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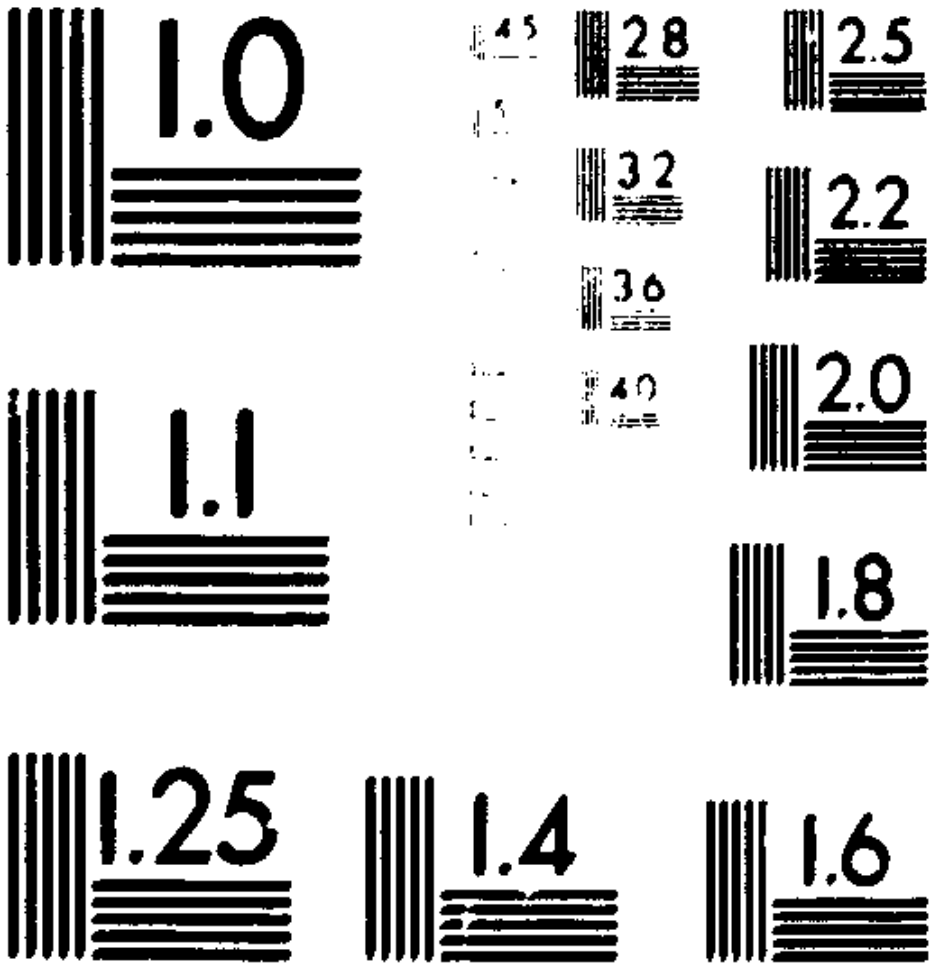
UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org



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INTRODUCTION OF MOBILE BRICKMAKING TECHNOLOGY

RP/URT/84/006

TANZANIA

Technical Report*

Prepared for the Government of the United Republic of Tanzania
by the United Nations Industrial Development Organization
acting as executing agency for the United Nations Development Programme

Based on the work of W. Buchanan,
brickmaking consultant

United Nations Industrial Development Organization
Vienna

3350

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CONTENTS

Explanatory Notes

1. Operational Rate of Exchange

   The unit of currency in Tanzania is the shilling, the UN operational rate is 17.00 shillings for 1 US $. The actual bank rate of exchange during the mission was around 17.5 shillings for 1 US $.

2. An explanation of technical terms is given under Section A of the report, "Brickmaking and the Mobile Unit".

Abstract

Introduction of Mobile Brickmaking Technology - RP/URT/84/006

1. A mission of nine days was undertaken in the United Republic of Tanzania from 6th to 15th September 1984. In addition, related activities, briefing, and debriefing took place outside of Tanzania.

2. The mission concluded that mobile brickmaking technology could be of benefit to Tanzania in supplying better building materials in certain rural areas. A project should be implemented to establish the optimum production methods and economic viability.

3. The National Housing and Building Research Unit of the Prime Minister's Office would be the logical Government Implementing Agency.

4. Due to an extended wet season, there could be benefits in having a pre-project stage, and then dividing the 12-month implementation stage into two parts.

5. A production method and equipment list have been recommended, together with a timetable for implementation.

I. INTRODUCTION

1. Prior Activities

a. A UNIDO staff member, Mr. N.G. Biering, carried out a one-week mission to Tanzania from 20 to 28 August 1984. Mr. Biering's mission established that there was keen interest in developing a mobile brickmaking facility, particularly since Government policy favoured the promotion of de-centralized manufacture of good quality fired (or unfired) clay bricks. At the same time, Mr. Biering established that staff, funds, and logistical support might be available to a project for evaluation of mobile brickmaking technology. The wider implications of a successful project in disseminating information and transferring technology to other African countries was also seen a real possibility by using the equipment in Tanzania for demonstration and training.

b. The writer visited Rieterwerke in Konstanz, West Germany, on 31 August 1984 - 1 September 1984 to evaluate what equipment that company might be able to offer by way of a small mobile facility. The background to this visit was that it was known that Rieterwerke had designed a mobile brickmaking plant some years before, although their mobile facility was substantially larger than the current one being considered for Tanzania. Discussions were held with Mr. Norbert Guder, Sales Director. It would appear that the equipment produced by Rieterwerke is larger than that required for the mobile plant being considered here. Nevertheless, they could be interested in submitting a quotation once the final details are known.

2. Briefing

Briefing for the mission took place at the UNIDO offices in Vienna. Detailed discussions were held with Mr. Biering on 3rd and 4th September 1984.

3. Duties:

Whilst in Vienna, the writer agreed to provide the following services according to the following schedule: -

" The purpose of the project is to develop and prove the appropriatedness of the concept of a mobile brick manufacturing unit capable of producting quality facing bricks for short-term construction requirements in areas not justifying a permanent mechanized brick plant. The subscriber will carry out the duties specified on the job description corresponging to this post. He will also be expected to prepare a final report setting out the findings of his mission and his recommendations to the Government."

The duties listed under the Job Description are:

" 1. To analyse the situation, i.e. carry out some groundwork on the spot to determine what already exists there and what additional inputs are needed;

2. To finalize the project document, probably in conjunction with Mr. Biering who will join him on 22/23 August 1984;

3. To define the modalities of implementation."

It may be noted that, in fact, Mr. Biering's mission preceded that of the writer and the project document will be finalized during debriefing in Vienna.

4. Arrangements within Tanzania

The writer reported directly to the UNIDO Senior Industrial Development Field Adviser (SIDFA), Mr. S.K. Henein. There he was introduced to Mr. P.S. Mgimba of the National Housing and Building Research Unit (BRU) which is a parastatal body within the Prime Minister's Office. The BRU had a programme of meetings already arranged, starting on Friday, 7th September. During that period, the following organizations were visited for discussion on the mobile brickmaking technology:

7/9/84	- Building Research Unit - UNDP/UNIDO
8/9/84	- Prime Minister's Officer (Deputy Principal Secretary)
10/9/84	- National Housing Corporation - National Construction Council
11/9/84	- Tanzania Saruji Corporation - Small Industries Development Corporation
12/9/84	- Ministry of Industries and Trade - Ministry of Works
13/9/84	- "Round-Table" discussion at BRU
14/9/84	- Visit to Mambiri brick factory near Kisarawe - Resident Representative a.i., UNDP
15/9/84	- Leave Tanzania

5. Acknowledgements

The National Housing and Building Research Unit must be sincerely thanked for their co-operation and assistance, and for their very positive attitude to the development of the proposed project. In particular, the Director, Mr. A.L. Mtui, and the Building Economist, Mr. P.S. Mgimba, who was the national Team Leader of the mission, were helpful.

The SIDFA, Mr. S.K. Henein, and JPO, Mr. E. Skjønsberg, gave full co-operation to the mission, including arranging transport as and when required.

Thanks are also due to the various officials who gave frank assessments of the prolems they envisaged as well as good advice and encouragement. Those persons with whom disucssions were held include:

Mr. M.J. Mwabulambo, Deputy Principal Secretary, Prime Minister's Office
Mr. G.M. Kawiche,Civil Engineer, BRU
Dr. G. Mlingwa, Executive Secretary, National Construction Council
Mr. S. Backstrom, Manager of Research and Planning, Tanzania Saruji Corporation
Mr. G.M. Mwakarukwa, Industrial Geologist, Tanzania Saruji Corporation
Mr. K.H. Mwemba, General Manager, National Housing Corporation

Mr. D.E. Masanja, Assistant Commissioner, Community Development, Prime Minister's Officer
Mr. J.V. Bapuraj, Technical Adviser, Small Industries Development Organization
Mr. E.M. Manyaro, Engineer, Small Industries Development Organization
Mr. Sekwao, Chief Architect, Ministry of Works and Communications
Mr. W. Bocco, Director of Buidlings, Ministry of Works and Communications
Mr. Mdelela, i.c. Construction, Ministry of Works and Communications
Mr. R. Church, Resident Representative a.i., UNDP

II. RECOMMENDATIONS

1. A project should be implemented to evaluate the economies and technical feasibility and technical feasibility of a small-scale mobile brickmaking unit (MBU); using clay grinding - mixing - extrusion equipment.

2. In view of the high training component linked with the need to attain maximum production for proper economic evaluation, the mobile unit should only produce at two sites during the 12 months of UNIDO assistance.

3. Since labour intensive brickmaking is seriously curtailed by wet weather the project should be implemented in two stages, one being from October 1985 - February 1986, and the other being from June 1986 - December 1986 (but taking into account delivery dates for project equipment).

4. To maximize the effectiveness of the 12 months of expert services, a consultant or UNIDO staff member should carry out some 5 to 6 weeks of preparatory work in obtaining samples from the first production site fore the successful tenderer who will supply the brickmaking equipment; and to liaise with suppliers of equipment such that they can give more effective quotations based on conditions in Tanzania.

5. The three full-time staff from the National Housing and Building Research Unit who will be attached to the MBU, should go on a study tour to the supplier of the brickmaking equipment to see it assembled, and to see similar equipment in operation.

6. In view of the strong demand for UNIDO funds, the Government of the United Republic of Tanzania should make an early request for project implementation, if it is decided that the project is to go ahead.

7. If the project is successful in proving the viability of mobile brickmaking technology, other African Governments should be appraised of the results such that they can evaluate the potential of such technology in their own country. In such cases where other Governments decide that the technology can be applied in their own country, the UNIDO and Tanzanian Government should develop a small regional training centre based upon a single mobile unit.

8. The Government Implementing Agency for the project should be the National Housing and Building Research Unit (Prime Minister's Office) and the location of the first mobile unit should be reasonably close to the Building Research Unit.

9. UNIDO should obtain quotations for supply of a small manually operated tile press, i.e. a "Fly Press" together with moulds to make interlocking roof tiles and ridge tiles.

10. The equipment purchased for brickmaking should be of well proven design, with sufficient ancillary equipment and spare parts being purchased such that it is independent of other maintenance and supply services under field operation conditions. A small 1-ton pick-up and 3.5 metre caravan should be included in the equipment list.

III. FINDINGS

A. Brickmaking and the Mobile Unit

This report will no doubt be read by some of the technically well qualified personnel with whom discussions have been held. It may also be read by administrators and others whose qualifications are non-technical and who must make assessments based what are recommendations made from technical considerations. It is therefore considered relevant to give a brief and essentially limited description of the brickmaking process, and some of the factors which have led to the specific recommendations which have been made. Where specific brickmaking terms are used, they are explained in footnotes.

1. The Concept

Mobile brickmaking technology has been proposed as a viable method to supply building materials to rural areas which do not otherwise have a convenient supply of such materials, and where the "market" is such that a permanent facility is not justified. In particular, the bricks or similar products made through the mobile facility should be of an acceptably high quality. Successful proving of the technology would pave the way for its expansion in Tanzania and transfer to other African countries.

With respect to additional benefits, the mobile unit would have a small team of two or three people permanently attached to it. All other labour would comprise people from the area in which the bricks are being made. Thus a considerable amount of training would be given to those people in both operation of the mechanized unit and the wider aspects of labour intensive brickmaking.

2. Raw Materials

The raw materials used in brickmaking are:

a. Burnt bricks: Clay, water, fuel, sometimes sand.

b. Stabilized bricks: Sandy clay to clayey sand, water, a stabilizer such as hydrate of lime or portland cement.

c. Sun dried bricks: Clay, water.

There are a variety of factors to be considered with respect to the raw materials and the types of bricks mentioned above, e.g.:

Clay is a single name which is commonly used to describe a diverse range of materials. Pure clays are recognizable minerals with a particle size of less than 2 microns* and sometimes as small as 0.2 microns. Pure clays are seldom found in nature, and brick "clays" may contain less than 50% of clay minerals. The remainder of the "clay" comprises a variety of different materials and other materials which vary in particle size, chemical, and mineralogical composition. It may be appreciated therefore, that brick "clays" are extremely variable in composition and in physical characteristics. The art and science of brickmaking is employed to take the most suitable of these materials and make bricks which conform to acceptable standards of size, shape, strength, and durability.

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* One micron = 1/1,000 part of a millimetre.

Mechanical and automated brick factories rely on a continuous supply of consistently reliable raw materials which vary only within the acceptable limits of their process equipment. To ensure such a supply of materials, they spend considerable time, effort, and capital to establish the quality of raw material reserves. Even then, they may have their production equipment "tailor-made" to suit the raw materials and spend further production time in refining their fixed plant and the process itself.

From the above, it will be apparent that a single production line has limitations in dealing with all materials which are potentially suitable for brickmaking. In fact, the mobile unit will have a considerable degree of flexibility providing that optimum raw materials are selected and allowing that techniques of material preparation are followed. The mobile unit will not be with crushers to deal with hard rock or shaley clay materials, but its confirguation and equipment should be such that it can process most clay materials** capable of being dug by hand. It should also be possible to grind wet or "dry" clays.

3. Shaping

There are essentially two types of extrusion processes, these being de-aired extrusion, and non de-aired extrusion. The de-aired process passes the wet clay mixture through a vacuum chamber, removing much of the air present and giving a denser clay body. This is the most versatile process in terms of the range of products which can be made, e.g. hollow and perforated bricks and blocks , paving tiles, etc. The equipment is more complex and more expensive whilst consuming more power or energy for production. The non de-aired process uses a similar type of extruder*** but cannot produce such a dense, stiff, clay column as the de-airing extruder. It is less expensive and may have lower total power requirements than an equivalent de-airing extruder.

Mechanized clay preparation followed by hand-moulding would likely have the best potential to handle the most diverse range of clay materials in terms of making bricks. Not all extruders can successfully extrude all brickmaking materials and for this reason, equipment suppliers may alter certain design features on their extruders to accommodate specific types of raw material. With the extruder being considered for the mobile plant, only very limited changes can be made to the extruder itself. However, it will still be possible to utilize the preparation-mixing section of the unit to prepare a mixture for hand-moulding if this becomes necessary.

A film entitled "Brickmaking in Malawi" has been requested from UNIDO for showing to the BRU and other interested parties, since it has a short section showing mechanized preparation followed by hand-moulding.

** Virtually all clay materials in the ground, or even after air-drying, still contain some moisture. However, wet clay materials or mixtures may be those to which water is added to help develop the plastic qualities of the actual clay minerals present and to soften the clay such that it will blend better with the non-clay material present.

*** A brick extruder in the sense used here comprises a feed opening which accepts prepared wet clay. the material passes into the barrel of the extruder which contains a large screw - like a meat mincer - and the revolving screw forces the clay along the barel, consolidating the clay body to pressure it out through the extruder mouth.

The clay which comes out of the extruder has been formed into a solid column of (usually) rectilinear cross section. This column has to be cut into brick sizes. Modern brick factories with high capacity extruders (6 000 to 30 000 bricks per hour) use fully automatic processes to cut the column into bricks. Such processes are sophisticated and expensive, employing fairly complex electrical and mechanical systems. With a small extruder, it is preferable to use a manual cutting table into which cut sections of the clay column are slid by hand to be cut by wires into lots of 10 bricks. These bricks are pushed through the wires onto a wooden pallet which is then lifted on to a wheel barrow. This type of manual cutter is relatively inexpensive and requires little maintenance.

4. Drying

The bricks will be dried in the open air and one of two methods may be employed:

a. For small amounts of bricks, say up to 200,000 the wet bricks will be laid on to ground which has been levelled and, if possible, covered with sand. They will be covered with grass to protect them initially from too rapid drying caused by wind and sun, then after about one week, will be stacked to complete the air drying process.

b. For larger amounts of bricks and where the mobile unit is expected to be required more regularly, it will pay to construct a simple shed of bash poles with a thatched roof. Again, the floor must be very flat to avoid distortion and cracking of the bricks as they dry. A shallow bed of sand on the floor will assist the bricks to dry with fewer losses.

If the mobile unit were required to be located in one place for periods of one year or more, it would be wise to consider more permanent drying facilities. However, except for a single unit being parked as a demonstration/training unit, it is presumed that the mobile unit will be moved several times in each year.

5. Firing

Firing of bricks can be done in kilns of various designs. Capital costs, production levels, and the nature of the bricks to be fired all play part in determining the type of kiln. With a mobile unit, it does not make economic sense to invest in a number of expensive kilns of varying sizes and at diverse locations. The clamp kiln is the method which will likely be chosen to burn the bricks. A clamp is simply a stack of bricks which has fireholes running through it if wood is used as fuel, or is set on top of a bed of coal (plus fine coal mixed with the clay) if coal is used as the fuel. However, where roofing tiles are to be made, it is likely that a small kiln will be required.

Three of the advantages of the clamp kiln are that:

a. It is already used in Tanzania;

b. It can be of any size from 20,000 bricks to over 1,000,000 bricks; and

c. when coal is the fuel, clamp firing can be very economical in fuel consumption.

6. General Remarks

In considering a mobile brickmaking unit, it is important that the equipment as such is not of an experimental nature. It should be of simple, rugged design which has been well proven in the past, it should be free from electronic controls, or electro-mechanical systems which may cause difficulties under rugged conditions, and maintenance requirements should be simple and minimal. This practical evaluation will be of well-proven equipment working under novel conditions in rural areas.

Limiting factors on the size of the mobile unit are cost of purchasing the unit, and what can be carried on a single trailer of maximum length of 7 metres and width of less than 2.25 metres. The trailer must have a similar ground clearance to, say, a 4-wheel drive 7 cu.metre Mercedes truck, and be sufficiently stable to negotiate dirt roads in what are, effectively, cross country conditions. At the same time, it is preferable that the loaded trailer is, in cross section profile, suitable for rail transport (at 7 metres the length is not a problem).

The number of manufacturers who supply such equipment may well be limited, since the modern tendency is to produce much bigger machines. However, at least one potential manufacturer has been located and it is possible that UNIDO can locate more.

B. Discussions within Tanzania

As indicated in the Introduction (paragraphs 5 and 6) wide-ranging discussions were held in Dar es Salaam. Much valuable advice and background information was given, and potential problems were pointed out. However, it should be noted that what one person saw as a problem was not always seen as a problem by others. Nevertheless, it is considered relevant to note some of the problems or perceived problems which the mobile brickmaking unit (MBU) might face, and to give comments which derive from the writer and other officials. In particular, a round-table dicsussion held at the BRU and attended by 27 people was most useful in stimulating cross discussion between the many interested parties. A full list of participants is given in Annex I to this report.

Potential Problem	Remarks
1. In the choice of mechanized handmade bricks versus extruded bricks, it is possible that some of the available clays are not suited to extrusion without first altering parts of the extruder.	The MBU has the facility to prepare clays for hand-moulded bricks.
2. Whilst the idea of a mobile unit is good, the roads in Tanzania are poor, very bad in rural areas.	It has to be accepted that even a mobile plant cannot go everywhere. however, it should be able to go anywhere that a normal truck and trailer can go. Each location should be judged on its merits.

Potential Problems	Remarks
3. Tiles are also required in rural areas. Will the mobile plant be able to make tiles?	Not directly, in the form proposed. However, UNIDO should get quotations for a simple fly press to make tiles. It is likely that the MBU can prepare the material. However, it is unlikely that there will be space on the trailer for a tile press.
4. With respect to burnt bricks, stabilized bricks, and sun-dried bricks, there is often a lack of social acceptance. Concrete blocks being prefered.	With respect to Government and similar buildings, there should be no problem in using bricks if they are available at a reasonable price, and at acceptable standards of quality. For other potential users, both availability and price will be considerations, but some public relations work may be needed to get more acceptability.
5. The trailer size should be less than 7 metres length and the weight not more than 7 tons. It should have a high ground clearance.	Brickmaking equipment is necessarily heavy and considerable equipment will be on the trailer. For cost and other reasons, e.g. proven equipment, it will be necessary to consider standard equipment. It is too soon to say exactly what the dimensions and weight will be. With respect to ground clearance a balance is needed between overall height and stablity.
6. It would be preferable to have the MBU mounted on a truck body rather than a trailer.	This is one possibility, but it would be cheaper to use trailers where a single truck might service more than one trailer. The truck will also carry ancillary equipment and spares that cannot be carried on the trailer.
7. The location of the first mobile unit should be: - near Dar es Salaam - in the North of the country - in the South of the country	As a self-contained MBU, it could go in a number of locations. However, a site some 7 km from Dar es Salaam has been suggested by the BRU. This will allow more monitoring of its initial work by the BRU.
8. The MBU should be located with the: - BRU - Small Industries Development Unit	After discussions, it was agreed that the first MBU would be operated under the Prime Minister's Office and the BRU should the Implementing Agency. The Community Development Department of the PMO would supply much of the labour needed. For future MBUs, a committee, including BRU and SIDO, will decide on which Government agency should be responsible.

Potential Problems	Remarks
9. There is a shortage of brick layers and the quality of bricklaying has declined in terms of both standard and efficiency of work.	There are a number of vocational schools training bricklayers and in terms of the limited output of the MBU, it is not foreseen that this will be a problem. With respect to declining standards neither the solution nor even the problem is simple. A long-term strategy needs to be developed and specialized advice is needed. This should be followed by action.
10. Although there are trained bricklayers, they cannot afford or cannot obtain tools and hence employment. This could raise problems in the rural areas especially, where the bricks from the MBU are to be used.	It might be possible to supply some basic tool kits through the proposed MBU project since overall success depends on the bricks being used. A basic tool kit might comprise one each trowel, spirit level, rule, plump bob, bricklayer's hammer, and pegs. The cost of one kit is likely to be about US $ 50. Ten sets would be recommended.
11. Whilst the idea of using the MBU as a training-demonstration unit for other African countries, this should only take place after the proving stage.	Recommendations have already been made that the MBU should be proved as a viable concept before other countries are involved.
12. There will be difficulties of diesel fuel availability in rural areas.	The MBU should have a 400 litre storage tank. There should also be a small diesel pick-up vehicle attached to the project for collecting fuel, communication, site visits, etc. Where there are local electricity supplies, these may possibly be used to power the unit.
13. There should be soil testing facilities with the MBU.	The BRU has good facilities for testing clays and most testing will be done there. Even so, the possibility of limited testing facilities with the MBU should not be precluded.
14. With respect to fuel supplies to burn bricks, even small scale industries can have problems. The effects on the environment must also be considered.	For burnt bricks or tiles, the MBU can only work where there are adequate supplies of fuel. This may be in the form of wood or coal, and supplemented by other fuels. The effect on the environment is most important and there is a case to consider to make users of wood responsible for re-planting. However, the many years of wood consumtion have left a large deficit in some areas that will be expensive to make up.

Potential Problem	Remarks
15. The developing steel industry may require all the country's coal output.	The MBU, where it uses coal to make bricks, will prefer to use coal dust (dress) which would not likely be required for the steel industry. Even so, it is unlikely that the steel industry will consume all the coal produced. Trials for coke production have given good results.
16. In some cases the cost of bricks is higher than that for concrete blocks where coal is needed as fuel.	The basic cause of this was attributed to the high handling costs for coal.
17. Some roads have bridges over them with a clearance of 14 feet (4.3 metres).	Current indications are that the MBU should clear this height.

Following the round-table discussions at the BRU, the Government and related participants agreed that a small committee should be formed with the BRU taking the co-ordinating role. The committee should, inter alia, press for initiation of the project and follow it up through the implementation stage. The various bodies who have been proposed as comprising the committee are:

National Housing and Building Research Unit,
Prime Minister's Office;

Community Development,
Prime Minister's Office;

Small Industries Development Organizations,
Ministry of Industries and Trade;

Tanzania Saruji Corporation; and

National Housing Corporation.

Of prime importance to the success of the proposed project is the existence of suitable clay deposits within the country. Discussions with geologists and engineers have indicated that there are suitable clay deposits throughout the country. The BRU and the Saruji Corporation have test results on some such clay deposits. However, it would be necessary that samples of clay were taken from the site proposed for the first location of the MBU, and that these samples be sent to the equipment supplier.

Although considerable interest was expressed in the mobile unit being able to make clay roofing tiles, it is doubtful if a tile press could be incorporated on the MBU trailer. However, UNIDO should get quotations for a fly press with moulds for interlocking and ridge tile production.

On 14 September 1984, two brickplants were visited at Mambiri, near Kisarawe. Both plants are operated by the National Housing Corporation. One was operated on an intermittent basis, whilst the other had ceased production since 1983 when the crankshaft of the stationary engine broke.

The small plant which was operating made re-pressed bricks using a small extruder to produce the rough "clots", these being left for one or two days prior to being finally shaped in fly presses. Output was said to be 1,000 to 2,000 bricks per day when the presses were used. Production was obviously intermittent when, in fact, it could be on a much more continuous basis. Output on a monthly basis was said to be 10,000-15,000 bricks. It is considered that output, using two fly presses, should be about 50,000 bricks per month. However, the kiln capacity might reduce this to about 30,000 bricks per month, and during cold or wet weather production is slower.

Although production of roof tiles had been attempted it appeared that a suitable clay body had not been developed from which good tiles could be made.

The second brickplant was not operating due to mechanical problems. The brickmaking equipment, including a de-airing extruder and power operated fly press, is powered by a Petter-Feilding diesel engine through a system of pulleys and flatbelts. Much of the product system appears to be in need of repair.

Given the investment already there, in terms of premises, kilns, etc., there is a good case to upgrade the operation of both of these small brickplants.

C. Equipment Requirements

The description of the brickmaking equipment is intended to be sufficiently flexible to permit a range of supplies to make quotations based on their standard product lines.

1. The Proposed Brickmaking Method is:

Manual clay digging; hand feeding on to belt conveyors; conveyor feed into a double rolls grinder, differential speed type preferred; conveyor feed from the grinder, either to a stockpile or to another conveyor; conveyor feed to a double shafted mixer; direct feed from the mixer into a non de-airing extruder; cutting of the clay column on a manually operated side-cutting table where the bricks are pushed on to a wooden pallet, to be manually removed on the pallet; the table should cut 10 bricks at a time.

Electric power will be supplied from a single diesel generator, or from two diesel generators where one powers the rolls grinder and associated conveyors, and the other powers the feed conveyor to the mixer, the mixer itself and the extruder.

The output of the system should be not less than 1,200 bricks per hour, assuming a wet brick size of 200 x 100 x 70 mm, an output of 1,500 bricks per hour is considered to be preferable (see Note 1).

Note 1: It is also acceptable that the extruder has a higher capacity than 1 500 bricks per hour. With respect to the die or extruder-mouth size, the supplier should calculate exact sizes based on a burnt brick size of 190x90x65 mm and a firing temperature of 900°. This calculation will be made on the basis of clay samples to be provided. If samples cannot be provided, a precise wet brick size shall be advised; 200x100x70mm wet brick size can be used for purpose of quotation.

The brickmaking equipment will be operated from a trailer. Those items which can be or must be used off the trailer during production must be capable of being stowed on the trailer for transporting. It should be assumed that loading and unloading the trailer will be done manually without the use of cranes of lifting tackle unless supplied with the trailer. Overall size and stability of the trailer are prime considerations, since it will be towed on rough unsurfaced roads.

Spare parts and ancilliary equipment not directly required for brickmkaing shall be stored on the towing vehicle, not on the trailer.

It should be assumed that all necessary equipment and parts have to be supplied for the brickmaking system to operate. It is possible that no parts, even nuts, bolts, and screws, will be readily available in Tanzania. This should also be taken into account when recommending spare parts. Structural steel should, wherever possible be fabricated from standard profiles available to the construction industry.

2. Grinding Rolls and Belt Conveyors

The rolls shall be fed by a belt conveyor fitted with scrapers, the cost of which should be included in the quotation. A take off conveyor should also be supplied of the same belt size as the feed conveyor. Spare belting and fasteners should be included under spare parts.

The grinding rolls shall consist of independently driven smooth rollers, preferably running at differential speeds. The capacity of the grinding system should be sufficient to supply the mixer. Feed from the grinding system may be dropped through the trailer plat form to the take-off conveyor, which will then have the charging end located under the trailer.

The supplier should quote for a suitable rolls grinding attachment, or otherwise indicate (with quotations) which method of grinding the roller faces can be employed. The rolls grinding attachment need not be permanently affixed, unless this is considered essential, but the means of fixing (if necessary) should be included in the quotation.

The rolls, feed conveyor, and take-off conveyor should be driven through electric motors (220/380 volts 50 Hz) which are suitable for exposed tropical weather conditions. All electric motors shall have isolator switches and overload relays. The drive from motor to equipment should be through "V" belts and pulleys, flat belts can be considered.

3. Double Shafted Mixer, Extruder, Feed Conveyor

The feed conveyor shall be of the belt type, fitted with scrapers.It shall be capable of being fed from the discharge conveyor of the grinding rolls, except where that conveyor is feeding to a stockpile, in which case it can be fed from ground level. The belt width should be the same as that used for the feed and discharge conveyors of the grinding rolls system. Wherever possible, all pulleys, rollers and bearings hsould be standard between the three conveyors.

The double shafted mixer should feed directly into the extruder, or be an integral part of the extruder system. Minimum length of the trough is considered to be 1.5 metres, but this is not mandatory providing that the mixer can process the required amount of material to accept the feed from the grinding rolls and to feed the extruder. Provision should be made by way of suitable pipework, spray nozzles, and valves to permit water to be fed to the mixer. A rugged flow meter should be incorporated in the system, fitted with valves to permit the flowmeter to be by-passed if necessary.

The extruder shall be of the non de-airing type, fed directly from the d/s mixer. It is envisaged that the nominal barrel diameter will be at least 300 mm internally. Output should be rated at 1 500 bricks per hour, of an extruded cross section 200 x 100 mm, i.e. 2.31 cu.mt. per hour, when making some allowance for water at the cutting table. The die should be fitted with provision for water lubrication.

4. Diesel Generator

Electricity for operating the equipment should be supplied from two identical diesel generating sets. One set will supply the grinder and two associated conveyors whilst the other shall supply the mixer-extruder and one conveyor. The reason for specifying two generators is to permit the two parts of the system to be operated independently, to allow one part of the system to be operated even if one generator is undergoing maintenance, to allow, possibly, easier storage of two smaller sets on the trailer, in particular to save diesel fuel if only part of the system is operating or if ancillary equipment is being operated independent of the brickmaking system. However, a supplier can quote for only one larger generator if he feels that this outweighs any advantages of having two smaller sets. In either case, the estimated fuel consumption at full load should be stated.

The generator(s, should be with manual start rather than battery electric starter. If a manual starting system is used, on spare starting handle and starting dog-pulley should be included in the list of spare parts.

The generator(s) should be fitted with fuel tanks to permit from 4 to 8 hours running at full load. They should be suitable for operation in exposed tropical conditions.

A 400 litre capacity reserve full tank should be supplied, preferably fixed to the trailer, of all metal construction, and with lockable inlet and outlet points. The locks should be included as well as a fuel gauge. A removable metal strainer/ filter should be located in the inlet or filler point. One spare strainer should be included in the list of spare parts. It is acceptable that only a filler point is located on the tank, in which case a hand pump and hose should be supplied to charge the generator fuel tanks from the 400 litre reserve tank.

5. Wire Cutter

The preferred type is a manually operated side cutter with, as required, a bridging table between extruder mouth and the cutter. The cutter should have the capacity to cut ten bricks at a time, of nominal thickness 70 mm, but with provision to adjust this thickness, say between at least 72 mm and 65 mm.

The sequence of operation may be that the clay column from the extruder column is manually cut into a length of 770 mm, this piece is slid forward into the cutting table, operation of a lever will push the cut column partly through the wires but far enough to ensure that the next piece of cut column is left free passage into the cutter. This next piece of column, when pushed through the wires will complete the cutting of the first piece which will land on a wooden pallet set flush with the cutting table top The pallet of 10 bricks shall be removed and the system repeated.

Suppliers may quote for alternate cutting systems but electricity powered systems are not preferred.

It is not envisaged that the cutting table should be fixed on the trailer during brickmaking since the trailer dimensions will be too small. It is envisaged that the cutting table will be stowed on the trailer for transporting, but if this is not possible by virtue of limitations of space, it may be possible to stow the cutting table on the towing vehicle.

6. Trailer

The trailer should be of rugged construction, suitable for towing on rough unsurfaced roads as well as on tarmac roads. It is envisaged that the trailer length will not exceed, and preferably be less than 7 metres with equipment loaded for towing. Trailer width should not be more than, and preferably less than 2.2 metres. Ground clearance to the lowest extremity, eg. axles, should be more than 350 mm.

The trailer should be fitted with parking, stop, and indicator lights as well as a suitable braking system. If the trailer must be supported during production, suitable jacks should be supplied.

Since it is conceivable that the trailer might be transported by rail, a sketch of the various size limitations is appended. The length of the trailer is not felt to be a problem at about 7 metres. The main restrictions are on height and width.

The supplier should give full details of the trailer, towing hitch, lighting system, and braking system. These details will include laden weight and capacity, ground clearance, width, height, etc.

7. Building Equipment and Supplies

a. Water Pump

- A water pump, diesel or petrol engine, shall be supplied or capacity specified for separate purchase by UNIDO. The pump should have sufficient capacity to feed the mixer and extruder assuming a feed pipe of 500 metres length, 20 mm internal diameter, lift of 5 metres, and the pipeline material being reinforced plastic. The pipeline shall be supplied, with the pump, in lengths of 100 metres together with all necessary joints, e.g. quickfit types or jubilee clip types.

  The pump inlet pipe should be 10 metres long and fitted with a strainer to preclude sand, gravel, and vegetable or similar matter being sucked in.

  The pump should have fuel tank capable of running itfour hours at full load.

b. Portable Generator

- A 1 kW portable generator suitable for supplying 220V 50Hz single phase power; diesel engine preferred, but petrol engine acceptable.

- 200 metres of 3-core electrical wire with suitable plugs and socket (earthed) to be supplied with the generator.

- 0.5 metre copper earthing rod and 5 metres copper earth wire for the generator.

c. Welder and Supplies

Since most of the maintenance to the brick unit will have to be done in rural conditions, welding facilities are required for emergency repair work and to, possibly, build up the faces of cutter knives and augers.

The supplier should specify a suitable electric welder and range of electrodes. The welder will be powered from one of the two generators on the trailer.

Together with the welder, the following parts should be supplied:

- 20 kg of each type of welding rod required or 40 kg if only one type required;
- Two pairs of welder's goggles, one face mask and welder's hammer.

d. Miscellaneous

- Twenty wooden pallets, of a size to be specified by the supplier of the cutting table. The pallets shall be suited to fit one at a time on to the discharge side of the cutting table such that they can be lifted off, with the bricks, on to a wheelbarrow.

- One mechanics tool kit (tradesman quality) plus any special tools recommended by the supplier of the MBU.

- One 3 kg or 7 lb. sledgehammer with hickory handle, plus one spare handle to the axe head.

- One carpenter's tool kit including jack plane and smoothing plane, ripper and cross cut saws, 2 files for shapening saws, and setting tool for saw teeth (tradesman quality).

- Two bow saws, 3 ft. of 1 metre, with total of 10 spare blades.

- Ten each of the following (handyman quality):

  - Bricklayer's hammer with 25 mm blade, with steel handle if available;
  - Bricklayer's trowel, approx. 10 inch or 250 mm blade;
  - Pointing trowel;
  - Bricklayer's plumb bob and line;
  - Line pegs;
  - Spirit levels, 600 mm (2 ft);
  - Bolsters, 75 mm (3 inch) blade:
  - Tape measures, metal, 3 metres;
  - One only surveyor's tape, 50 metres.

- Two tool boxes, heavy duty metal (e.g. 3 mm steel plate). Approx. size 1000 x 500 x 300 mm. Fitted with hinged top or front (assuming the top to be 1000 x 500 mm and the front to be 1000 x 300 mm) and supplied with two heavy duty hasps and staples (fitted) plus two heavy duty padlocks each.

  Note: Standard sized boxes may be quoted for if they approximate to the above in size and are of strong construction.

- 1 electric drill, two speed, approx. 600 watt, with 12.5 mm or 1/2 inch chuck.

- Two sets of high speed drills, sizes from 3 mm to 15 mm, parallel shank, capable of fitting the chuck of 14.8 above.

- Two each metal files with 250 blades and with handles:

  Fine
  Bastard
  Coarse

8. Spare Parts

The supplier of the MBU should quote for supply of spare parts for all equipment items supplied by or through him. It should be assumed that the operating life (in terms of spares required) will be 3,000 running hours for the grinder, mixer, extruder, cutting table, and conveyors; and 2 years for all other equipment.

9. Vehicles

- One ton pick-up truck, diesel engine, right hand drive with workshop manuals to cover engine, transmission, steering, and suspension. E.g. Peugeot 504 or Toyota Hilux; two wheel drive.

- Spare parts for above vehicle assuming requirements for 40,000 km of operation and including one full set of shock absorbers, six air filters, six fuel filters, six oil filters, one complete set of brake pads and/or shoes.

- Tow hitch and electrical connecti. ; for item below.

- Caravan, one/two bed size, 3.5 metre length with paraffin (kerosine) stove.

- Fifteen builder's wheel barrows, all steel construction, pneumatic tyres, axles to run in sealed ball or roller bearings; to be supplied dismantled.

Remarks

UNIDO should liaise with all suppliers to evaluate the possibility of supplying the equipment to Dar es Salaam in a container. The vehicle and caravan are required well in advance of the brickmaking equipment and containerized transport, whilst preferable, is not essential.

D. Timetable for Project Implementation

It should be stressed that it is the Government's prerogative to decide if or when the project should be implemented. However, the following tentative workplan is put forward since,

a. the Government should be appraised of the activities which might take place and the times involved, and

b. the Government should be given the opportunity to make an early decision on whether or not to implement the project since any United Nations funds which might be available for project implementation cannot be set aside indefinitely.

Each of the activities given below is shown in condensed form with explanatory notes. It may not be necessary to give such detail in a project document but it is felt to be necessary here.

Workplan

	Start	Finish
Government request for project implementation		31/10/84
Final site selection, sampling of clay for dispatch to equipment supplier. Selection of Mobile Brickmaking Unit team of 3 for initial study tour.		14/11/84
Discussions with potential suppliers to appraise them of the specific requirements of the MBU.		30/11/84
Note: It is envisaged that the above activities will involve either 5 weeks of preproject expert services or of a UNIDO staff member. In particular it is felt to be most important that the actual site is examined and that samples be prepared for dispatch to the successful tenderer. It will also be essential that the expert consults with all the suppliers to appriase them of the requirements of the MBU and of the full equipment and spare parts requirements such that they can make reasonable quotations for supply based upon appropriate design.		
It is also important that as much preparatory work as possible is completed prior to the arrival of the brickmaking adviser/CTA.		
UNIDO receives quotations for major equipment items and places orders for supply.	01/12/84	31/12/84
UNIDO places orders for project vehicle and all other supplies not being purchased from the MBU supplier.	01/01/85	31/01/85

	Start	Finish
3 man team from BRU on study tour to supplier factory	01/09/85	30/09/85
During this period the team shall see the equipment being assembled, participate in erection - dismantle exercises, and visit factories using similar equipment even although it may not be mobile.		
UNIDO CTA/Brickmaking Adviser arrives in Dar es Salaam. Site preparation starts, erection of office-storeroom and drying shed. Clay digging starts.	01/10/85	30/11/85
Project vehicle and caravan arrive.	01/10/85	15/10/85
Arrival of MBU and associated equipment and spare parts. Port clearance, transport to site and initial trial operation by supplier's representative.	01/11/85	21/11/85
Note: The manufacturer's representative will be advised as soon as the MBU has been transported to the site. There is no point in him being in Tanzania before that time.		
Start of brickmaking with particular regard to training of the labour force.	22/11/85	28/02/86
Note: The period of highest rainfall in the coastal region is shown as December-May (Bodoegaard, T. Climate and Design in Tanzania, Building Research Unit, 1981). This would be the least productive period for any labour internal brickmaking operation - if bricks can be made at all. This poses a serious problem to a project of relatively short duration. The pattern of rainfall is shown in Annex II.		
Consideration should be given to making the project into two sections with respect to expert services, e.g. 1 October 1985 - 28 February 1986 and 1 June 1986 - 31 January 1987. This situation would be altered by any radical change in delivery of the MBU. An additional benefit would be that the project would get a full 12 months of expert services, instead of 10.5 months plus 1-5 months leave period that comprises a normal 12 month working contract. It would be necessary to find an expert who would accept such a split assignment. For the purposes of the balance of the activities shown here, it is assumed that there is no break in the expert services, but that transporting of the MBU does not take place until the start of the dry season, i.e. June.		

	Start	Finish
Burning of bricks made during period. Making lime stabilized bricks and portland cement stabilized bricks. Training in dismantling-assembling mobile plant and in transportation - according to road conditions. Field trips to select second site.	01/03/86	31/05/86
Transport MBU to second site. Establish brickmaking operations, e.g. using coal as fuel. Training of labour in brickmaking techniques.	01/06/86	31/08/86
Final assessment of project activities to date. MBU returns to Dar es Salaam site. Final report on project activities.	01/09/86	31/09/86

Note:
A select committee co-ordinated by the BKU shall review project activities on a 3-monthly basis.

The proposed budget for the Government contribution is shown in Annex III. The Government budget is based on information received in Tanzania with respect to the cost of personnel in the field. However, with respect to brickmaking supplies, it is difficult to estimate these in advance. Therefore, it has been assumed that some 850,000 bricks will be produced, half using coal delivered at 2000/-per ton, and half using wood delivered at 450/-per cubic metre. It may be possible that initial bricks produced could be "sold" in exchange for fuel supplies.

IV. CONCLUSIONS

A mobile brickmaking unit (MBU) could be a technically viable prospect in Tanzania where it can have definite advantages in providing building materials.

Substantial training activities will be required

a) for the three man-team attached to the MBU, and
b) for the general work force attached to the MBU each time it changes location.

With respect to a UNIDO assisted Government project, the National Housing and Building Research Unit of the Prime Minister's Office should act a Government Implementing Agency. Labour for brickmaking should be supplied through the Community Development section of the Prime Minister's Office.

The range of products which can be produced are, essentially, solid bricks. However, these might vary from extruded and hand-moulded burnt clay bricks, to lime or portland cement stabilized bricks, to sun dried bricks.

There will be limitations on the operation of any mobile unit during the wet season since the bulk of the operation still takes place in the open air. Road transport during the wet season may be impossible except on bitumen roads.

The two principal fuels used for producing burnt bricks will be coal or wood. Other fuels such as sawdust and agricultural by-products might supplement the use of wood but would have less impact where coal is used.

There are few brickmaking production lines which can efficiently handle all potential clay material. This is more so with a small mobile unit with a limited range of equipment. Therefore the raw materials should be chosen with care, and the full versatility of the MBU used to process them according to their individual requirements.

Since only a part of the process is mechanized and much is to be done by manual means, constant supervision will be required to maintain high quality of the product. This is true with any production process.

In terms of the aid which can be given by UNIDO during a one year period, a major constraint could be an inability of the MBU to make bricks during the wet season. In this context, it might be noted that, of the 12 month life of the project, from three to six months could be considered the wet season (see Annex II). This situation might be ameliorated by having some activities carried out in a pre-project phase and by having the 12 month implementation phase divided into two parts.

The brickmaking equipment used should be of standard and well proven design. Any experimental or development work should only be to establish the optimum method and economies of operation and not to establish the viability of the equipment as such.

The National Housing and Building Research Unit of the Prime Minister's Officer is capable of, and competent to act as Government Implementing Agency for the project.

Particularly, in view of the relatively short time available for project implementation, it will be necessary that the MBU is assured of reasonable supplies of diesel fuel to enable it to operate.

In view of the fact that the MBU will normally operate outside of urban areas, it will be necessary to provide a small pick-up vehicle and caravan. With respect to the caravan, it need not be new, provided it is in good condition. Total cost of these two items should be kept to less than US $ 15,000 landed at Dar es Salaam. The pick up vehicle is especially important in view of the general lack of transport, the need to maintain communications, the need to bring fuel to the MBU, and to survey for suitable brickmaking sites with access for the MBU.

ANNEX I

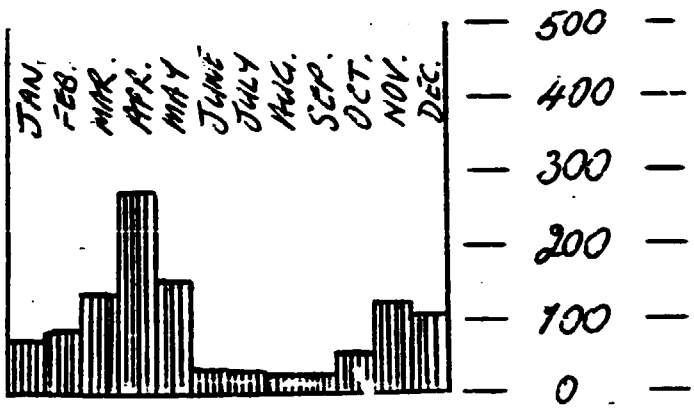
Participants in Round-Table Discussion held at the National Housing and Building Research Unit, Dar es Salaam, 13 September 1984

Name	Organization	Position
A.L. Mtui	BRU	Director
W. Buchanan	UNIDO	Consultant
H.H.J. Kitundu	BRU	Sen.Asst. Erec. Engineer
J.A. Gwambasa	BRU	Technician, Civil and Building
V.H. Kinati	BRU	Sociologist
M.L. Mpuya	BRU	Sociologist
G.M. Kawiche	BRU	Civil Engineer
J.A. Yatera	BRU	Architect
T.S. Ndatulu	BRU	Building Economist
P.S. Mgimba	BRU	Building Economist
M.S. Mazanda	BRU	Sociologist (ADSW)
A.J. Fundia	BRU	Quantity Surveyor
A.B. Mwaigwisya	BRU	Architect
P.O. Hagman	BRU	Architect
F.G. Mwafongo	BRU	Architect
G.C. Mgoha	BRU	Quantity Superveyor
E. Skjønsberg	UNIDO	JPO
S. Backstrom	SARUJI	Manager, Research and Planning
E.B. Masamu	TBS	Civil Engineer
E.M.M. Chasawa	BRU	Technician, Civil and Building
B.C. Muhegi	National Construction Council	Civil Engineer
J.V. Bapuraj	Small Industry Dev. Organization	Advisor
E.M. Nanyaro	SIDO	Engineer
Dr. G. Mlingwa	National Construction Council	Executive Secretary
D.E. Masanja	Prime Minister's Office	Assistant Commissioner, Community Development
J.S. Baradyana	BRU	Asst. Exec. Engineer
G. Mwakarukwa	SARUJI	Geologist

ANNEX II

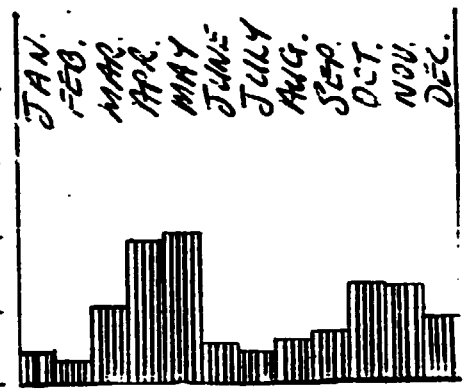
Rainfall Patterns-Coastal Area

Rainfall in mm



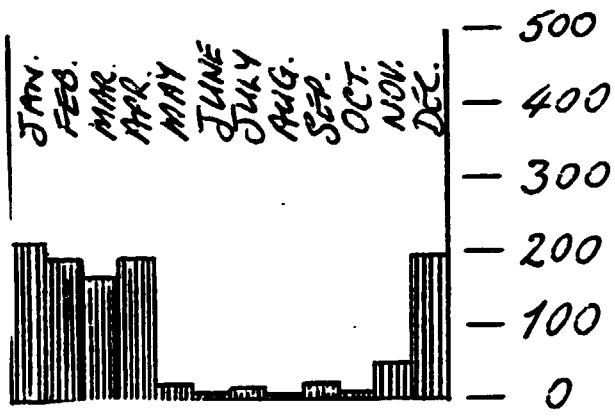
Zone: Coastal Tropical

Dar es Salaam-Airport Met. St.



Zone: Costal Tropical

Mlingano Research and Training Institute



Zone: Coastal Tropical

Mtwara-Airport Met. Station

Pattern of rainfall in the Tanzanian Coastal Zone, extracted from data given in Bodoegaard,T., "Climmate and Design in Tanzania. Guidelines for Rural Housing". Building Research Unit, Ministry of Lands, Housing and Urban Development*, Dar es Salaam, 1981.

* The Building Research Unit is now (1984) attached to the Prime Minister's Office.

ANNEX III

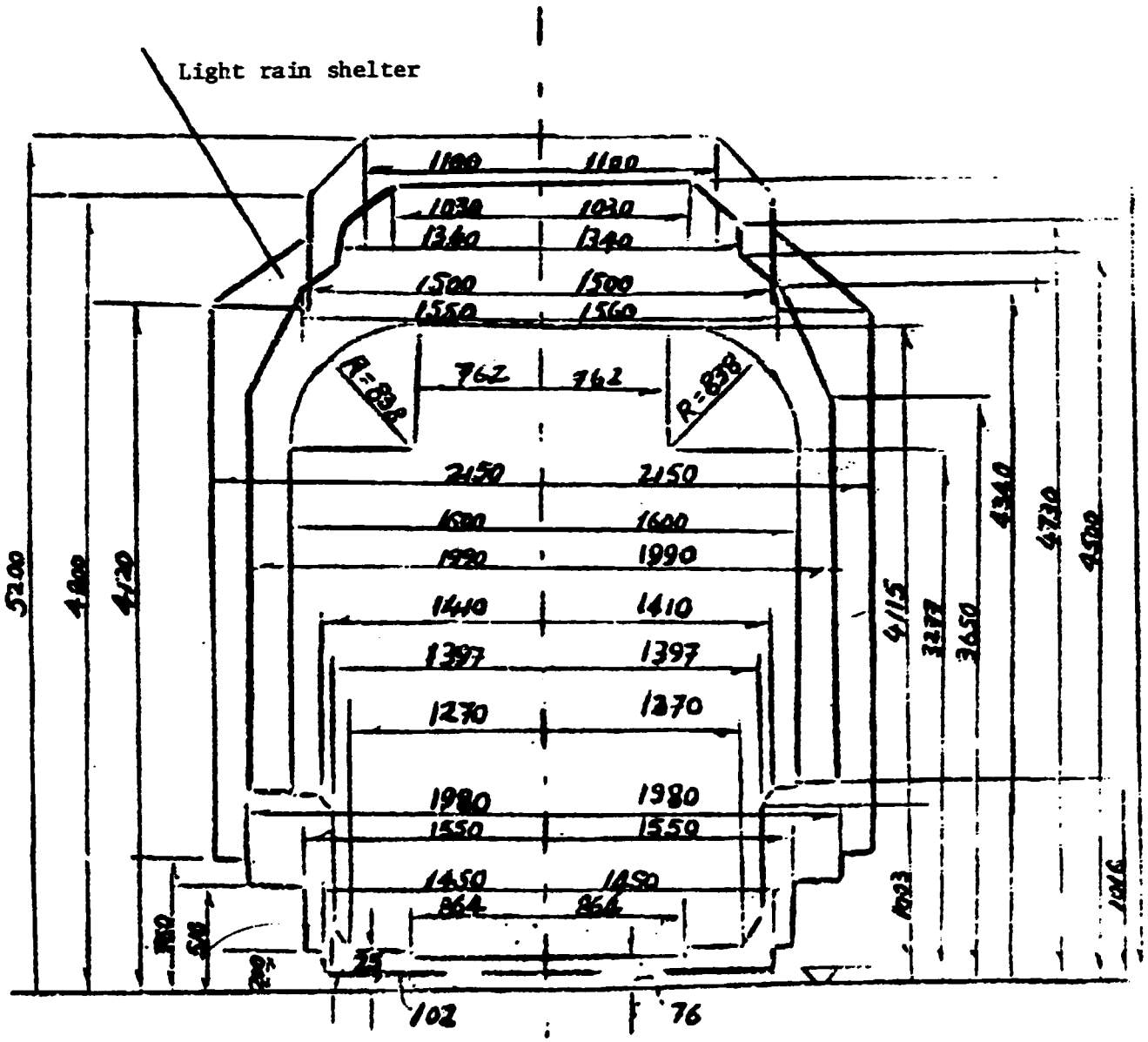
RP/URT/84/006 - Proposed Project Budget Covering Government Contribution in Kind (Tanzanian Shillings)

	Total		1985 - 86		1986 - 87	
	m/m	T.S.	m/m	T.S.	m/m	T.S.
PERSONNEL						
Engineer-Project Director	16	104,480	10	65,280	6	39,200
Supervisor- Mobile Brickmaking	16	90,000	10	56,250	6	33,750
Plant Operator/Mechanic-Mobile Brickmaking	16	90,000	10	56,250	6	33,750
Driver	3	16,800	2	11,200	1	5,600
Administrative Support	7	35,000	3	15,000	4	20,000
Brickmaking Labour (30)	360	216,680	180	108,340	180	108,340
TOTAL - Personnel		552,960		312,320		240,640
EQUIPMENT						
Office-Building Research Unit		24,000		14,400		9,600
Office/Store - Mobile Brickmaking Sites		40,000		20,000		20,000
Drying sheds		80,000		50,000		30,000
TOTAL - Equipment		144,000		84,400		59,600
MISCELLANOUS						
Vehicle operations		221,500		21,500		200,000
Brickmaking supplies and MBU fuel		445,000		222,500		222,500
TOTAL - Miscellanous		666,500		244,000		422,500
TOTAL		1,363,460		640,720		722,740

Government Financial Year from July to June.
Transport - allowed 1,200 km truck à 100/- plus running costs UN project vehicle.
Brickmaking supplies-fuel (wood and coal) based on estimate of max. 850,000 bricks with coal à 2000/- per ton and wood at 450/- per m^3, delivered.
Assumed diesel requirements for MBU operation = 4 500 litres.

ANNEX IV

Clearance Diagram for Structures, Locomotive and Rolling Stock Gauge and Loading Gauge for Out-of-Gauge Load



The middle thick line is loading gauge for out of gauge load

The outside thin line is clearance diagram for structures while the inside one is for locomotive and rolling stock gauge