salvaged corrugated metal roofing at even lower prices is a further complicating factor.

In general, the thrust of research programs of many institutions has shifted away from basic materials testing toward:

- Integrated social, technical and economic studies. Multidisciplinary staffs of engineers, architects, economists and sociologists are common with many housing research organizations.

- Making information more usable and accessible, particularly cost analyses. A number of organizations are engaged in developing cost indices and construction manuals for low-cost housing construction. Dissemination is accomplished in a variety of forms--posters, pamphlets, films--and in the local languages as well as English and French.

- User reaction studies, especially research into acceptability of specific materials and traditional living patterns and customs. In addition to traditional preferences for certain materials and unit layouts, plot organization and ethnic family relationships are investigated.

- Encouraging more efficient use of materials. Studies attempt to reduce materials waste by analyzing existing codes and standards which are often obsolete and overly conservative and by promoting appropriate reductions in standards.

- Studies and projects aimed at upgrading the low-cost housing industry. Much work attempts to improve on-site productivity by investigating and instituting better methods of on-site organization and management.

- Development of prototype designs, not only for houses but also for sewage disposal units, water storage elements and community facilities such as schools and health clinics. This work appropriately views housing not narrowly as house structure, but as total living environment.

A repeatedly expressed need by staff of institutions visited was for more applied research through demonstration projects, pilot projects and participation in the planning and construction of housing schemes. To sustain and enrich research, a close and active linkage with a continuing program of housing construction, backed by government policy and commitment, is critically important. This ensures continuity and guarantees the opportunity for immediate application and subsequent feedback to research proposals. Where this kind of relationship exists, research was found to be well focused, disciplined, and progressive.

This report was developed and prepared by Joseph Handwerger, consultant to the National Savings and Loan League of Washington, D.C., under whose aegis the project was performed. Melissa Burns assisted in background research.

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and Aerial Navigation
Bujumbura

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Faculty of Architecture
University of Yaoundé
Yaoundé

Laboratoire des Travaux Publics du Cameroun
B.P. 2004
Yaoundé, Messa

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Direction de l'Urbanisme et de l'Habitat
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Yaoundé

Ministère du Plan
Yaoundé

Société de l'Equipement des Terrains Urbains
Yaoundé

Société Immobilière du Cameroun
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Yaoundé

Timber Development Center
P.O. Box 369
Yaoundé

MINISTRY OF EQUIPMENT AND HOUSING
YAOUNDE, UNITED REPUBLIC OF CAMEROON
Enoch Kwayeb

CA/I

The Ministry's program in rural and urban development includes:

- Development of Sites and Services Projects.
- Establishment of Village Centers Within a Rural Housing Development Framework in Order to Integrate Rural Development and Discourage Rural-Urban Migration.
- Research and Experimentation with Local Materials for Use in Low-Cost Housing.

Chad

Faculté des Sciences
University of Chad

Ministère de l'Aménagement du Territoire et de l'Habitat
Fort Lamy

Ministère des Finances, Bâtiment et Matériels
N'Djamena

Le Ministère de la Fonction Publique
N'Djamena

Côte d'Ivoire

Association des Ingénieurs et Techniciens Africains
B.P. 794
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Bureau National d'Edutes Techniques de Développement
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Département de Technologie
Université d'Abidjan
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Direction de l'Urbanisme et de l'Architecture
Ministère des Travaux Publics
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IC/2 Laboratoire du Bâtiment et des Travaux Publics
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Ministère de la Construction et de l'Urbanisme
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Ministère de la Recherche Scientifique
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Abidjan

IC/3 Programme de Développement des Nations Unies
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Yamoussoukro

CENTRE DE RECHERCHES ARCHITECTURALES ET URBAINES (CRAU) IC/1
UNIVERSITE D'ABIDJAN
BOX 8892
ABIDJAN, IVORY COAST
Jacques Gregoire, Director

Sponsored primarily by the Ministry of Scientific Research, CRAU receives additional support from the University of Abidjan for its post graduate teaching function and from contractual research for non-governmental organizations such as the United Nations Development Program.

The primary areas of interest of the Centre's program have been:

- Cultural and historical basis of traditional settlement patterns and housing in the Ivory Coast.
- Economic and social problems in rural development.
- Modernization of rural habitat.

While CRAU does no basic materials research, it has a close relationship with the Department of Public Works' Laboratory of Building and Public Works which does basic materials testing. Future work is expected to center on comprehensive architectural-social studies of rural and urban low-cost housing and will involve:

- Examination of cultural traditions, traditional settlement patterns and traditional housing;
- User-need studies;
- Formulation of social guidelines;
- Development of site layouts, unit designs and materials specifications in low-cost housing schemes.

CURRENT PROJECTS:

- Modernization of Rural Housing in Connection with the Bandama Valley Authority's Program of Resettlement of Villages and Rehousing of Inhabitants Displaced by the Kossau Dam Project.
  The work is sponsored by UNDP. CRAU's involvement includes studies of traditional housing and settlement patterns, age group relationships, family-to-family relationships, ethnic grouping, village-to-village relationships and formulation of guidelines for village layout and unit design. A special problem encountered is the difficulty of developing designs acceptable to the settlers, who prefer traditional house styles but desire modern materials.

- Urban Housing Studies.
  This ongoing project studies user-needs, and ethnic and family groupings of urban immigrants. The study will lead to guidelines for community organization and physical space organization of neighborhoods and housing units to facilitate the integration of

immigrant ethnic groups. Architectural design guidelines, alternative unit designs and recommendations of building materials and methods will be prepared.

- Prototype Rural School Study.
  User-needs studies have been completed. Guidelines for classroom organization and typical designs for school buildings will be developed.

- Restoration and Renovation of Grand Bassam, the Old Capital of the Ivory Coast.
  Survey of the geographic, economic, social and architectural context, formulation of town planning, land use and building restoration guidelines.

- Inventory of Vernacular Rural Housing.
  Traditional house forms by region and ethnic group are being documented.

PUBLICATIONS:

The Kossou Dam and Bandama Valley Planning.
N'Guessan Kouame, October 1975

Problems in the Updating of Rural Housing.
N'Guessan Kouame, October 1975

Mutation in Rural Ivory Coast Housing - A Case Study: Baoule Housing.
N'Guessan Kouame, June 1976

Updating of Rural Housing.
Alain Maillard, March 1975

Project for a Training Center for Para-Architects and Urban Planners.
Maillard, Nedelec, Agnissan, April 1976

Ivory Coast: Construction Materials and Systems.
Bamba Adama, September 1975

Continuity and Changes in Traditional Schemes of Daily Occupation in Rural Areas.
Bob Hardy, October 1975

Construction System for Low-Cost Rural Housing.
Bob Hardy, October 1975

Shelter Possibilities for Latrines in Rural Areas.
Bob Hardy, December 1975

DEPARTMENT OF PUBLIC WORKS
LABORATORY OF BUILDING AND PUBLIC WORKS
B.P. 4003
ABIDJAN, IVORY COAST
C. Bamba, Chief Engineer
P. Simonnet, Civil Engineer

The laboratory performs routine tests of materials used in public road and housing construction. Research on low-cost indigenous materials has been limited to cement- and lime-stabilized earth.

UNITED NATIONS DEVELOPMENT PROGRAMME
B.P. 1029
YAMOUSSOUKRO

IC/3

PROJECT IN ASSISTANCE IN RESETTLEMENT AND SELF-HELP CONSTRUCTION

PURPOSE

In 1969, the Government of Ivory Coast began construction of the Kossou Dam in the Bandama Valley. When full, the lake created by the dam will cover 170,000ha and require the relocation of about 80,000 inhabitants, of which 70,000 are resettling in about 70 villages around the lake. To guide this enterprise, the Government created the Bandama Valley Authority (AVB), which is being assisted, since 1971, in its rehousing and resettlement programs through two UNDP projects.

PROJECT 1

Resettlement and Rehousing

The objective of the first project was to assist the Bandama Valley Authority in rehousing and resettling populations displaced by the rising waters of the Kossou Dam. Specifically, the project has assisted in planning and building three pilot demonstration villages. In order to develop suitable housing and community facilities the project activities have included experimentation, demonstration and popularization of housing plans and building methods; research on local materials improvement of traditional clay with earth-compacted blocks, modular building elements, carpentry, wood windows and doors, agricultural and handicraft sheds, schools, dispensaries, markets, shops, places of worship, bus terminals, and training of skilled and semi-skilled workers.

PROJECT 2

Self-Help Construction

The second project, begun in 1975, involves extending the self-help methods to additional villages. The aim is to assist the Government in developing its rural housing policy by continuing to assist the AVB in planning and building a comprehensive rural settlement network in the central and northern regions of Ivory Coast. The immediate objective is to implement an aided self-help village building program in villages in the region. This project will cover the essential social, economic and physical elements of development, employment, savings promotion and co-operatives, the production of building materials, building technology, environmental sanitation and health facilities.

Empire Centrafricain

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Ethiopia

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Addis Ababa

Ministry of Public Works and Water Resources
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National Planning Commission
Addis Ababa

National University of Ethiopia
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ET/1 Materials Research and Testing Department
Faculty of Technology
Addis Ababa University
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Addis Ababa

MATERIALS RESEARCH AND TESTING DEPARTMENT
FACULTY OF TECHNOLOGY
ADDIS ABABA UNIVERSITY
BOX 518
ADDIS ABABA, ETHIOPIA
Dr. Zawde Berhane, Head of Department

The main activities of the Department are applied research on indigenous building materials and soil mechanics, routine testing of building materials and foundation soils, and teaching.

CURRENT PROJECTS:

- Autoclaved Calcium Silicate Bricks Produced from Local Raw Materials.
- Production of Stabilized Soil Blocks Using Lime and Cement as Stabilizing Agents.
- Survey of Availability of Raw Materials for Sand-Lime Brick Production.
- Stabilized Soil Blocks.
- Quality of Clay Bricks and Concrete Hollow Blocks Produced in Addis Ababa.
- Pozzolanic Properties of Local Scoria.
- Effect of Different Curing Media Under Differing Climatic Conditions on the Strength of Concrete.
- Quality of Concrete Produced in Addis Ababa.
- Use of Crushed Basaltic and Trachytic Sands in Mortar and Concrete.
- Moisture Variation in Heavy Clays and in Black Cotton Soil.
- Resistance of Ethiopian Timbers to Termite Attack.
- Architectural History of Ethiopia in Pictures.

PUBLICATIONS:

Resistance of Ethiopian Timbers to Termite Attack.
L. Holmgren, 1963

The investigation results showed that Tid and Kosso are the most resistive to termite attack, while Zigba, Sombo and Karraro are very resistive.

Some Experiments on Stabilized Soil Blocks.
L. Holmgren, 1964

The report investigates stabilization with varying proportions of coarse and fine soils.

Compressive Strength of Concrete with Addis Ababa Cement and Suggested Specifications.
Zawde Berhane, 1966

Local concrete aggregate and sand are equivalent to imported aggregate and sands and concrete of compressive strength up to 700 kg cm^2 can be produced using locally produced Portland cement.

Preliminary Investigation Results on the Pozzolanic Properties of Local Scoria.
Zawde Berhane, 1967

The results showed that local scoria has pozzolanic properties and can be used as a replacement of up to 25% Portland cement.

Quality of Clay Bricks and Concrete Hollow Blocks Produced in Addis Ababa Area.
U.A. Halvorsen, 1968

Results showed that local clay bricks and concrete hollow blocks are of low quality. However, good raw clays for producing high quality bricks are available locally.

Effect of Different Curing Media on the Compressive Strength of Concrete in a Tropical Climate.
Zawde Berhane, 1973

Curing of fresh concrete by utilizing solar energy accelerates strength development of concrete without an adverse effect on higher age compressive strength.

Effect of Different Preservatives on the Termite Resistance of Some Common Ethiopian Timbers.
Zawde Berhane and Essa Yusuf, 1974

The following species of timber were studied: Tid, Zigba, Bahrzaf, Karraro, and Sombo. Chipboard was also studied. Tid was found to be the most resistant to termite attack and pentachlorophenol the most effective preservative chemical.

Properties of Fresh and Hardened Concrete Prepared with Addis Ababa Portland-Pozzolana Cement.
Zawde Berhane, 1976

Addis Ababa Portland-Pozzolana cement has a high water demand which adversely affects the 28 day compressive strength of concrete made with the cement. A number of means of overcoming the problem are suggested.

Gabon

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LABORATOIRE DU BATIMENT ET DES TRAVAUX PUBLICS GA/1
B.P. 766
LIBREVILLE, GABON

The work of the laboratory includes research in low-cost housing, use of cement and concrete in construction and formulation of building standards. A long term project investigates the use of stabilized soil and other local materials in low-cost housing. Other pertinent activities include research in stabilization of sand and erosion protection by accelerated implantation.

Gambia

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Ministry of Works and Housing
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Technology Consultancy Centre
University of Science and Technology
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Faculty of Architecture
University of Science and Technology
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UNIVERSITY POST OFFICE BOX 40
KUMASI, GHANA
J.W.S. De Graft-Johnson, Director

The broad objective of the Institute is to help the building and road design and construction industries to be more efficient, safe, and economical in providing for Ghana's building and roads needs. To accomplish this goal, a wide range of research and projects are focused on natural resource evaluation, building materials development, building design, physical planning of residential settlements, intermediate technology, properties of materials and their proper utilization, soil mechanics, road construction, and transportation planning.

The research activities are carried out by five main technical divisions. All divisions are engaged in consultancy work, so research is both basic and applied. Below are listed the divisions and their broad areas of concern.

Materials Division
- Natural resources of building and road construction materials
- Structural use of timber
- Use of sandcrete and landcrete blocks
- Manufacture and use of clay products
- Durability of paints
- Plasters and wall renderings

Building Design and Planning Division and Environmental Physics Section
- Building codes and regulations
- Low-cost housing
- Building design and construction
- Thermal environment in buildings
- Problems of urbanization
- Rural housing

Structures Division
- Structural use of timber
- Structural performance of walls and roofs
- Use of reinforced concrete and prestressed concrete in structures
- Earthquake considerations
- Bridge structures
- Building codes and regulations

Soil Mechanics Division
- Distribution and engineering properties of Ghana soils
- Use of laterite in road construction
- Earthworks and stability of slopes
- Pavement design

- Soil stabilization
- Foundations

Transportation and Traffic Engineering Division
- Road traffic statistics
- Studies into road traffic accidents
- Land use and traffic
- Transportation economics
- Urban traffic studies
- Studies into rural road needs of Ghana

Materials for Housing Construction

Investigations into the development and use of local building materials has always been an important aspect of the Institute's research program. The major goal has been to get primary materials on the market with proper quality control. The approach of the research work is:

- to survey Ghana's natural resources and determine the extent to which they can be used and developed.
- to find and develop substitutes or alternatives for imported materials.
- to help increase production of basic materials in great demand by using existing technology or by transferring or adapting technologies.
- to promote through design appropriate and efficient use of all materials whether imported or indigenous.

The materials studied so far include:

- Clay brick and tiles
- Lime
- Cement (from local limestone deposits)
- Timber
- Bauxite-waste (pozzolana)
- Building stone
- Stabilized earth
- Building boards of bagasse and rubber

The studies have covered aspects such as resource evaluation, production process, utilization in construction, market analysis, etc. Considerable progress has been made with respect to clay bricks and tiles, timber and stabilized earth. The studies regarding cement from local limestone, building stone, pozzolana from bauxite-waste, and bagasse are in their preliminary stages.

The Institute has also been concerned with the design and construction of components such as windows, doors, sanitary wares, etc.

Collaboration with National and International Agencies

On the national level the Institute maintains close collaboration with agencies such as the Public Works Department, the Ministry of Housing, the Ghana Housing Corporation, the Ministry of Works and the Tema Development Corporation. On the international level the Institute fosters collaboration with various organizations and agencies working in the field of building and road research and documentation. The Institute is undertaking joint projects with foreign institutions such as the Building Research Establishment of the United Kingdom, the Road Research Laboratory of the U.K., the Bartlett School of Architecture of the University College of London, and the Southwest Research Institute of the United States. Such joint projects promote contact and exchange of ideas in addition to making it possible to complete comprehensive projects in reasonable time. Joint projects include work on building climatology with the University College of London, studies of temperature variation under road pavements in the tropics with the British Road Research Laboratory; investigations of termite resistance of building materials with the British Termite Research Unit in the British Museum; and the studies of problem soils of Africa with U.S.A.I.D.

The Institute is also a member of the International Union of Testing and Research Laboratories for Materials and Structures (RILEM), the Association of Special Libraries and Information Bureaux (ASLIB), and The International Council for Building Research Studies and Documentation (CIB).

CURRENT PROJECTS

Materials Division

- Calcium Silicate Products
  Although calcium silicate brick is extensively used in most countries, its feasibility has not been studied in Ghana. The study will investigate the feasibility of using sand-lime bricks in areas lacking suitable clays for clay brick manufacture. The project has 3 parts:

  1) Lime and silicious materials will be selected, analyzed, graded and proportionately mixed to produce autoclaved bricks.
  2) Laterite will be processed to enhance its reactivity with lime in producing bricks through pressure moulding and normal curing.
  3) Laterite will be treated with seawater or calcium chloride and compressed.

  Attempts have been made to obtain sand-lime bricks with compressive strength of 2000 P.S.I. using activated silica and sand. Specimens of lime-laterite treated with sodium chloride or calcium chloride have been made to attain 1,200 P.S.I. A process has been developed by which sand-lime bricks of intermediate strength can be produced without autoclaving, but a press capable of developing 3-4 tons

P.S.I. pressure is required. Local efforts to design such a press have failed. The project has been suspended until a suitable press is designed and fabricated.

- Pozzolana Project
The use of Portland cement as building material involves a high foreign exchange element. The objective of this project is to investigate the use of local materials such as pozzolana for use as cementing material in building. This will be accomplished in two phases:

  1) Laboratory work. Bauxite-waste will be collected and laboratory tests will be conducted to determine the physical, geotechnical, chemical and mineralogical properties. This will be followed by the manufacture of pozzolana. Experiments will then be conducted to test its effects on the following:

     - o Effect of the lime-pozzolana ratio and curing conditions.
     - o Effect of curing conditions on the lime-pozzolana mortars.
     - o Effect of particle size distribution of the pozzolana on strength.
     - o Determination of shrinkage properties of the lime-pozzolana and cement-pozzolana mortar.
     - o Determination of soluble salts of the pozzolana.
     - o Determination of blending ratio for the cement-bauxite/waste pozzolana.
     - o Effect of seawater and sulphates on the mortar.
     - o Comparison of foreign pozzolana and this bauxite-waste pozzolana.

  2) The second phase will involve a pilot scheme for the manufacture of pozzolana with both bauxite-waste and other earthy materials. Walls will be built with pozzolana-cement and field trials carried out to test their durability. A rotary kiln and ball mill will be required.

  The main work of Phase I of developing pozzolana from bauxite-waste is completed. Long-term studies continue on alkali-aggregate reaction and strength development with time.

- Mining Wastes Evaluation for Use in Building and Construction
The objective of the study is to utilize and control the disposal of mining wastes which are potential environmental contaminents. The project will be divided into the following three phases:

  Phase I: Field Work
  A comprehensive survey will be conducted on the mining industry in Ghana with a view to identifying, classifying and quantifying the waste and to collect samples for laboratory tests.

Phase II: Laboratory Work
To evaluate the geotechnical, physical, chemical, mineralogical and engineering properties of the wastes; to determine the toxicity and radioactivity of the wastes; to produce synthetic building and construction materials from the wastes; to investigate the engineering consequences of using mining wastes in building and road construction.

Phase III: To appraise the project for technical and economic viability and to determine the potential social impact in using the waste.

- Clay Bricks and Tiles
The objectives of the project are:

  o To set up brick factories in rural areas.
  o To introduce the use of clay bricks into the building industry.
  o To develop continuous wood-fired kilns for reducing cost of firing of bricks.

  Small scale field trials will be carried out to determine productivity of labor, fuel requirements and costs for small-scale production. Two rural brick factories have been established and an experimental brick kiln is in operation.

- Production of Lime in an Oil-Fired Kiln
Lime has significant uses in building and road construction and its production using local resources has not been sufficiently examined. Local production of lime in a wood-fired kiln has been investigated. The aim of this study is to investigate the production of lime by firing local limestone in an oil-fired kiln.

- Termite Research Project
This project is being carried out with the support of British technical aid with the objective of studying and evolving methods of improving the resistance of timber and other building materials to termite attack. The investigation includes field testing as well as laboratory experiments including termite entomology in order to understand termite behavior.

  Among the materials tested or to be tested are:

  o Approximately eighty timber species from geographically separated areas.
  o Polythene and UPVC water pipes.
  o Steridex plastic cladding in outdoor and indoor situations.
  o Thirteen types of wood-wool slabs.
  o Small wood blocks treated with chemical preservatives.

- Durability of Building Materials
  The objective of this work is to establish the weathering characteristics of building materials in the climates found in Ghana.

  The materials include:

  o Reinforced concrete, to study behavior of both concrete and steel.
  o Roofing materials, to study corrosion and cracks, dimensional changes and delamination.
  o Brick and concrete blocks, to examine the effect of weathering on rain penetration characteristics and crushing strength.
  o Paints, to examine their relative qualities.
  o Plastic sheets and pipes.
  o Timber and other building materials.

  An exposure site has been established and a number of walls of lateritic clay, clay from ant-hills, fired clay bricks and sandcrete blocks have been constructed. For each composition two walls have been constructed, one facing N-S and the other E-W. Different types of plaster have been used on the clay walls. The brick and sandcrete block walls are without plaster. Lateritic clay walls with sand-cement plaster have been well preserved during the past 16 months. A small roof of Roman tiles has also been constructed for exposure to natural weathering.

- Feasibility Study of the Manufacture of Portland Cement in Northern Ghana
  The study's objective is to develop local sources of cement as a substitute for imported clinker. The project has the financial support of the Bank of Ghana. The work will include an evaluation of limestone deposits and a feasibility study of market and the manufacturing process.

  A pre-feasibility study has been completed. Evaluation of limestone deposits has been undertaken in collaboration with the Geological Survey Department and a report completed. Attempts are being made to locate suitable clay deposits and to produce cement in the laboratory.

- Use of Non-Exportable Timbers in Construction
  Timber is a Ghanaian natural resource but very little of it is used locally in construction. Less than 10% of the available timbers are exported. Among the reasons for the low utilization of timber in Ghana are the lack of data on the durability of most of the species, and the lack of technical data such as strength and workability of most of the secondary (non-exportable) species.

  The objective of the project is to determine the strength and workability of some of the non-exportable timbers. These will

include Wonton (Morus Mesozgia), Potrodum (Erythrophleum Ivorensis), Ananta (Cynometra Ananta), Kokoti (Anopyxis Klaineana), Bompegya (Mammea Africana), Krubete (Pseudocedrela Kotschy), Agobeam (Borassus Acthiopum), Pampena (Albizia Adianthi Folia), Awiemfo-Samina (Albizia Feruginea) and Okoro (Albizia Zygia).

- Production of Lightweight Aggregates from Clay, and Production of Lightweight Concrete from Bloated Clay Aggregates.
  This project will investigate the feasibility of producing lightweight aggregates from locally available clays for use in lightweight concrete. Clay samples from various parts of the country will be tested for bloating characteristics and suitability for producing lightweight aggregates, and large scale production of aggregate will be considered.

  Preliminary investigations have been made but results have not proved successful partly because of the absence of a suitable furnace capable of developing high enough temperatures to sufficiently test the bloating characteristics of the pellets prepared. Clays from five locations have been tested. Maximum bloating values of the order of 1.5 were obtained.

  Lightweight concrete made from bloated clay aggregate will be tested to determine its suitability for use in building construction. Determinations will be made of suitable mix proportions and essential properties. A wall will be built to test the durability of the concrete.

- Development of Low-Cost Roofing from Indigenous Materials
  Roofing material is recognized as one of the key and more costly elements in housing and is considered a prime target for cost reduction, reduction of foreign exchange expenditure, and performance upgrading. Essentially, the project aims at matching indigenous filler materials with low-cost polymeric binders or locally available additives which can be processed locally to produce composite roofing material with a wide range of applicability in low-cost housing in developing countries. Project goals also include transfer of technology in associated organizations to assure future utilization of the technology, and describing products that may be the basis of local industry. The program emphasizes:

  o Minimum foreign currency requirements.
  o Competitive costs.
  o Competitive performance.
  o Durability.
  o Acceptability.
  o Competitive installation methods.
  o Low capital manufacturing.
  o Renewable or underutilized ingredients.
  o Applicability in other developing countries.

Different phases of the work will deal with materials and process development and socio-economic base study, design, manufacture, testing and evaluation of prototype roofing, and manufacture and field testing of full-scale roofing. In addition to the roofing material itself, attention will be given to architectural design, construction and detailing, economics, and sociological factors.

Performance and durability criteria include resistance to static loading, impact, solar radiation, heat, rain, humidity, wind, fire, sound transmission, insects, pests, and fungus. Acceptability criteria include such factors as appearance, shape, form, and prestige.

The principal indigenous fillers considered include bagasse, sawdust, rice hulls, rice straw, coconut hulls, and clay. Of the candidate resin binder considered, only natural rubber is indigenous.

Test samples have been made of two composite processes, bagasse with natural rubber as a binder and bagasse with thermosetting plastic. The samples are undergoing durability and other testing. Equipment is being procured to establish an industrial process for manufacturing panels.

Building Design and Planning Division and Environmental Physics Section

- Housing Statistics Studies
  A unit will be set up within the division to collect statistical data on the building industry in general and housing in particular. Some of the information to be surveyed will be:

  o Construction, conversion, repairs and losses.
  o Production, supply and prices of building materials.
  o Employment in the construction industry.
  o Investment in dwelling construction and sources of finance.
  o Rents.
  o Building permits and occupancy permits issued.
  o Housing demand, need, and production.
  o Housing executive agencies' activities.
  o Rural housing activities.
  o Building materials - import, manufacture, cost.
  o Trends in construction costs.

- Rural Housing Project
  The poor quality of houses and the lack of amenities in the rural areas are among the factors which encourage rural-urban migration. The project's objectives are:

  o To develop structurally sound, inexpensive houses from indigenous building materials and skills.

- o To devise techniques of over-all village development to rectify problems resulting from defects in the physical layout of the village.
- o To formulate specific future development projects for the village consonant with the desires of the inhabitants.
- o To attempt a general improvement of the economic situation of the village by the institution of various cottage industries.

The work will include:

- o Assembling a multidisciplinary extension team to work with village development committees in the following areas: village layout, drainage, sanitation, building materials and methods, wall protection, water supply, electric power distribution, cooperative organization, finance.
- o Development of economic incentives to rural population stability such as cottage industries and schools.
- o Development of a model building code for use in both rural and urban areas incorporating performance standards to permit local materials.
- o Refinement or improvement of local technology.
- o Review of various financing mechnisms to ascertain their suitability for transplantation or adaptation for use in Ghana.
- o Analysis of economic constraints to individual home loans in rural areas.
- o Investigation of cooperative housing finance in Ghana.

- Low-Cost Housing Project

At present there is no coordinated effort to provide for an unfulfilled demand for low-cost housing located near employment opportunities in urban areas.

The objectives of the project are:.

- o To evaluate functional, social and economic requirements of low-income families and current provisions for establishing more and better guidelines for the spaces and facilities required.
- o To analyze the cost and performance of different constructions to determine where costs can be reduced and/or indigenous building materials may be substituted for imports.
- o To study the planning of housing developments in order to evolve precise standards for measuring the various factors that affect their planning.
- o To apply the results obtained in the construction of a number of prototype houses.
- o To identify specific areas where costs can be reduced in dwellings, components, and site development.
- o To establish alternative building materials and procedures.
- o To design prototype houses using wood and to design prototype building components of wood such as doors and frames, windows and louvres, vents, cabinets, roof framing members and roof coverings.

o To mobilize private capital for investment in housing.
o To study the effects of current tax-structure on housing.

- Timber for Elementary School Building
  The high cost of building materials has resulted in very high costs in providing elementary school buildings. The project was undertaken at the request of the Ministry of Education. The African Timber and Plywood Ltd. is a collaborating agency.

  The objectives of the projects are:

  o To evolve an efficient but reasonably cheap building technique for the construction of elementary school buildings from locally available building materials.
  o To collaborate with A.T.P. Ltd. in the development of a suitable timber construction system to be used in the construction of both elementary school buildings and teachers' housing.
  o To build a prototype primary school.
  o To build a prototype three-bedroom bungalow.

- A Comparative Study of High-Rise and Low-Rise Public Residential Development in Ghana
  The Commissioner for Works and Housing requested a technical report on the subject to guide government policy on public housing. Public residential development in Ghana has more low-rise than high-rise for dwellings and a common assumption is that the former, occupies more land than the latter. The objective of the investigation is to develop studies of the land problem and other factors to consider in choosing between high-rise or low-rise.

- Slum Rehabilitation Studies
  The degeneration of certain parts of urban settlements into slums is assuming alarming proportions in Ghana. Not only are the existing slums a problem for city authorities, but unplanned developments taking place at the urban fringes are creating new squatter areas.

  The objective is to initiate a study program aimed at improving housing conditions within the existing slums as well as formulating plans for the urban fringes to avoid unplanned development. A joint study program has been proposed between the Institute, Tema Development Corporation and Bouwcentrum International Corporation of Holland to undertake a study of Ashiaman near Tema. This will involve surveys leading to a rehabilitation program for the settlement.

- Artificial and Natural Lighting
  The provision of adequate and suitable lighting is a problem in certain types of buildings such as schools, hospitals, offices and workshops, where the choice of a particular lighting system is important from the point of view of inadequate illumination levels, aesthetics, comfort and health of the occupants.

The aim of the daylighting study is to develop simple means of predicting illumination levels in rooms taking into account the climate of Ghana.

- Thermal Performance of Local Building Material
  There is little data available on the thermal characteristics of local building materials.

  In this investigation, thermal behavior of different walling materials under tropical climate will be studied. Four chambers of different building materials--swish, sandcrete, timber and woodwool--will be built and roofed with aluminum sheeting for measuring thermal performance.

- Comparative Study of the Thermal Performance of Burnt Clay Blocks
  The thermal performance of burnt clay block from the point of view of comfort of occupants is not quantitatively known.

  The study will investigate the thermal performance of burnt clay blocks by comparing the thermal performance of a thermal model constructed with burnt clay blocks with existing models constructed in other materials.

- The Effect of Wall Orientation on the Indoor Climate
  Orientation of walls is one of the principal factors in the transmission of heat from the outside environment into rooms especially in the tropics where the solar radiation intensity is extremely high. The amount of solar energy absorbed by the wall depends on the exterior color of the wall, the orientation of the wall with respect to the path of the sun, and the thermophysical properties of the wall material. The objective of the investigation is to study the effect on indoor climate of wall orientation, external color, ventilation, etc.

- Climate Data for Thermal Environmental Design
  Buildings and towns in Ghana should be designed and planned in conformity with climate to ensure comfortable environments. Data on the prevailing climate is necessary but not available in a form which can be used readily. The aim is to provide climatic data for planning and design purposes. A presentation of temperature and wind data has been made. The present phase is to extend this work to cover rainfall, solar, radiation, hours of sunshine, cloud cover, humidity, etc.

Structures Division

- Studies into Ghanaian Earthquakes
  Data to facilitate the design of structure to withstand earthquakes is presently unavailable. The objectives of this study are to locate epicenters and intensities of earthquakes in Ghana and to suggest a code of practice in seismic design of structures.

- Feasibility Studies of the Use of Brick Bridges for Feeder Roads
  The studies will examine brick construction as a substitute for concrete and steel construction of bridges. A specimen bridge is under construction.

- Strength of Wire-Nailed Joints in Selected Ghanaian Secondary Species of Timber
  Improperly designed timber joints in roofs have caused roof failures during storms. This study aims at establishing a scientific basis for wire-nailed joint design in selected Ghanaian secondary species of wood. Green specimens of the timber species will be tested as well as air-dried specimens.

- Revision of "West African Building Code - Part III: Loads"
  The "West African Building Code - Part III: Loads", which deals with dead and imposed loads to be used in design was published in 1960. No revision of this edition has been published since. To up-date Part III of the Building Code, a review of existing codes in different countries will be made and a new code taking into consideration local conditions and requirements will be compiled.

Soil Mechanics Division

- Geotechnical Study of Urban Ghana for Land Use
  There is lack of information on the location and quantities of geological materials for construction work in urban areas. This has resulted in over-estimation of tenders leading to the abandonment of projects for lack of funds in cases of initial underestimation. This study aims at the preparation of a geotechnical map of urban areas in Ghana. Aerial photographs of urban areas will be studied and features suggestive of geotechnical problems will be transferred to geological maps. Traverses will be made to confirm the air photo interpretation. Delineated deposits and problem areas will be mapped at 1:200 scale so that quantities of deposits can be calculated.

- The Study of Ghana Clays
  There is a lack of detailed information on the use of clay as building material. This project studies the occurrence and characteristics of Ghana clays from engineering, geological and ceramics standpoints. Qualitative and quantitative analyses of clay deposits will be made. From the analyses, clay deposits will be classified according to their use.

  Samples from eight clay deposits have been collected and both the fired and unfired properties studied. Based on the results of the study two brick factories have already been established. A third is to be established.

- Slope Stability and Erosion Control
  Most cut-slopes in Ghana live short of their full designed life.

This study is to investigate the stability of slopes in lateritic soils, clays and weathered rocks. Information on the cost of maintenance of slopes will be collected and analyzed to determine economics of permanent remedial measures on critical slopes. This will be followed by a comprehensive study of the stability of slopes higher than fifteen feet. Laboratory data on the physical, chemical and mineralogical properties of the slope materials will be carried out to supplement the field data.

- Pavement Design. Experimental Pavement Test Sections, Including Road Base Stabilization.

  The use of stabilized soil for the base of flexible pavements in Ghana is becoming increasingly important because of increased traffic and the rather poor quality of the lateritic gravels available. The practice, though not new to this country, still leaves a number of questions unanswered about the performance of roads constructed with stabilized lateritic gravels. Cement-lime stabilization, being costly, warrants careful investigation, design and construction to achieve optimum results. Use of cement-lime stabilization requires a quantitative assessment of the performance of cement-lime stabilized materials in the field.

  Information will be gathered on the necessary thickness of cement-lime stabilized materials in the road structure for various traffic and soil conditions. Information will be gathered on optimum mixes which give satisfactory performance, experience minimum cracking, and withstand the effect of weathering in the field. The adequacy of pavement design methods for cement-lime stabilized laterite materials and the rate of gain of strength in the field under various regional factors will be investigated.

  A preliminary report entitled "Use of Local Lime in Stabilization of Road Bases" was presented at the U.N. Economic Commission for Africa Conference on Highway Engineering in Africa, held in Addis Ababa, April 1974.

- Road Construction Studies (Field Compaction Studies)
  The project studies excessive pavement failures, particularly the development of pot-holes, rutting, plastic deformation and cracking due to poor material selection and poor compaction. Factors which contribute to deterioration of local rock materials and soils in the roadway structure are being investigated and methods of controlling them suggested.

  Four reports dealing with various aspects of this project are being prepared. They are:

  o The behavior of laterite materials in the roadway structure.
  o Evaluation of laterite materials of Ghana for low-cost road construction.

- o The development of highway geotechnical standards for Ghana.
- o Laboratory compaction and stabilization studies of a black cotton soil of Ghana for low-cost road construction.

Transportation and Traffic Engineering Division

The work of this division is not listed as it is outside the scope of this survey.

PUBLICATIONS:

The following selected list of publications provides a general picture of the scope of past and ongoing work of the Institute:

Prolonging the Life of Earth Buildings in the Tropics
A.A. Hammond

Laterite Soils for Rural Housing
A.A. Hammond

Clear and Natural Finishes for Exterior Woodwork in West Africa

Timber Floors

Preservation of Wooden Frames of Windows and Doors

Strip Foundations for Small Buildings in Expansive Soils

The Dry-Wood Termite (Crypototermes Havilandi)

Fungus Decay in Wood

Air-Drying of Sawn Timber (The Way to do it in Ghana)

Geotechnical Characteristics of Troublesome Laterite Materials
M.D. Gidigasu and S.K. Bani

Lime Production from Typical Carbonate Deposits in Ghana
J.K. Ayetey and J.O. Gogo, November 1973

Economics and Financing of Rural Housing and Community Facilities in Ghana

Housing in Rural Ghana - Occupations, Incomes and Preferences

Soil-Cement Blocks. A Field Test for Suitable Mix Proportions

Sandcrete Blocks

Allowable Spans for Timber Rafters and Purlins

Aids to the Design of Shading Devices for Latitudes 4° N to 12° N

A Comparison of Cost and Methods of Construction of House Foundations Dessicated Clay at Accra

Design and Sitting of Living Accommodation

Air-Drying of Five Species of West African Hardwood

Thermal Comfort Study in West Africa

Manufacture of Burnt Clay Bricks in Wood Fired Clamps
July 1971

Microbiological Attack on Paint Film in the Tropics
"Journal of the Color Chemists Association" Vol. 43, No. 12.
P. Whiteley, December 1960

Tests on Joints in Timber Beams
"CIB Bulletin" No. 4
R. Tyler, 1962

The Control of Termites in Buildings
"Ghana Journal of Science" Vol. 5, No. 1.
H.N.O. Quao, 1965

Is the Use of Timber for Housing to be Encouraged?
H.N.O. Quao and K. Amonoo-Neizer

Use of Stabilized Soil as Building Material
N.S. Bawa and M.D. Gidigasu, November 1965

Houses for the People
Paper No. 5, Ghana Academy of Science Lecture Series on "What Ghana Could Have Done with its Money and Natural Resources and What Can Be Done Now."
J.W.S. De Graft-Johnson, June 1966

A Contribution to the Study of Phsico-Chemical Implications of Tropical Westhering and Laterization
"Geotechnical Engineering" Bangkok, Vol. 2, No. 2.
M.D. Gidigasu

Proceeding of Symposium on Environmental Design for Tropical Climates
J.A.K. Nutsugah, September 1973

A Housing Survey in Ghana - A Report of the Low-Cost Housing Committee
December 1973

Timber for Secondary Buildings - A Proposal for Elementary School Construction Program in Ghana
J.A.K. Nutsugah

Manufacture of Portland Cement in Northern Ghana. A Prefeasibility Study.
A.K. Chatterjee, June 1974

Actions to Achieve Cost Reduction in Public Construction
"Construction Materials Manufacture" Vol. 4
October 1974

Testing the Termite Resistance of Small Treated Blocks with Water-borne Preservatives
"Holzforschung" Vol. 29.
M.B. Usher and J.K. Ocloo

DEPARTMENT OF HOUSING & PLANNING RESEARCH
FACULTY OF ARCHITECTURE
UNIVERSITY OF SCIENCE AND TECHNOLOGY
KUMASI, GHANA
F.A. Abloh, Head of Department

GH/2

The Department of Housing and Planning Research was established in 1959 on the recommendation of the United Nations Technical Assistance Team to undertake research, in cooperation with the Building and Roads Research Institute, into better methods for meeting housing needs in Ghana.

The Department primarily relates its work to development problems of Ghana, with emphasis on urban and rural low-income housing. This includes the development and use of indigenous materials, the improvement of local construction techniques, development of more suitable tools and standards, and the design of individual houses and housing estates. National and regional development planning provides the context within which research project priorities are set.

CURRENT PROJECTS:

The Department's program is divided into seven areas:

1. Rural Housing & Rural Development

- Rural Building Training and Extension Schemes.
  Although effective and often inexpensive solutions for many of the rural housing problems are already available, the necessary techniques have been slow in spreading to the rural areas where the need is greatest. The Department has formed mobile demonstration teams for extension work and has established a rural training center on the University campus where a basic course in block-making and block walling is held each month for both private and Government building organizations. In addition, model houses designed for construction by self-help methods making use of locally made components are being built for several Government agencies for demonstration purposes.

  The Department continues to be the sole consultant for the country's housing cooperative program. A number of pilot cooperative societies have been set up in the Brong Ahafo Region, Greater Accra and Ashanti. More societies have been registered and are active in both Ashanti and Brong Ahafo.

- Improved Sanitary Installations for Unserviced Houses & Areas.
  This project is concerned with the improvement of water supply, toilets, and baths, including improved soak-away pits for rural houses where pipe-borne water is not available. Solutions may

also be applicable in urban areas where private residential developments often remain unserviced for an initial period. Examples are:

o Modified and Improved Pit Latrines.
This project provides standard designs and demonstration installations of modified and improved pit latrines common in rural areas. The improvements include stabilized soil-cement walls, concrete slab platforms, and simple but permanent wall enclosures and roofs.
o Design and Pilot Installation of Rainwater Filter and Reservoir.
The project aims at solving problems of dirt particle infiltration into storage tanks experienced in earlier demonstration installations in rural areas. A temporary storage tank constructed of soil-cement blocks finished with cement mortar plaster and containing a sand filter at the bottom was developed and is being tested.

2. Urban Housing

The Department's work on urban housing improvement has the following objectives:

- To reduce the cost of services and structures through improved design, construction, and administration.
- To increase private participation through the introduction of phased building and new financing techniques in ownership schemes.
- To increase the use of indigenous materials, tools, and techniques, in order to reduce dependence on imports.

The following projects are being undertaken:

- The Tema Pilot Cooperative Scheme.
A pilot demonstration housing project is under construction in Tema, following an intensive survey and analysis of existing housing. Fifty-two core houses with services have been constructed in a neighborhood of Tema New Town under the sponsorship of the Ministry of Labor, Social Welfare and Cooperatives with assistance by the International Cooperative Housing Development Association and U.S.A.I.D. The construction was undertaken by the Pioneer Cooperative Builders, Ltd., a group of building craftsmen of various trades who grouped themselves into a cooperative body with assistance from the Department of Planning and Housing Research. The houses, designed by the Department, are core house types, L-shaped around a courtyard. The houses consist of one or two room cores with kitchen and sanitary facilities and a foundation slab for extension to four or five room houses. Construction includes both contractor and aided self-help work. Responsibilities for collection of monthly payments,

refuse collection, etc., have been assumed by the cooperative member-occupants. The houses reportedly are affordable by families with incomes of $850 to $1050 (1976) per year, or 80% of the population.

- Unauthorized Housing in Urban Areas.
  This study examines the phenomenon of unauthorized extensions in public housing estates and develops guidelines and proposals for the integration of uncontrolled urban settlements into the urban structure of Ghanaian towns.

- Use of Locally Produced Materials.
  The project aims at increasing the use of soil-cement blocks for building in urban areas and the use of precast sanitary fittings and other locally made components.

- User Reaction Studies.
  The purpose of the studies is to establish a feedback system to monitor the utilization of living space in Ghanaian houses, such as the use of kitchens as cooking areas or as living areas. This study covers both private and public housing.

- Intensification of Urban Cooperative Housing.
  Eleven registered housing cooperatives in Brong Ahafo are about to begin construction.

- Pilot Project of Rehabilitation of Urban Houses.

3. Development of Alternative Materials and Components, Tools and Techniques

The purpose of this project is to make possible the production of good modern housing at reduced costs through the better utilization of local manpower and materials.

The manually operated Tek Block Press developed by the Department, has proved to be a success. A new power-operated press being researched is designed to have a much larger capacity and to produce blocks with greater efficiency. While soil-cement blocks have become popular, no commercial establishment to undertake mass production has been identified.

A production unit has been set up and is engaged in the production of sanitary fittings, moulding of blocks and production of various wall and floor finishes. It is also investigating the development and fabrication of other materials and components. The unit serves as the technical laboratory for research projects which require practical experiments. This unit employs chiefly local materials, tools, and techniques. As part of the Department's extension services, the unit is responsible for the construction of the prototype low-cost houses discussed above. The unit also produces

experimental precast sanitary fittings and components, which are designed and developed by the research team.

4. Timber Utilization

The program emphasizes the design and production of timber components and elements of low-cost housing through the use of unskilled and semi-skilled labor. The program includes:

- Documentation of timber low-cost housing in Ghana.
- Design and erection of prototype houses from timber products.
- Development of a set of tentative standards for design and construction.

The Department works in collaboration with the Building and Road Research Institute and the Forest Products Research Institute. The Department is attempting to popularize use of timber by utilizing timber louvres in its own building and by the extensive use of timber in a new student hostel. A demonstration roof of timber shingles has also been erected, as well as a number of prototype houses.

The Department is also engaged in the formation of a timber building core within the establishment of the Ghana Timber Marketing Board. This involves:

- The training and supervision of the building core by the Department to carry out the construction of demonstration projects financed by the Board.
- The arrangement of secondment of members of the building team to the University, Forest Products Research Institute and to specific institutions within the building industry to study requisite techniques.
- The development of production methods and system building in housing.
- The design of selected building types for agency development.

5. Dissemination of Information

The program for the dissemination of information has two main objectives:

- The preparation and distribution of research information to the public by means of films, demonstrations, booklets and posters.
- The exchange of information with research and development agencies outside of Ghana.

An instructional film on the operation of the Tek Block Press has been made and a Departmental bulletin is issued triannually.

6. Development of New Planning Techniques

The main objective of this program is the formulation of standards and criteria for the physical planning of towns. The development of a land use and space inventory was begun in order to identify traditional patterns in Ghanaian towns so that space standards might be evolved on the basis of local conditions. Guidelines now employed are largely the result of physical planning practices in England and other western countries and have been found to be unacceptable.

The first phase of the project which dealt with the broad land use characteristics of some 55 Ghanaian towns was done in 1969 and 1970. The second phase involves a detailed study of land use in individual towns. Under this study all the regional capitals will be covered, followed by other towns selected on the basis of their economic, political or social importance. To date all the regional capitals have been covered. Analysis of data is in process.

7. Training of Ghanaian Research Staff

The Department has recruited well qualified Ghanaians who are now working with its international staff in the above areas. The training program includes service with organizations overseas.

PUBLICATIONS:

The Towns of Ghana.
D. Grove and L. Huszar, 1964

A study of the role of service centers in regional planning. Problems of distance, study of relations between the urban center and surrounding areas in Ghana.

Growth of Towns in Ghana.
F.A. Abloh, 1967

A study of the social and physical growth of selected towns in Ghana.

Block Press Handbook.
J.S. Okle, 1971

A reference book for making soil-cement blocks with a Tek Block press.

Timber Research and Development.
1970

A summary of research progress and proposals.

Tema Pilot Housing Scheme.
F. Pfister, 1971

A proposal for a pilot housing cooperative in a Tema community. Motivations, theory, costs of dwelling cooperative.

Nsutam New Township Project.
F.A. Abloh and J.S. Okie, 1971

Studies of economy, demography, and sociology for a town of 0 to 10,000 people. Data. Plans.

Timber Research and Development in Ghanaian Design and Building Construction.
J.P.R. Falconer, 1968

Research studies and programs.

Timber Design and Construction Manual.
J.P.R. Falconer, 1969

A texbook for the use of timber in Africa including information on protection against various agents. Plans. Details.

Stabilized Soil-Cement Blocks.
A.A. Gbeckor-Kove

A textbook on making soil-cement blocks.

Timber Housing in Ghana.
M. Tamakloe, S.J. Hallaver, D.N.D. Nwankwo, 1971

A survey of some existing examples including user surveys, studies of the use of timber, corrosion, and protection against various agents.

New Volta Towns.
M. Tamakloe, 1971

A sociological study of two towns including user surveys of households' way of life and statistics after resettlement.

Household Composition.
M. Tamakloe, 1971

A sociological study of household composition after the Volta River resettlement.

Remoteness of Work Place From Dwelling Place.
F.A. Abloh, 1971

A study of the social and economic implications of distance in Ghanaian urban centers.

New Nsutam Resettlement Scheme.
E.K. Tamakloe, F.A. Abloh, J.S. Okie

A study of requirements for resettlement of one district including plans.

Current Research.
1971

Report of current projects of the Department.

Design and Construction of Modified Traditional Atakpame Houses.
J. Beck, 1971

A project report on low cost housing for rice farmers near Asutsuare, Volta Region.

Design and Production of Precast Sanitary Fittings and Components.
J. Beck, 1972

A report on the Department's production of sanitary fittings and components.

Tema Cooperative Housing Scheme.
I. Ohene, 1973

Performance Requirements and Basic Details for Use of Soil-Cement Blocks.
B.C.A. Obi, 1972

Research Projects in Pictures.
I. Ohene, J.L. Litow, S. Obeng-Appau, 1974

A pictorial review of Department's research projects.

DEPARTMENT OF RURAL DEVELOPMENT
BOX 55
ACCRA, GHANA
Stanley Pierce, Director

Funded with interest-free grants from the Central Government, the Department is responsible for initiating pilot demonstration projects of low cost houses in rural villages and towns using local building materials.

Housing cooperative societies of twenty or more members are formed. The society must have title to land parcels which can accommodate fifty or more houses. Members of the cooperative must be capable of paying a deposit of ₵ 300.00 ($260.00, 1976). Interest charges and mortgages are 10% with a term of ten to twenty years.

Through close liaison with the major Ghanaian research organizations, the Department endeavors to put into practical use the result of their research.

FOREST PRODUCTS RESEARCH INSTITUTE
UNIVERSITY P.O. BOX 63
KUMASI, GHANA

The Institute is engaged in a wide range of basic and applied research in the development and utilization of Ghana's forest productions, including natural and artificial regeneration, forest botany, forest entomology, forest and wood pathology, wood anatomy, wood chemistry, wood preservation, timber mechanics and forest economics. Following are some of the Institute's research projects which are directly related to low-cost housing:

- Wood-Cement Boards.
  This project, sponsored jointly by the Government of Ghana and the International Development Research Center of Canada, investigates the utilization of Ghanaian species in the manufacture of lightweight building boards for use in low-cost houses. These boards have great potential in tropical countries because of their thermal and acoustic properties and because they lend themselves to speed in construction. They can be used for wall and ceiling construction and, with proper treatment, in roof construction.

  Out of fifty Ghanaian wood species that have been tested for their suitability in use in the manufacture of cement-excelsior boards eleven have been found suitable. A prototype two-bedroom house has been built on the campus of the University of Science and Technology and the cost was found to be competitive. Observations are being made on this house to determine its durability. Additional prototype houses are planned in other ecological zones to determine the effect of the climate on these houses. Opinions of occupants of the house on the U.S.T. campus have been favorable, particularly in respect to thermal comfort and sound insulation.

- Sawmill Studies.
  Because of the problems and costs involved in transporting timber from conventional sawmills to users, this study investigates the technical problems of developing smaller sawmills. A portable sawmill was developed and is being used in the study to provide information on the suitability of mobile sawmills under various local conditions.

- Preservative Treatment of Small Round Posts.
  Posts are tested with the aim of determining the treatability by conventional pressure methods of some indigenous and exotic species and observing their performance under service conditions in various regions of the country.

- Building Timber Preservation by Dip-Diffusion Treatment.
  Preliminary work has begun on the treatment of building timbers by a dip-diffusion process using a boron-based diffusion preservative

of the type used for the treatment of building timbers in Papua New Guinea. Celtis spp. and the sapwood of Odum have been treated satisfactorily by this method, complete penetration being obtained after a diffusion storage of three-four weeks.

PUBLICATIONS:

Woodwool for Low-Cost Houses
Eighth Biennial Science Conference, Ghana Science Association
F.W. Addo-Ashong and W.K. Ashiabor, April 1973

The Efficacy of Some Fire-Retardant Chemicals Incorporated into Ghanaian Timber
"Technical Newsletter" Vol.6, Nos. 3 and 4.
B. Adamczak

Preliminary Studies on Woodwool Resistance to Termite Attack in Ghana
"Technical Newsletter" Vol. 6, Nos. 3 and 4.
S.K.N. Atuahene

Assessment of Performance of Treated Poles in Service in Ghana. An Assessment of the Performance of Preservative-Treated Poles in Areas of Ghana.
J.E. Barnacle and F.F.K. Ampong

Guinée

Commissariat des Travaux Publics
Bissau

Département des Affaires Urbaines et de la Construction
B.P. 14
Bissau

Institut National de Recherches et de Documentations
B.P. 651
Conakry

Ministère du Domaine Economique
Direction Générale de l'Urbanisme
B.P. 581
Conakry

Ministère des Travaux Publics de l'Urbanisme et de l'Environnement
Conakry

Haute Volta

UV/1 Laboratoire National du Bâtiment et des Travaux Publics
B.P. 133
Ouagadougou

Ministère des Travaux Publics, des Transports et de l'Urbanisme
Ouagadougou

LABORATOIRE NATIONAL DU BATIMENT ET DES TRAVAUX PUBLICS UV/1
B.P. 133
OUAGADOUGOU, UPPER VOLTA

The Laboratory's work includes research and testing of building materials and training of government employees in soil mechanics and the use of building materials. A recent research project is concerned with the utilization of lime in road construction and house building.

Kenya

East-African Industrial Research Organization
P.O. Box 30650
Nairobi

Department of Physical Planning
Ministry of Lands and Settlements
Nairobi

Faculty of Architecture
Design and Development
University of Nairobi
Nairobi

Department of Geology
University of Nairobi
P.O. Box 30197
Nairobi

Ministry of Housing and Social Services
P.O. Box 45958
Nairobi

Ministry of Public Works
P.O. Box 30260
Nairobi

National Housing Corporation
Uniafric House, Kolnange Street
P.O. Box 30257
Nairobi

Office of Planning
Nairobi City Council
City Hall
P.O. Box 30075
Nairobi

Office of Social Services and Housing
Nairobi City Council
County Hall
Harrambee Avenue
P.O. Box 30075
Nairobi

KE/1 Department of Civil Engineering
University of Nairobi
Box 30197
Nairobi

KE/2 Housing Research and Development Unit
University of Nairobi
Box 30197
Nairobi

KE/3 Ministry of Works, Materials Section
Box 30043
Nairobi

KE/4 Human Settlements Section
Division of Economic and Social Programmes
United Nations Environment Program
Nairobi

DEPARTMENT OF CIVIL ENGINEERING
UNIVERSITY OF NAIROBI
BOX 30197
NAIROBI, KENYA
R. Smith, Head of Department

KE/1

The major research activity of the department is in support of teaching and is primarily concerned with soil mechanics, highway construction, foundations, concrete structures, timber engineering, public health, water resources and hydraulics.

Research projects which have implication in low-cost housing are:

- Sisal Reinforcing of Concrete.
  While Sisal reinforcing does not improve the flexural characteristics of concrete, it does increase its resilience and capacity to absorb impact shocks. Potential application is in the handling of precast elements.
- Use of Pumice as a Substitute Aggregate for Concrete to Produce Lightweight Concrete with Good Thermal Qualities.
- Use of Timber.
  - Properties and uses of Kenyan timber; seasoning, preservation, structural data and quality control.
  - Nailed and bolted joints of cypress timber.
  - Use of hardboard and local plywood.
  - Poles for various purposes.
  - Roof trusses.
  - Quality control of plywood and other board products; protection against insect, moisture and fungal attack; glue integrity.
  - Timber for building in Tanzania.
  - Karlobangi demonstration timber housing project.
    Note: Research in timber was the work of Prof. Peter J. Campbell, who is no longer with the department. The research documentation has been transferred to the Library of the Faculty of Architecture.
- Slow Sand Filters for Rural Community Water Supply.
- Small Filters for Individual Houses.
- Storage Tanks for Individual Houses to Keep the Water Clean.
- Waste Stabilization Ponds.
- Fish Ponds Fed from Toilet Water.
- New Types of Latrines.

HOUSING RESEARCH AND DEVELOPMENT UNIT (HRDU)
UNIVERSITY OF NAIROBI
BOX 30197
NAIROBI, KENYA
Kaj Anderson, Director
J. Eygelaar, Senior Research Fellow, Materials

The Unit is based at the University Faculty of Architecture Design and Development, but is supported by funding by the Ministry of Housing and Social Services which is the Unit's primary client. The unit also provides a teaching service in the University on low cost housing and urbanization problems and publishes a wide range of reports, papers, and recommendations concerning urbanization, site and services schemes, materials utilization and construction methods, and functional and economic aspects of housing for low income groups.

A stated basic aim of the HRDU is to find ways of housing the majority of people in Kenya for whom conventional newly built housing is too expensive. It is felt that the task entails not only the design of more economical houses but also the investigation of existing social patterns, housing policies, methods of financing and total available resources including human, material, and financial.

The objectives of the HRDU are:

- To explore social, technical and economic problems of housing and community planning and to help establish appropriate standards.
- To build a body of knowledge in preparation for advanced training in the fields of urban an regional planning and environmental science.
- To assist the Government of Kenya by advising on social, technical and economic aspects of housing and community planning.
- To produce prototype designs, to test building systems and to assist in the construction of experimental housing projects including community facilities in collaboration with public or semi-public bodies.
- To participate in the teaching of subjects concerned with housing and planning in the University of Nairobi.
- To document and disseminate the Unit's research and to act as a clearing station for documentation of the research of other institutions.

The present feeling is that considerable basic technical information on building materials has been developed, and that an important direction for the Unit is the dissemination of the information in more useable form. Cost studies, studies of more economical use of materials, both indigenous and imported, and formulation of guidelines are examples of current activity in this direction. Recent HRDU activities have also turned towards putting

the results of earlier research into practice through the design of prototype units and layout of low-cost housing estates. Examples are the design of a housing scheme for Kibera to provide housing for approximately 7,000 people in the low-income sector, and a design for a prototype autonomous house for low-income families based on the principles of conservation and maximum use of local materials, a project sponsored by the United Nations Habitat and Human Settlements Foundation. In addition, it is felt that socio-economic problems are now crucial issues in low-cost housing. Considerable attention is being given to investigation of acceptability of low-cost solutions, user-reaction studies, and economic analyses of ability to pay. Routine analyses of new materials and untried indigenous materials and investigation of their potential application in low-cost housing remains an on-going activity.

The staff of the Unit includes architects, planners, materials engineers, services engineers, economists, sociologists, construction technicians, building technicians, and social interviewers. It is felt that the Unit's research benefits from a multi-disciplinary review process.

CURRENT PROJECTS:

- Lime-Stabilized Soil.
  The aim is to develop cheap blocks and lime-based finish materials with better bonding characteristics. Investigations are being made into materials which bond well with unstabilized and stabilized soil structures. These tend to be lime and bituminous products rather than cement protective finishes normally used. The results of this investigation have special significance in upgrading of soil-walled structures.

- Reduction of Material in Simple Trusses.
  Using previous research and standards for simple short-span wood trusses, this investigation aims at reducing material and simplifying connections and construction of trusses within acceptable limits of reduction in performance. While not necessarily pertinent to house construction, the work seeks to reduce costs of roofs of simple community facility buildings. The work was incorporated into the design of a prototypical health building described below.

- Timber Dimensions and Costs Data.
  Most economical timber dimensions and costs are given for specific uses such as purlins, studs, cladding, etc.

- Thermal Performance of Materials and Composite Construction.
  Initial investigation centers on roofs. For example, corrugated galvanized iron, the most commonly used roofing material, is being tested in combination with a number of locally available, cheap insulating material such as papyrus matting, bamboo, and sisal stems used as a cladding on the underside of the corrugated metal roofing. Other tests are being made on a sandwich panel of black polythene and papyrus matting.

- Cost Studies/Manual for Low Cost Construction.
  Data sheets are developed on low cost materials comparing costs and performance characteristics of different manufacturers' products. Raw cost of material is given as well as costs of material in place. For example, clay and cement tiles, now being produced, are compared with corrugated metal and asbestos sheets including comparisons of the costs of the complete roof system including roofing materials, supporting structure, etc. Information includes allowable spans, support, and attachment methods. Underway is a cost-performance study of windows and doors of various manufacturers. Cost-performance comparisons of walling materials in place has been completed. All elements of simple buildings will be covered and eventually the papers will be combined into a complete manual for construction of low cost houses. The aim is to develop a guideline document to serve as a working tool for local authorities in smaller towns, architects, small builders, and other individuals involved in low cost housing.

  In addition to technical data, financing information will be included such as sources of credit, interest rates and terms of loans.

- Simplified Sand and Charcoal Drip Filters.
  These filters have application in areas where treated reticulated water supply is not available.

- Investigation of Multrum Compositing Latrines.
  Modified improved multrum toilets will be installed and monitored.

- Study of Foreign Exchange Components of Secondary Imports Related to Materials.
  For example, the oil for energy requirement in cement block manufacture will be compared to the oil requirement in asphalt emulsified stabilized soil blocks.

- Study of the Institutional Framework and Building Process for Sites and Services Schemes.
  Surveys have been carried out in a number of projects. Included in a forthcoming paper will be some observations about the cost of building materials, labor, and the use of skilled and unskilled labor. Problems will be noted which have caused unexpected delays in implementation.

- The Kibera Experimental Housing Scheme.
  The project was undertaken at the request of the Ministry of Housing. The major aims of the scheme are:
  a) to minimize initial building costs by a phased construction of the houses, roads, sewerage system and water supply.
  b) to base the design on certain minimum standards such as an all-weather road to the house, basic sanitary facilities and a properly constructed roof.
  c) to allow for future improvements of the house in a way which

suits the occupants' financial situation and requirements.

d) to secure an acceptable environmental standard during the first years of the scheme when continuous construction is expected to take place. The basic structure will be the roofs which will be contractor built. Under the roofs, temporary infill will be allowed while self-help building activities will go on.
e) to interlink habitable rooms, out-door space and sanitary facilities in a way which allows subletting without causing inconvenience.
f) to base room dimensions on functional requirements.
g) to standardize structural components and roomsizes.

- Formulation of Guidelines for the Ministry of Housing and Social Services.
  A preliminary study underway analyzes the interrelationships between plot size, lot use, heights, and densities in urban low-cost housing.

- Monitoring Self-Help Activities Under New National Housing Corporation Guidelines.

PUBLICATIONS:

Foundations for Low Cost Houses.
J. Eygelaar, February 1976

For single-storey houses in the low cost sector considerable savings can be obtained by replacing the usual concrete strip foundations by trenches filled with hard core. This type of foundation is well suited for execution by unskilled self-help groups. The paper contains detailed cost calculations and graphs for concrete strip foundations and trench fill foundations, both for self-help construction and as contractor-built items.

The Future Planning of a Majengo-Masaku Swahili Village.
Marja C. Hoek-Smit, March 1976

The report is a detailed study of a traditional urban squatting area (Majengo) in Masaku Town and formulates planning guidelines aimed at a controlled improvement of the area. Recommendations are based on a study of legal, socio-economic, technical and environmental health aspects of the area. Where appropriate, the information obtained has been compared to data collected during similar surveys of a newly-built low income residential area in Masaku Town.

Roofing Tiles for Low Cost Structures.
J. Eygelaar, November 1975

As is shown in the HRDU paper, *Roof Structure for Low Cost Housing* (J. Eygelaar, 1975), locally manufactured roofing tiles compare

favorably with corrugated roof sheeting for small-span structures. To enable designers to make proper use of these local products, the essential data of 5 types of tiles manufactured in the Nairobi area are shown on a tabulated data sheet. Shapes, dimensions and fixing details are shown on sketch sheets.

African Traditional Architecture.
Kaj Anderson

A photographic and architectural survey of house types in Kenya. The book includes sections on traditional settlements and their historical background, architectural patterns of indigenous houses, ethnic groups, geographical features, house types, and materials and methods of construction.

Climatic Aspects of Design, Material Selection, and Construction Methods of Rural Housing.
J. Eygelaar, October 1975

A paper presented at the seminar on rural environment and housing in intertropical Africa, held at Butare, Republic of Rwanda in October 1975.

Housing By-Laws in the Kenya Building Code.
J. Eygelaar, September 1975

Building by-laws cover a large range of building types. The paper aims at a simplified systematic presentation of all clauses relevant to the planning, design and erection of houses as a first step towards an illustrated explanatory manual.

Design for Medical Building.
P.J. Mein, August 1975

A manual for the planning and building of health care facilities under conditions of limited resources. The manual contains design, construction and cost guidelines for the building of medical facilities in rural areas where architectural expertise is not readily available. The full range of architectural activity is covered from initial feasibility studies to supervision of the building work on site. The guiding principle throughout is that, for medical buildings, the expenditure of material, monetary and manpower resources should be reduced to the lowest level consistent with adequate and acceptable medical care.

Roof Structures for Low Cost Housing. Cost Comparison for Various Roofing Materials.
J. Eygelaar, April 1975

For a simple low cost shelter the cost of six roof structures (support structure plus roof covering) with different covering materials are compared. It is shown that although actual costs of covering materials and

structural requirements differ, the differences in the cost of the overall structure are minor, and create possibilities for a greater variety in roof choice for low cost structures.

Rural Medical Buildings in East Africa.
P.J. Mein, February 1975

Summarizes the problems involved in the design of health facilities in remote areas pointing out the lack of architectural input generally and design standards in particular. Recommends preparation of architectural data for use in the field, the more widespread distribution of technical personnel and the formulation of special design and construction standards for rural medical buildings.

Design for Climate.
C. Hooper, January 1975

Guidelines for the design of low cost houses for the climates of Kenya. An analysis of the impact of the different elements on house design. Division of Kenya into six climatic-comfort zones: Semi-Desert, Savannah, Cost, Lake, Highland and Upper Highland. Climatic description of each zone with climatic data sheets for representative locations. Guidelines for the design of low cost housing in each zone.

Roof Slopes for Low Cost Structures.
J. Eygelaar, January 1975

The paper suggests the abandonment of the common practice of indicating slopes in round number of degrees. The paper argues and exemplifies the introduction of simple slope ratios and suggests how these should be related to various roofing materials.

Cost of Metal Roof Sheeting for Low Cost Structures.
J. Eygelaar, November 1974

Types and sizes of metal roof sheeting manufactured in Kenya are varied. Manufacturers' price lists do not allow straight-forward cost comparison of the various types available. The paper contains dimensioned sketches of the various types and cost comparison tables for the products of the two major manufacturers.

Cost of Softwoods Related to Sawn Sizes.
J. Eygelaar, October 1974

Cost of Softwood per unit cubic measure (cubic meter) varies with the sawn size. Moreover, short lengths of timber are sold at lower unit prices than standard lengths. Planing charges do not relate to sawn sizes, therefore costs of planed sections show a different size-cost relation. The paper contains comparative cost-size tables and graphs for standard length timber, short lengths timber and for planned timber. Data is provided for the three main construction timbers: Cypress, Podo, and Cedar.

National Housing Corporation Rental Schemes.
Lucy J. Kamau, June 1974

A technical/user-reaction survey and analysis. Survey and analysis of a series of schemes, designed by the National Housing Corporation. The report covers eight different schemes. The houses are rental, one story, detached or semi-detached designed for single-family occupancy.

The Kibera Self-Help Scheme.
E. Lohman, April 1974

Plot size and plot use in an urban low-cost housing scheme.

Kibera New Village, Nairobi.
C. Hooper, March 1974

A selective appraisal of a courtyard housing scheme. This short report on a new housing scheme in Nairobi combines the results of user-reaction surveys and technical evaluations.

Kariobangi Experimental Timber Houses. User-Reaction, Construction, Kitchen Design and Climatic Performance.
C. Hooper, February 1974

The Kariobangi experimental scheme, which consists of 27 contrasting timber framed houses designed by architects in four different institutions, was built with the object of developing timber for use in urban housing. The report includes a user-reaction study, an appraisal of timber construction techniques used, an investigation into the design and use of kitchens and storage facilities, and an evaluation of the thermal performance of these light structured houses in Nairobi's climate paying particular regard to ventilation and performance of openings.

Pilot Rural Housing Schemes.
C. Hooper, January 1974

Note on visits to pilot Ministry of Housing projects. Commentary on user reactions and the construction. Some houses have timber frame walls with external plaster claddings.

Vacuum Sewage Disposal System.
C. Jurrjens, October 1973

As an advisory service to the Ministry of Housing, a short note has been prepared on the vacuum sewage disposal system 'Vacusan'(Electrolux) and its relevance in Kenya.

Cost Analysis of Laterite Building Blocks.
J. Eygelaar, 1973

A short note on a comparative (cost/technical) analysis of lime stabilized

blocks, concluding that because of an unfavorable price position, lime-stabilized blocks cannot compete with cement-stabilized blocks in Kenya.

Design of Foundations on Deep Black Cotton Soil.
J. Eygelaar, 1973

A short paper outlining the main principles as worked out for the National Housing Corporation. The paper forms the basis for future research related to live projects.

Prototypical sewerage Disposal System Design for Small Low Cost Housing Schemes on Deep Black Cotton Soil.
C. Jurrjens, April/June 1973

A short paper outlining the main principles and guidelines as worked out for the National Housing Corporation. The paper forms the basis for future research related to live projects.

Housing Policy Guidelines for African Countries.
N.O. Jorgensen, November 1972

This paper, which was requested by the U.N. Centre for Housing, Building and Planning, includes sections on general housing policy considerations, priorities, land, financing, administration, construction, training and research.

The 'Building-Flow' System Applied to Simple Low Cost Housing.
J. Eygelaar, July 1972

The paper outlines the present production of low cost houses in Kenya, identifies constraints and the possibilities of prefabrication. The paper suggests and evaluates the introduction of a flow system for low-cost housing in Kenya.

Site and Service Schemes, Analysis and Report.
P. Houlberg, N.O. Jorgensen, R. Steele, May 1971

This analysis of 12 existing and planned site and service schemes in Kenya was carried out on request by the National Housing Corporation in order to develop recommendations for the planning and operation of a large number of new schemes programmed.

Mathare Valley, A Case Study of Uncontrolled Settlement in Nairobi.
D. Etherton, N.O. Jorgensen, R. Steele, B.S. Thethy, N.M. Mulili, P. Patel, September 1971

A survey of the largest area of uncontrolled urban settlements in the outskirts of Nairobi. The report describes two surveys, one conducted in June 1969 and one in July 1970. The data collected covers the economic, physical, social and organizational aspects. The summary

and recommendations formed the basis for the Nairobi City Council's improvement plans implemented in the area.

Dwelling Unit in Public Low Cost Housing.
Vol. 1: Interim Analysis and Report
Vol. 2: Recordings
P. Houlberg, October 1970

In Vol. 1 it is attempted, through the analysis of existing dwelling types, to develop a critical method in the evaluation of low cost dwelling designs, and, within the limits given by the source materials, to establish guidelines for future developments and future research. Vol. 2 contains drawings in scale 1:100 plus relevant data concerning the 67 dwelling types selected for the study.

Improvable Minimum Standards.
F. Jorgensen and L. Menezes, May 1969

An alternative approach to the concept of housing standards is attempted through the examination of existing standards. It is suggested that fixed measurements in standards be related more to activities rather than to rooms and persons.

Saving Habits of Low Income Families With a View to Housing.
N.O. Jorgensen, November 1968

This paper reports the findings of a pilot survey of 68 households. It is essentially a consumer survey with special emphasis on what people spend and want to spend on housing in the widest sense.

Financing of Housing in Kenya; Some Major Issues.
N.O. Jorgensen, November 1976

The paper deals with the economic considerations involved in the formulation of a housing policy in Kenya. The effects of increased investment in housing on such fields as employment, price level, balance of payments, etc. are discussed. Suggestions for how this increased investment can be brought about are also included.

MINISTRY OF WORKS, MATERIALS SECTION
BOX 30043
NAIROBI, KENYA
N.B. Onduto, Chief Materials Engineer
W.J.S. Campbell, Chief Quantity Surveyor
P.T. Wignhamer, Timber Structural Advisor

KE/3

The materials section performs routine testing of materials used in public construction. Test results are not synthesized or published with the exception of an annual confidential report on the performance of paints.

A project on the application of timber in trusses was recently completed, establishing standards for trusses used in public construction. A series of standard trusses for spans of 5 to 40 meters with pitches of 15^{o} to 40^{o} were designed.

CONSORTIUM RESEARCH AND DEVELOPMENT PROJECT KE/4
DIVISION OF ECONOMIC AND SOCIAL PROGRAMMES
UNITED NATIONS ENVIRONMENT PROGRAM (UNEP)
NAIROBI, KENYA
N.O. Jorgensen, Head, Human Settlements Section

The objective of this project is to promote research and demonstration in the field of human settlements by creating a network of leading institutions dealing with human settlements technology and by assisting these institutions in carrying out consortium type research and demonstration projects consistent with UNEP's concept of human settlements as ecosystems.

The present plan is to organize the network based on subregional centers serving as focal points for carrying out the research and demonstration programs. Nearly three hundred institutions in Africa that deal substantively within the area of human settlements technology have been identified. The network of institutions is organized into six African subregions. A leading institution in each subregion will coordinate the efforts of each involved institution within the subregion to assure that the individual contributions form a coherent result. Cooperation on a subregional basis is expected to gain the advantages of pooling resources and avoiding duplication of research efforts.

The focus of the program will be on the following five technological aspects selected for their direct impact on slum and squatter settlement improvement programs:

1. Building materials, especially those using least energy.
2. Water supply and saving devices.
3. Waste management and sewage disposal.
4. Renewable sources of energy.
5. Urban transportation.

A pilot project to activate the African network is under consideration for the Sudan, with the National Building Research Station serving as the subregional focal point. The project involves the design and building of a community of 200 houses for low-income families in Khartoum using "asfadobe" bricks and introducing innovative environmental approaches.

Lesotho

Lesotho Housing Corporation Ltd.
P.O. Box 460
Maseru

Ministry of Public Works and Communication
P.O. Box 20
Maseru

Town and Country Planning Section
Ministry of the Interior
P.O. Box 174
Maseru

Liberia

LI/1 Ministry of Local Government, Rural Development
and Urban Reconstruction
Private Mail Bag
Monrovia

Ministry of Public Works
Lynch Street
Monrovia

SOILS AND MATERIALS LABORATORY UNIT LI/1
DEPARTMENT OF PUBLIC WORKS
MONROVIA, LIBERIA

The major work of the Unit is routine testing and analysis of soils and building materials for highway and building construction.

CURRENT PROJECTS:

- Experimentation in the Use of Cement in Highway Base Stabilization.
- Mix Design for Stabilization of Silty Clays and Granular Soils for Housing Construction.

Madagascar

Bureau de Recherches Géologiques et Minières
B.P. 458
Tananarive

Laboratoire National des Travaux Publics et du Bâtiment
B.P. 1151
Tananarive

Service de l'Architecture, de l'Urbanisme et de l'Habitat
Ministère de l'Aménagement du Territoire
B.P. 233
Tananarive

Service de l'Architecture, de l'Urbanisme et de l'Habitat
Ministère des Travaux Publics
Tananarive

Caisse Nationale de Prévoyance Sociale
B.P. 233
Tananarive

MA/1 Societé d'Equipement Immobilier de Madagascar
26, rue de Liège - B.P. 66
Tananarive

SOCIETE D'EQUIPEMENT IMMOBILIER DE MADAGASCAR MA/I
26 RUE DE LIEGE, B.P. 66
TANANARIVE, MADAGASCAR

An objective of the organization is the development of low-cost housing in urban and rural areas.

CURRENT PROJECTS:

- Prefabrication of Mobile Wooden Houses for People Engaged in Reforestation in the Haute Mangoro Region.

- Research in Building Materials, Architectural and Structural Problems, Termite Resistance and Rot-Proofing, and Expanded Use of Bamboo in Low-Cost Housing in Varying Climatic Conditions in Madagascar.

Malawi

Malawi Housing Corporation
P.O. Box 414
Blantyre

Town Planning Office
Ministry of Works and Supplies
P.O. Box 279
Lilongwe

Mali

Laboratoire National des Travaux Publics
Rue du Lt Fadiala Keita
Bamako

Service de l'Habitat, de la Construction et de l'Urbanisme
Ministère des Travaux Publics
Bamako

Mauritius

Central Housing Authority
Port Louis

Mauritius Housing Corporation
Edith Cavell Street
Port Louis

Ministry of Housing, Lands and Town
and Country Planning
Port Louis

Mozambique

Laboratorio de Enghenaria de Mozambique
Av de Mozambique CP 1918
Can Phumo

Ministry of Public Works and Housing
Lourenco Marques

Niger

Bureau de Recherches Géologiques et Minières
B.P. 458
Niamey

Faculté des Sciences
University of Niger
Niamey

Ministère des Travaux Publics, des Transports et de l'Urbanisme
Niamey

Nigeria

Department of Geography
University of Ibadan
Ibadan

NI/2 Faculty of Engineering
University of Lagos
Lagos

Faculty of Environmental Design
University of Lagos
Lagos

Faculty of Science and Technology
Admadu Bello University
Zaria

Faculty of Science and Technology
University of Ibadan
Ibadan

Faculty of Science and Technology
University of Lagos
Lagos

Faculty of Science and Technology
University of Nsukka
Nsukka

Federal Building Research Institute
P.O. Box 212
Zaria

Federal Department of Forest Research
P.M.B. 5054
Ibadan

Federal Ministry of Economic Development
Central Planning Office
Independence Building
Tafawa Balewa Square
Lagos

Federal Ministry of Works and Housing
Tafawa Balewa Square
Lagos

Kaduna State Housing Authority
Kaduna

Materials Testing and Research Division
Federal Ministry of Works and Housing
P.M.B. 12635
Ikoyi
Lagos

Ministry of Works and Lands and Transport
Port Harcourt
River State

Nigeria Housing Development Society Ltd.
11 Breadfruit Street
P.O. Box 2078
Lagos

NI/I Department of Estate Management
University of Ife
Ile-Ife

DEPARTMENT OF ESTATE MANAGEMENT
UNIVERSITY OF IFE
ILE-IFE, NIGERIA
Dr. Kunle Ade Wahab, Acting Head

Research focuses mainly on building materials, housing technology, construction economics, and housing policy in Nigeria, with a particular concentration on housing for low-income people.

CURRENT PROJECTS:

- Stabilization of Clay for Walls.
  Development of machinary for stabilizing clay and other granular material. Development of a mechanical process for compression of material.

- Development of Appropriate Technology for Production of Low-Cost Housing in Nigeria.

- Relationship Between Technology and Employment in Housing Provision.
  This study is funded by the International Labor Organization.

- Business Organization and Procedure in West African Construction Industry.

- Productivity Studies in House Painting.

- Traditional Building Techniques in Western Nigeria.

- The Problems of Indigenous Contractors in Nigeria.

- Service Performance of Residential Buildings.

- Housing Provision and Standards.

- Shelters for Rural Farmers - Osoya Villages.

- Housing Needs and Development.

- Design and Construction of Low-Cost Experimental Middle-Income and University Staff Housing.

- Design and Construction of Low-Cost Housing for Essential Farm Workers.

PUBLICATIONS:

Construction and Housing Market in Nigeria and a Suggested Housing Policy.
K.A. Wahab

The work is a doctoral thesis by Dr. Ade Wahab, entitled "A Suggested Rationalization for the Use of Construction Resources to Meet the Housing Requirements of Nigeria". The object of the work is to provide a policy framework for more effective use of construction resources to improve the supply of housing accommodation in Nigeria. Some of the subjects dealt with are construction resources--land, capital, materials, manpower, management, space and construction standards, design process, "percentage completion", government encouragement of home ownership, construction industry, and methodology for measuring aggregate housing supply. Some housing projects are examined.

Nigeria and Her Housing Problems - Searching for Solutions.
"Construction in Nigeria", Vol. 6, No. 11.
K.A. Wahab, 1972

Maintenance Surveys for Housing Performance.
"Construction in Nigeria", Vol. 7, No. 7.
K.A. Wahab, 1973

Standards for Good Home Design in Nigeria.
"Housing", (U.K.) Vol. 8, No.5.
K.A. Wahab, January 1974

A Housing Policy for the Urban Areas of Nigeria.
"Ekistics" (Greece) Vol. 38, No. 244.
K.A. Wahab, July 1974

Meeting the Housing Needs of Nigeria.
"Proceedings of the Third International Symposium on Lower Cost Housing Problems", Concordia University, Montreal, Canada
K.A. Wahab, May 1974

The Influence of Value Judgement on Housing Costs in Nigeria.
"Proceedings of the Third International Symposium on Lower Cost Housing Problems", Concordia University Montreal, Canada.
K.A. Wahab, May 1974

Prescription for an Efficient Construction Industry.
"Construction in Nigeria" Vol. 6, No. 12.
K.A. Wahab, 1972

Exploring Appropriate Housing Technology for the Developing Countries.
"Estate Management Society Journal" Vol. 3, No. 3.
K.A. Wahab, 1974/75

Scientific Rationale for Standards and Criteria Specification in the Provision of Shelter in Developing Countries in Africa.
K.A. Wahab and M.A.O. Ayeni, 1975

The Uses of Local Building Materials and Effects on Cost.
"Proceedings of the Third Annual Conference of the Nigerian Institute of Quantity Surveyors", University of Ibadan.
K.A. Wahab, June 1974

The Potentials of Clays for House Building.
"Proceedings of the Second International Conference on Housing - Association of Housing Corporation of Nigeria", Ibadan.
K.A. Wahab, April 1975

Strategies for Low-Cost Housing for the Developing Countries.
"Housing-Journal of the Institute of Housing Managers", U.K.
K.A. Wahab, 1975

FACULTY OF ENGINEERING
UNIVERSITY OF LAGOS
LAGOS, NIGERIA
Dotun Adepegda, Professor

Research is concentrated in the use of lateritic soils and laterite in building materials.

CURRENT PROJECTS:

- Stabilization of Lateritic Soil for Brick Making.
- Development of Ceiling Boards from Laterite.
- Development of Insulating Building Blocks.
- Development of Laterized Concrete Using Laterite Fines in Lieu of Sand.

PUBLICATIONS:

A Comparative Study of Normal Concrete with Concrete which Contained Laterite Instead of Sand. "Building Science" Vol. 10
Dotun Adepegda

The Effect of Water Content on the Compressive Strength of Laterized Concrete. "ASTM Journal of Testing and Evaluation" Vol. 3, No. 6
Dotun Adepegda

Structural Strength of Short Axially Loaded Columns of Reinforced Laterized Concrete. "JTEVA" Vol. 5, No. 2.
Dotun Adepegda, March 1977

Rwanda

Faculté de Technologie
Université Nationale de Rwanda
Kigali

Service de l'Urbanisme et des Habitations
Ministère des Travaux Publics et de l'Equipement
Kigali

Banque Rwandaise de Développement
Kigali

Sénégal

African Institute for Economic Development and Town Planning
B.P. 3186
Dakar

Faculté de Technologie
Université de Dakar
Dakar

Laboratoire du Bâtiment et des Travaux Publics
B.P. 189
Dakar

Ministère du Développement Industriel et de l'Environnement
Dakar

Ministry of Public Works, City Planning and Transportation
Dakar

Office d'Habitation de Loyer Modéré
Dakar

Sierra Leone

Faculty of Engineering
University of Sierra Leone
Freetown

Ministry of Development and Economic Planning
Ministerial Building
George Street
Freetown

Ministry of Housing and Country Planning
Freetown

Ministry of Works
New Englandville

SL/I Advisory Services in Technology Research and Development
Department of Engineering
Forah Bay College
University of Sierra Leone
Freetown

ADVISORY SERVICES IN TECHNOLOGY RESEARCH AND DEVELOPMENT SL/1
DEPARTMENT OF ENGINEERING
FORAH BAY COLLEGE
UNIVERSITY OF SIERRA LEONE
FREETOWN, SIERRA LEONE

The Division (ASTRAD) is involved in research on low-cost building materials and methods particularly locally available materials for general construction and for import substitution.

PUBLICATIONS:

Investigation into the Suitability of Crushed Laterite Rocks for Use as Coarse Aggregates for Concrete.
K. Thomas and W.E. Lisk

The paper deals with the problems, limitations and potentials of the material. Physical properties are presented, attention is drawn to the need for controlling standards of concrete products made of this material, and advice is given for obtaining the best results.

A Study of Some Timbers in Sierra Leone and the Determination of Some of Their Elastic Properties.
W.E. Lisk

The project aims mainly at determining some of the elastic properties of some of the timbers found in 'Forest Reserves' and Protected Forests' in Sierra Leone. The samples in these investigations include: Gessi Main (Daniellia Ogea), Hendui (Lophira Alata), Yais (Terrietia Utilis), Gofelly (Mismusope Heckilli), Sakpei (Berlina Curfusa), Bundui (Nauclea Diderrichii), and Njelei (Entradrophagina Sp.).

The strength properties determined were the moduli of elasticity in bending, compression parallel and perpendicular to the grain, the modulus of rupture, the modulus of rigidity, the maximum compressive strength parallel to the grain, the maximum compressive strength perpendicular to the grain and the maximum shearing stress parallel to the grain.

The Use of Laterite for Earthcrete Construction.
"Journal of Engineering Education and Research in Tropical Africa"
Vol. 2, No. 1
J.F. Elliott and C.A. Wright, 1976

Investigations were carried out on a sandy lateritic soil termed beach laterite to determine its suitability for earthcrete construction by testing stabilized block samples for compressive strength and durability. Block samples of different cement contents and moisture contents were manufactured in a CINVA-Ram machine and cured under two different conditions. The blocks were then tested for compressive strength and

durability, and the effects of differences in percentage composition and curing procedure on compressive strength were determined. A modest but comparative strength/cost analysis of the blocks was then made with respect to sandcrete blocks to determine the economic advantage of earthcrete blocks manufactured with beach laterite.

The Design of Mixes with Special Grading Characteristics.

This work investigates materials possessing satisfactory properties for the manufacture of good quality concrete.

A Critical Appraisal of the Methods of Assessing the Engineering and Other Potential Uses of Tropically Weathered Soils.
B. Chinsman and N. Pratt, 1976

This paper presents results of an investigation which seeks to establish that inappropriate techniques of evaluation and assessment may be responsible for the limited uses so far found for the red lateritic soils which occur abundantly in Africa.

Soil-Cement Blocks; Effect of Soil Composition on Durability and Other Properties.
R. Sperling

Soil-Cement Blocks; A Field Test for Suitable Mix Proportions.
R. Sperling

Somalia

Ministry of Housing and Coordination
P.O. Box 530
Mogadiscio

Ministry of Public Works
Mogadiscio,

National Housing Agency
P.O. Box 530
Mogadiscio,

Sudan

Department of Architecture
University of Khartoum
Khartoum

Faculty of Engineering
University of Khartoum
Khartoum

Ministry of Construction and Public Works
P.O. Box 308
Khartoum

Ministry of Housing and Social Services
Khartoum

Ministry of Local Government, Housing and
Community Development
P.O. Box 597
Khartoum

National Council for Research
P.O. Box 2404
Khartoum

Scientific and Technological Research Affairs
Higher Council for Research
Khartoum

SU/1 National Building Research Station
University of Khartoum
Box 35
Khartoum

SU/2 Regional Educational Building Institute for Africa
Box 1720
Khartoum

NATIONAL BUILDING RESEARCH STATION
UNIVERSITY OF KHARTOUM
BOX 35
KHARTOUM, SUDAN

The primary function of the Station is to carry out and promote research in design, construction and performance of buildings in the Sudan and to stimulate the application of research results and technological achievements in the building industry.

Research encompasses the following areas:

- Building materials and construction methods
- Building design, performance, economics and operation
- Building regulations, codes and standards
- Environmental studies
- Urban and rural planning
- Finance

Building materials research is performed by separate organizational sections dealing with concrete, cement, lime and gypsum, ceramics, and soil mechanics and foundation engineering. Increased activity in the timber research and environmental design is anticipated. The work of the sections covers aspects such as materials resources, production technology, materials testing, design behavior, and regulations, standards and codes of practice.

Publication and dissemination of information within the Sudan and internationally are considered important activities. The Station acts as a deposit center and library for building research documentation. Training courses are conducted for personnel in the building industry.

CURRENT PROJECTS:

Studies in:

- Problems of Concreting in Hot-Dry Regions.
- Use of Seawater for Mixing and Curing of Concrete in the Port Sudan Area.
- Production and Use of Cement Blocks.
- Use of Lime in Earth Stabilization for Roads and Buildings.
- Manufacture and Use of Gypsum.
- Improvement and Development of the Burnt Clay Brick Industry in the Sudan.
- Strength of Fissured Clays.
- Behavior of Imported Building Materials in the Sudan.
- Use of Bored Pile Foundations for Light Structures.
- Measurement of Swelling Pressure.
- Thermal and Insulating Properties of Local Building Materials.
- Influence of Climatic and Social Conditions on Traditional House Design in the Sudan.
- Design of Houses for Low-Income Families.

NATIONAL BUILDING RESEARCH STATION
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- Measurement of Swelling Pressure.
- Thermal and Insulating Properties of Local Building Materials.
- Influence of Climatic and Social Conditions on Traditional House Design in the Sudan.
- Design of Houses for Low-Income Familes.

- Surveys for Town Planning of Khartoum, Khartoum North and Omdurman.
- Development of a Building Materials Manual.

PUBLICATIONS:

Survey of the Clay Brick Industry in the Sudan.

Building with Rammed Earth.

Climate of the Sudan.

Solar Heat Control of Buildings.

REGIONAL EDUCATIONAL BUILDING INSTITUTE FOR AFRICA SU/2
BOX 1720
KHARTOUM, SUDAN

While the focus of the Institute is assistance in the planning and execution of educational building programs, aspects of the Institute's activities have application in housing. Research on improving school building design aims at achieving an optimum standard in different climatic and soil conditions and has included:

- Research in Soil Stabilization.
- Research in the Use of Wood in Roofing.
- Design and Development of Prototypes for School Buildings of Simplified Design Using Local Materials and Labor and Self-Help Construction Methods.
- Surveys of School Building Problems Outside the Sudan.
- Development of School Building Prototypes for Mali and Sudan.
- Development of Pilot Projects in the Ivory Coast and Somalia.

The research on soil stabilization and the use of wood in roofing is carried out in cooperation with the National Building Research Station of the University of Khartoum.

The Institute serves as a regional documentation center and disseminates its own work through publication of reports and studies and through training courses and seminars.

Tanzania

Faculty of Science
University of Dar es Salaam
Dar Es Salaam

Ministry of Communication and Works
P.O. Box 9144
Dar Es Salaam

Ministry of Lands, Housing and Urban Development
P.O. Box 9132
Dar Es Salaam

Ministry of Regional Administration and
Rural Development
Mozagoro Road
P.O. Box 2676
Dar Es Salaam

National Housing Corporation
P.O. Box 2977
Dar Es Salaam

Tanzania Housing Bank
P.O. Box 1723
Dar Es Salaam

TA/1 Environmental Sanitation Research Project
Box 1588
Dar Es Salaam

TA/2 National Housing and Building Research Unit
Ministry of Lands, Housing and Urban Development
Box 9344
Dar Es Salaam

ENVIRONMENTAL SANITATION RESEARCH PROJECT TA/1
BOX 1588
DAR ES SALAAM, TANZANIA
Professor W. Kilema, Project Director
Uno Winblad, IDRC Resident Advisor

RESEARCH PROJECT IN ALTERNATIVE WASTE DISPOSAL METHODS

PURPOSE

The purpose of this project is to develop a system for on-site disposal of body wastes and kitchen refuse with special reference to conditions in villages and peri-urban areas in Tanzania.

Sponsors and Staff

The project is jointly sponsored by the Tanzania National Scientific Research Council and the International Development Research Center. Project Director is Prof. W. Kilema, Faculty of Medicine, University of Dar es Salaam. The research staff consists of a senior health officer, a laboratory technician and an IDRC resident advisor, plus part-time consultants in the fields of microbiology, soil and sociology.

THE PROJECT

The project, involving the testing of more than a dozen types of compost latrines in three Tanzanian villages and a squatter area near Dar es Salaam, was started in July 1975. The first test units were constructed in November/December 1975. Three basic types of compost latrines are being tested in experiments with 60 household-size units:

Discontinuous Type (Pit Latrine, R.O.E.C.)
A discontinuous type is one in which a new latrine is built when the first is full. These toilets are expected to last for several years. Normally they do not allow for any recovery of waste as humus. In these villages, two of the four discontinuous toilets tested allow for ground soakage. The other two do not. Two contain only excreta while in the other two excreta is combined with grass or household refuse.

Alternating Types (Gopuri, Sopa Sandas)
Toilets have two pits or vaults which are used alternatively, each one normally for a period of four to eight months. When the first pit is full, it is closed and the second one used instead. When the second is full, the stabilized compost is removed from the first, which is then used again. The two alternating models being tested are of Vietnamese origin and differ in providing or not providing for ground soakage.

Continuous Types (Multrum)
The seven continuous types being tested are simplified variations of the Swedish multrum or humusdrum, into which grass or straw is put as well as excreta. They can be used without interruption as

the accumulation in the vault moves by gravity along a sloping floor and is removed at the lowest point after about six months of composting. With the use of twigs or air conduits the system is made aerobic in order to reduce the problems of smell and flies and to facilitate evaporation. The seven models vary in angle of sloping floor (18°, 25° or 30°) and in whether they are made aerobic by using twigs or a conduit or left anaerobic.

Participant households are instructed in the proper use and maintenance of the latrines by the health officer attached to the project.

The project has also been concerned with cultural questions. A social survey was carried out in the fifty-six households concerned, fourteen in each village or settlement, to discover what taboos and habits existed in the use of latrines. Technical studies have concentrated on design, construction and cost of the toilets. Medical studies are concerned with the disposal of the output and the risk of faeces-born diseases. Samples are taken by the health officer and sent for laboratory analysis at the Faculty of Medicine, University of Dar es Salaam, to test for the survival of pathogens. Checks are regularly made on the misuse of toilets and on problems of fly breeding and odors.

PRESENTATION OF RESULTS

It is the intention to present the practical results of this project at a series of seminars and in a manual to be published in Swahili and English. The final report is scheduled for January 1978.

NATIONAL HOUSING AND BUILDING RESEARCH UNIT
MINISTRY OF LANDS, HOUSING AND URBAN DEVELOPMENT
BOX 9344
DAR ES SALAAM, TANZANIA
O. Birkeland, Director
Z. Poonja, Chief, Materials Research Section

The National Housing and Building Research Unit (BRU) was established as a division in the Ministry of Lands, Housing and Urban Development in 1971 with support from the Norwegian Agency for International Development (NORAD). NORAD has provided expatriate research staff and grants for laboratory buildings, equipment, and staff housing.

The main goals of the Unit are:

- To improve use of local materials and local technology in building, to increase the durability of materials and structures and to improve hygenic conditions.
- To develop house designs which are in accordance with traditional settlement patterns, climatic conditions, family structure and culture, and with the preferences of the Tanzanian people.
- To perform research on production and cost aspects of construction in general and low-cost housing in particular.

BRU at present concentrates most of its work on housing in rural areas, though some projects concerning urban housing are also undertaken. Many investigations are valid both for rural and urban housing.

The Unit consists of a Technical Section, a Building Section, and a Human Requirements Section. An information Section is being established. Dissemination of information in useable form to those involved in low-cost housing construction is considered an important function of the Unit.

Earlier work centered on material development and utilization. This work continues, but current and future projects focus on economic and cost aspects of materials and housing improvement of on-site construction efficiency, cataloguing material sources and availability, formulation of design guidelines and building regulations, development of unit designs and plot layout, studies of traditional buildings, and user reaction analyses. The design and construction of prototypes based on the Unit's research findings will be a major future emphasis.

CURRENT PROJECTS:

Technical Section

Priority is being given to:

- Utilization of locally available materials. The aim of the research

is both to reduce the importation of materials and to reduce the transporting of materials over long distances within the country.

- Preparation of an inventory of building material resources in Tanzania by identifying the location and capabilities of suitable materials.

- Development of structures utilizing these materials.

Projects

- Properties of Blocks and Bricks
  The aim is to investigate strength and durability characteristics of a number of walling materials including mudblocks, soil-cement blocks, sand-cement blocks, concrete blocks, and burnt clay bricks. Resulting information and guidelines for use will be published.

- Compressive Strength of Walls Including Resistance to Buckling
  The aim is to investigate the connection between the strength of soil-cement blocks and mudblocks and the strength of walls made of these blocks. Tests on full-scale walls will be made in order to arrive at allowable loads. The report on the results of tests will include recommended dimensions of walls.

- Surface Treatment of Exterior Walls
  The investigation seeks to develop inexpensive surface treatments to protect mud walls and mud and pole walls against weather and to provide an inside surface treatment which is easy to clean. Test walls have been built and various surface treatments have been applied. Early results indicate that a lime-soil mortar of a 1:10 ratio of a few millimeters thickness provides good results.

- Soil Stabilization
  Laboratory investigations are underway in exploring lime stabilization of Tanzanian lateritic soil.

- Roofing Materials
  Development of local material for roofing is considered an unsolved problem. The most common roofing materials are thatch and imported corrugated sheets of iron and aluminum. Work is in progress to develop clay roofing tiles which can be placed on poles as purlins. Studies to improve thatched roofs are also being made.

- Burnt Clay Products
  Small permanent field kilns for burning bricks and roofing tiles are being developed.

- Gypsum Boards
  Possibilities are being studied of making boards for ceiling and wall cladding of waste gypsum from fertilizer factories reinforced

with waste sisal. Cleaning the gypsum appears to be simple and the boards appear to have good properties.

- Building Materials Resources
  Maps for each region of the country are being prepared which will describe the availability of clay, limestone, and soil suitable for stabilization.

- Building Regulations and Specifications
  Building regulations and specifications now in force are obsolete and include many references to British standards and imported materials. Appropriate regulations and master specifications for maximum use of local materials are being developed.

- Intermediate Technology
  In focusing on the special problems of rural housing, attention is being given to improving construction output through technologies appropriate to the non-urban situation where certain tools and equipment common in urban areas are not available. This work includes modification of the CINVA-Ram block-making machine for Tanzanian use, and the development of tools and equipment for the small-scale builder which can be produced locally by the users and operated by hand. Examples are wheelbarrows and simplified level-setting devices.

Building Economy Section

The Building Economy Section performs research on production and cost aspects of construction in general and low-cost housing in particular. The basic intention is to investigate possibilities of increased capacities in the local building industry, better capacity utilization, higher productivity, and lower cost. Special emphasis is placed on investigation of possibilities of import substitution by development of local resources and technologies. An important task of the section is to provide economic data to the other sections.

The Section has concentrated on four fields of work.

- Economic-statistical analyses of the housing and construction sectors.
- Building cost analyses including cost calculations and comparisons of alternative building technologies.
- Site management and productivity including planning methods, time consumption, and cost control.
- Development of small-scale contracting organizations. Early work indicates that great potential exists for expansion of building capacities, increased productivity and reduction of building costs. A main constraint to development is lack of experienced personnel in planning and management positions. Priority will be given to education and training of foremen, site managers and building technicians.

Projects

- Housing and Construction in the Tanzanian Economy
  Economic-statistical data will be compiled to provide a comprehensive picture of the housing and construction sectors and their role in the national economy. An important aspect is the identification of development problems and future development possibilities. Economic-statistical models of the construction sector in Tanzanian economy have been developed. Preliminary results were presented at seminars arranged by the National Scientific Research Council in November 1975 and by the Economic Research Bureau of the University of Dar es Salaam in January 1976.

  Analyses of sectoral development and construction requirements are presently being carried out. Investigations of construction capacities are planned.

  The report will provide information for housing and construction policies and plans.

- Building Cost Index
  The Building Economy Section is in general responsible for cost analyses and cost calculations of the technical solutions and designs developed by the other sections of the unit. An important part of this work is providing cost comparisons between alternative materials and constructions.

  An earlier investigation compares costs of four building technologies: mud, pole and plaster; sand-cement blocks; concrete blocks; and soil-cement blocks. Another investigation performed in 1975 compared costs of one-story houses and multistory flats, indicating that blocks of flats are far more expensive and import consuming than one-story houses.

  A building cost index is being developed for various materials and constructions with unit costs. The index will be published quarterly.

- A Survey of the Tanzanian Building Industry
  The aim of this study is to carry out an up-to-date survey of the conditions and problems of the building industry for use in formulation of building policies and plans. The study will be integrated with a study of the building industry planned by the Ministry of Works.

- Planning, Organization and Productivity of On-Site Production
  Necessary increase in the capacity of the construction sector and reduction of building costs are inhibited by low efficiency on building sites. Though unit labor costs are low, total labor cost can be considerable due to low utilization of labor resources.

The project aims at higher productivity and lower costs by the introduction of simple planning, management and cost control systems and new production methods and tools. Sites have been visited, production and consumption figures have been collected, and a working report on the experiences has been prepared. The experiences and recommendations will be published in a pamphlet. Methods suggested will be tested on a number of sites, and seminars and courses on site planning and management will be arranged.

- Organization of Building Cooperatives
  Organization of fundis into building cooperatives to serve as small-scale contractors has been considered a possibility for expanding the capacity of the building industry.

  A survey of established cooperative societies of fundis was carried out in Dar es Salaam, Arusha, Kilimanjaro, Tanga and Mara regions. The investigations dealt with organizational aspects, project information, building materials, management skills, site management and financial aspects.

  A working report based on this information is being developed.

Human Requirements Section

The Human Requirements Section investigates qualitative housing needs in Tanzania. Housing design requirements are surveyed including number, dimensions and functions of rooms needed for families of different sizes, location of rooms within houses, sizes of windows, doors, etc. required. Data is provided to the Technical Section to enable human requirements to be built into the design of houses and components.

Background information is collected, including statistical information on settlement patterns, climatic conditions, health hazards, family structure and family life, house usage, and opinions and preferences of users regarding their houses. This information is transformed into general design or planning recommendations, design guidelines, mininum requirements, and building regulations.

The section also takes part in evaluation of demonstration houses built.

Projects:

- Housing in Sites and Services Projects
  This project consists of three parts:

  1. A study conducted through the use of questionnaires into the needs and preferences of the target population in the World Bank financed sites and services project in Dar es Salaam. This information will be used in the formulation of design criteria for house types for low-income urban housing. The survey

will focus on house planning, house building, and house use, and will consider factors that influence the planning of the house, how building materials are acquired, what the house building skills of the people are, and the aspects on which people need help and information.

The study is scheduled to be completed by the end of 1977.

2. The design of house types for the target population groups. Three house types are developed, each with three stages of development so that a small house may be built initially and later extended when the owner can afford it. The houses expand from $45m^2$ to $80m^2$.

3. Building of demonstration houses. All three stages of one of the designs will be built.

- Guidelines for Design of Rural Low-Cost Housing
  The recommendations formulated in this project are based on accumulated experience from other projects, observations from study tours to several regions, information in available literature on housing in Tanzania, and on studies of similar work done in other countries. The work concentrates on the functional aspects of design. A chapter on the technical aspects of materials and constructions is included as well as recommendations concerning plot planning.

  The aim has been to make the recommendations useful and understandable to as many as possible concerned with housing problems. Primarily, however, the recommendations are written for those working in the rural construction and housing units in the districts. The guidelines will be illustrated with drawings and translated into Swahili.

- Health and Housing
  This project aims at bringing together existing information to produce a practical handbook on general health considerations and the practical physical remedies to promote sanitary rural housing, particularly in Tanzania.

- Climate and Design in Tanzania
  The aim of the project is to present a handbook which will provide guidelines for designers, engineers, students, and others on climatic considerations for the design and construction of housing and other buildings. The handbook will contain an examination of the climate zones, with detailed design and construction recommendations for each zone. It will consider aspects such as climate, climate control, comfort, and health.

- Annual Housing Statistics
  This study will include information on building materials, house types, and fundis within the building sector.

- Study of Rural Housing in Dodoma District
  The traditional Gogo house has many advantages in that it is very well suited to the climatic conditions. The main problems are the structure, roof materials, and room height. This project studies the traditional Gogo house with the purpose of suggesting improvements in design, materials and construction.

- Design of House Types for Village Management Technicians
  As part of the national rural development program, 1,500 houses for village technicians will be built in all districts, aided by a loan from the World Bank. The Unit has developed ten prototype house designs based on local traditions and climatic conditions. Houses are to cost around $2,000 (1976).

Information Section

The Unit attempts to disseminate the results of research in forms which make the information useable by a wide audience. Dissemination of information to rural areas is a priority goal. Reports present results of investigations. Pamphlets, data sheets, and posters provide practical information on building material production and use, and on building design and construction. Some material has been translated into Swahili, and the Unit expects to publish all future practical information in Swahili.

Seminars and training courses are conducted for government personnel involved in the building aspects of the National Resettlement Program.

PUBLICATIONS:

Reports:

Rural Housing in Tanzania; Report on a Prestudy
K.I. Edvardsen and B. Hegdal, 1972

Lateritic Soil-Cement as a Building Material
J.P. Moriarty and O. Therbildson, 1973

Economic Comparison of Building Materials; Survey of Dar Es Salaam
J.P. Moriarty and O. Therbildson, 1973

Pamphlets:

Better Burnt Bricks
T.I. Svare, 1974

Minimum Requirements for Permanent Single Story Houses
T.I. Svare, 1974

Guidelines for the Design of Rural Low Cost Houses
Christer Svard

To Choose Timber for Building
Nils Lundborg

Tanzania Building Products Catalogue

Data Sheets:

Climate in Tanzania; Simple Advice on Housing Construction
K.I. Edvardsen, 1973

Soil Mud Blocks
T.I. Svare, 1975

Burnt Clay Bricks; Hand Production-Burning in Field Kiln
K.I. Edvardsen, 1973

Soil Stabilization General
T.I. Svare, 1974

Stabilized Soil Blocks
T.I. Svare, 1974

Household Requirements; Main Household Activities and Facility Needs
B. Hegdal, 1973

House Layout; Three Sectioned House, Total Area 123.1m^2
B. Hegdal, 1973

House Layout; Total Area 70.2m^2
B. Hegdal, 1973

Working Reports:

Implementation of Reasonable Methods for Preservation of Wooden Poles
Ebrahim, A.A.N. & Kristiansen, 1972

Earth Wall Construction in Tanzania
P. Moriarty

The Producivity on Building Sites
F. Langkass

Togo

Building and Housing Center
B.P. No 2130
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Lomé

TO/1 Centre de la Construction et du Logement à Cacavelli
B.P. 1762
Lomé

CENTRE DE LA CONSTRUCTION ET DU LOGEMENT A CACAVELLI TO/1
B.P. 1762
LOME, TOGO

The major emphasis of the Centre's Activities is on the utilization of local materials and improved building techniques for low-cost housing in Togo.

The Centre engages in a wide range of research and project development activity, including:

- Research in sources, characteristics, production and utilization of indigenous building materials.
- Development of production centers and industrial installations for development of local materials, by-products and building components.
- Research and development of new construction methods and improvement of traditional techniques.
- Research in the improvement of house construction and the housing construction industry.
- Development of demonstration projects utilizing the Centre's research.
- Organization of training courses, seminars and demonstrations of building techniques.
- Quality control monitoring of building material production throughout the country.

CURRENT PROJECTS:

- Geological Surveys of Non-Metallic Raw Materials for Buildings.
- Earth Stabilization Using Cement and Lime.
- Manufacture of Lime from Dolomitic Rock.
- Lightweight Panels for Ceilings and Partitions.
- Development of Burned Clay Bricks and Ceramics Production.
- Demonstration of Experimental Earth Stabilization Techniques in House Building.
- Lime Production Techniques Using Local Dolomitic Rock.
- Waterproofing Materials for Protecting Earth Walls and Roofs.
- Low-Cost Rotproofing Preservatives for Organic Building Materials.
- Promotion of the Establishment of Small Materials Production Units Throughout the Country.
- Development of Standard Designs for Schools, Dispensaries, Rural and Urban Housing.
- Development of Pilot Rural Housing Projects.
- Training of Masons and Foremen in Use of Stabilized Earth and Burned Clay Bricks.

PUBLICATIONS:

Contribution of the Centre in the Promotion of Indigenous Materials in Housing
1973

Generalities on indigenous materials research in Togo.

Survey of Natural Raw Materials Resources

Geological Report
Analysis and inventory of the soils and materials in Togo. Location maps for natural resources; essay in chemistry; diagrams.

Bricks and Other Clay Products
1971

Feasibility study on the manufacture of clay bricks and burnt clay bricks in Togo. Natural resources, production process, cost of production.

Lime in Togo. Feasibility of Hand Production
1971

Research on the use of lime in Togo. Existing natural resources, production process, cost.

Preliminary Technical Report on Burnt Clay
1970

Research on the manufacture of burnt clay bricks and blocks in Togo. Location of clay deposits; natural resources, technological process.

Research and Results in Low-Cost Housing
1972

Analysis of the durability of soil cement used as construction material in Togo. Experience in building a small unit with indigenous materials such as soil, timber, magnesian limestone renderings without cement. Costs.

Report on a Study of Wastewater Treatment Using Settlement Ponds
1975

Study of a sanitary facility. Plan. Cost.

Preliminary Survey on Housing and Materials at Sokodé and Surrounding Region
1974

Analysis of housing and building materials in a Togo town of 10,000 - 50,000 residents and its region, Central Togo. Houses types according to roofs of sheet metal, straw, thatch and walls of soil or cement block. Evolution of traditional building processes. Self-help construction. Cost.

Prototype Low-Cost House
1972

Building of a small unit with materials indigenous to Togo: soil bricks, laterite, timber, rendering of magnesian limestone for foundations, walls and roofing. Costs and data.

Notes on Traditional Habitat in Northern Togo
1974

Study of traditional habitat. Architecture and plans of adobe houses by ethnic groups. Information on wall and other protection and thatch roofs.

Housing Study in Togo's Central and Northern Regions
1971

Analysis of traditional urban and rural housing in Savanes and Kara. Construction of housing, commercial buildings and schools. Urban planning. Materials, plans, pictures and maps.

Finding Economical Solutions to Rural Housing in Togo

Study of materials and systems for mass housing in Togo: roofing, foundations and mud walls; industrialization of concrete building elements; walls of soil cement blocks; organic refuse materials for the manufacture of blocks or sheets. Costs.

Rural Housing Study
1970

Study of rural housing in Togo's plateau region. Principles of urbanization; plans; cost estimates of rural housing; use of soil, wood and plant material for roofing.

Kouloumi Pilot Project. Resettlement of a Togo Village. First Report
1973

Study of the resettlement of a village in the central area of Togo. Analysis of traditional housing, mud walls, thatch and tin roofs, demography and income. Site plan of the new village including roads, trees, open space, community facilities, social centers, clinics, cost estimates. Resident participation, community development. Pictures.

Study of Comfort, Phase I

Measurement of temperatures in experimental cells; incidence of wall materials; comfort and living conditions in housing. Climate protection of walls in various materials such as burnt clay bricks, cement bricks, soil cement.

Climate in Togo. Information for Use in Housing
1973

Reference work on the climate of Togo.

Unpaid Workers - Self-Help Construction. Phase A
1974

Programs for the training of craftsmen in the construction trade.

Preliminary Training - Phase 1

Training program for construction workers.

Preliminary Training - Phase 2

Introductory course for hygiene assistants in the construction of sanitary equipment. Program of professional training in the construction of sanitary installations, water supply, water distribution system and drainage network for villages in Togo.

Subjects to be treated in future bulletins:

- Stabilized soil
- Lime by-products and their application
- Utilization of non-commercial timbers
- The burnt brick
- Open-modular system
- Traditional housing in Togo
- Elements of Togo's housing policy

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NATIONAL HOUSING AUTHORITY
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LUSAKA, ZAMBIA

ZA/1

The major activity of the Authority is providing consultancy services to national government and local authorities. Original research focuses on sanitation and self-help in low-cost housing.

PROJECTS:

- Treatment of Domestic Effluent in Stabilization Ponds.
- Methods of Low-Cost Sanitation: The Aqua Privy.
- Investigation of Patterns of Outdoor Plot Usage.
- Characteristics of Self-Help in Site and Services Schemes.

PUBLICATIONS:

Gardens and Outdoor Living

Self-Help in Action

INDEX OF RESEARCH SUBJECTS

HOUSES (cont'd)
  House improvement
   new house extention GH/2, NI/1, TA/2
   slum houses GH/1, KE/2
   traditional houses ET/1, GH/1, GH/2, IC/1, IC/2, KE/2, SU/1, TO/1
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  Prototype designs GH/1, GH/2, IC/1, IC/3, KE/2, MA/1, SU/1, TA/2, TO/1
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PLOT LAYOUT GH/1, GH/2, IC/1, KE/2, TA/1

CONSTRUCTION MANAGEMENT
  Cooperatives GH/2, TA/2
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  Pit latrines GH/2, IC/1, KE/1, TA/2
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   schools GH/1, IC/1, IC/3, SU/2, TO/1

HOUSING SCHEMES
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  Sites and services CA/1, GH/1, KE/2, TA/2, ZA/1

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  Statistics GH/1, NI/1, TA/2
  Urban CA/1, GH/1, GH/2, IC/1, KE/2, SU/1, TA/2