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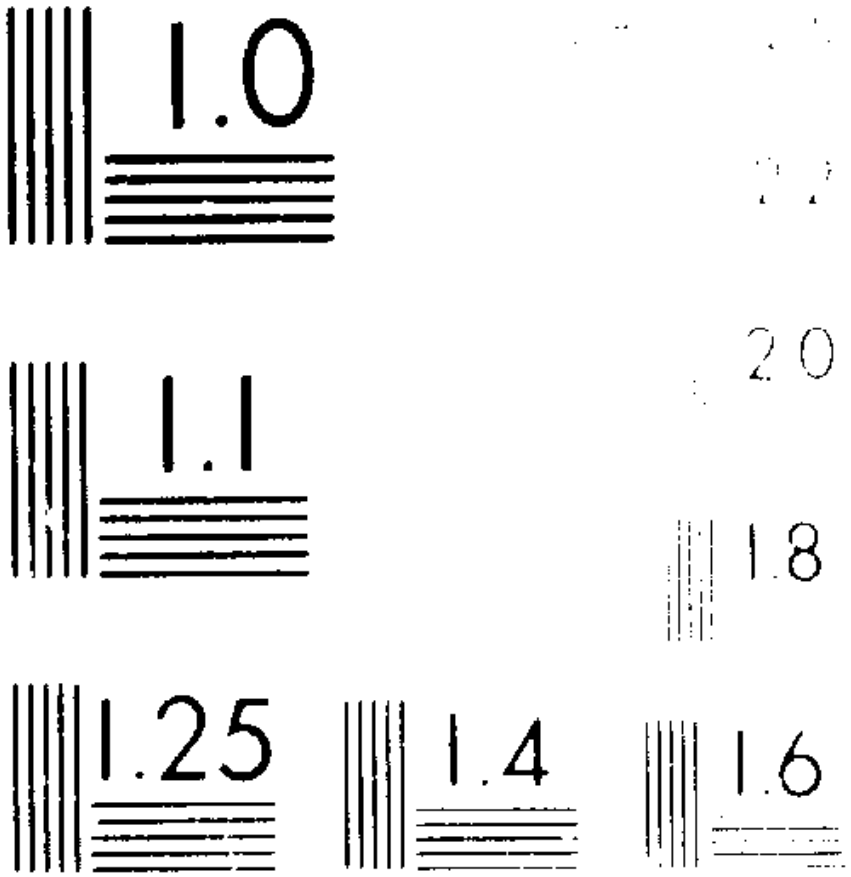
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15 April 1982
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DEVELOPMENT OF NEW TIMBER PRODUCTS.
DP/KEN/77/007
KENYA.

Terminal report*

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

Based on the work of C.R. Francis, expert in timber engineering

United Nations Industrial Development Organization
Vienna

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INTRODUCTION

A UNIDO project in Kenya from January 1975 to October 1978 was instituted to develop low-cost prefabricated wooden bridges and other timber engineered products. The main results of this project are described in UNIDO report DP/ID/SER.A/201 "Low-cost modular prefabricated wooden bridges".[1/] The aim of this project was to demonstrate timber engineering possibilities at a village technology level, or not much higher. For example only hand and portable electric tools were employed.

It was realised during this project that there was considerable potential in Kenya for increased use of timber construction and other utilisation at a rather higher level of industrialisation such as could be obtained by the use of basic woodworking machines. A new project was therefore formulated based on the provision of an adequately equipped machine workshop to demonstrate modern techniques for the manufacture of timber structures, joinery, furniture, etc. It was hoped that this would assist in the economic utilisation of the excess quantities of softwood timber projected to appear on the Kenya market.

The initial bridge construction project would be continued. Supplementary to the original project, a mobile timber preservation plant had been provided, but had not been commissioned. (Project VC/KEN/76/051). The commissioning and demonstration of this plant were also included in the Project.

[1/] This has been revised by Mr. Francis in October 1981.

PROJECT IMPLEMENTATION

Staff

Four international staff were recruited. These were Mr. C. R. Francis, timber engineer (Team Leader); Mr. S. K. Petersen, timber engineer; Associate Expert; Mr. F. Sorensen, timber technician and U. N. Volunteer Mr. V. Palcong, woodworking instructor. Mr. Petersen had been Associate Expert with the previous bridge project and remained in Kenya to initiate this project until the arrival of the Team Leader. The other members arrived a few months later.

The counterpart staff to be provided were to consist of a timber engineer, timber technician and a draughtsman. For most of the duration of the project only the first-named was available and his time was considerably occupied with work associated solely with bridges.

Since much of the programme was of a structural nature, an attempt was made to have a professional engineer seconded from the Ministry of Works. This was not successful. The expert considers that once the machines are functioning secondment of engineers or architects from other Ministries would be an excellent way of disseminating information on new timber construction techniques.

Workshop

It had been decided that the workshop building would be a laminated timber structure to demonstrate this form of construction. The location at Ngong Forest Station was without 3 phase electricity or water. There were considerable delays in constructing the workshop due to budgetary and administrative constraints. It has not proved possible during the duration of the Project to arrange connection of electricity to either the Project workshop or office which is on the same site. Consequently none of the machinery

supplied by UNIDO was able to be used and no practical demonstrations of industrial manufacturing or construction techniques was possible.

The whole project was designed around the concept of physical demonstration. Since this was not possible the project was largely a failure. Efforts were of course made to disseminate new ideas by magazine articles and preparation of manuals, but without being able to follow these up in any concrete manner most of their impact was lost.

PRESERVATION

There are fifteen pressure impregnation plants in Kenya, but only one diffusion plant. There is no regulatory system. The expert considered that as a first step to improving and extending preservation a suitable set of regulations was required. Consequently, a draft code of practice was prepared and submitted to the Kenya Bureau of Standards as a working document.

The major points included in this draft code and the reasons for them are as follows:

(1) Because of the variety of timbers available, a results type specification calling for specific loadings rather than a process type specification was adopted. Initially this may involve more analysis than a process specification, but it can cover a far wider range of timbers with differing absorptive capacities.

(2) Branding with the Bureau mark has been made mandatory and a system of inspection by the Forest Department suggested. This gives the code legal teeth within existing legislation and is essential if the code is to have any effect on quality.

Various levels of preservation have been suggested, based on

New Zealand practice. It may be that too many levels have been included and if preferred by the drafting committee some of these may be deleted. Also, the retentions and penetrations suggested may, if preferred, be altered to slightly differing figures without ill effect.

The code contains considerably more practical advice than is normal with a publication of this type. However, there is so much ignorance at all levels, both in the specifying professions and in the timber industry, and so few people with an in-depth knowledge of preservation in Kenya that the expert considers the slight additional cost involved in printing this advice is well justified as an effective way of disseminating this information.

DIFFUSION TREATMENT

There is only one company undertaking diffusion treatment in Kenya, and then on a not very satisfactory base. The expert considers that much wider use of this process should be made. The process is simple and capital costs are minimal. The process can provide adequate protection for the bulk of building timber used in Kenya, i. e. timber subject to termite attack but not subject to decay.

The diffusion chemicals sold in Kenya are the early BFCA[1/] formulations developed in Australia over 20 years ago. Modern thinking is that inclusion of chromium in this formulation inhibits the efficacy of this mixture and the simpler BFA formulation should be used. Experience in New Zealand with unfixed arsenic shows that early fears of poisoning are groundless, even when the arsenic is in the highly toxic tri-valent state.

Full details of formulations and background discussions are contained in the draft code (see above) and in the Project correspondence files.

[1/] Boron-Fluoride-Chromium Arsenic

A seminar was given to sawmillers at the Forest Industries Training Centre at Nakuru. This was well attended and there was considerable interest displayed. Several sawmillers expressed their intention of trying the process at their mills. The major factor inhibiting wider use of diffusion treated timber is ignorance of the benefits of treated timber in construction. To overcome this a publicity campaign by the salt supplier and wood preservers is required.

The major factor against the use of this process is the practice of milling dry logs. Diffusion can only take place in green timber and if it is to be successfully introduced then the inclusion of dry timber in preservation charges must be prohibited by Forest Department inspectors.

PREFABRICATED/PRECUT BUILDINGS AND COMPONENTS

The general standard of carpentry in Kenya is very low. Various factors contribute to this, all more or less interrelated. These include low public esteem of timber construction, lack of suitable materials, lack of training opportunities, ignorance in design professions.

The initial problem to be solved is use of good quality materials. Although high grade timber is available, the dimensional accuracy of sawing in sawmills is very poor and unlikely to improve without radical changes in the sawmilling industry. A primary requirement for economic timber construction is the ready availability of dimension timber. Ultimately this means the integration of planing with sawmilling facilities. This will only ever arise if there is a market justification. To demonstrate the advantages of dimensional accuracy, it is

recommended that all timber to be used in construction at the Project workshop and also at the F. I. T. C. (at Nakuru) should be planed to dimension. In this matter the Forest Department can give a lead to the rest of the country.

Because of the lack of operating machinery, there was no opportunity to demonstrate precutting or prefabricated techniques. Preliminary designs and a trussed rafter manual were prepared.

Most roofs in Kenya are pitched and framed from timber. The commonest system employed on domestic and commercial buildings constructed by the public and private sectors, is a system where heavy widely spaced trusses support under purlins which in turn support intermediate rafters. This is all framed in situ with considerable packing and trimming necessitated by variations in timber dimensions. It was also observed that the general standard of carpentry on building sites was low and that roof construction on a single building could occupy a period of more than a month.

These observations, together with the fact that something of a building boom is in progress led the expert to consider that the time was ripe for the introduction of trussed rafter manufacture. A comprehensive manual on the manufacture of trussed rafters was prepared and distributed [1/]. Various manufacturers capable of making the steel plates were contacted. A fairly favourable reception was given by the Ministry of Works architects, although unfortunately no architect there has any experience of construction using off-site fabricated trussed rafters and their advantages.

It is recommended that the Forest Department should collaborate with the Ministry of Works in promoting these components. The following points are critical:

Factory fabrication is essential - on site manufacture is unsatisfactory;

[1/] Reproduced as DP/ID/CER.A/353.

Planed timber must be used for accuracy.

Details of design, spacing, etc. are of secondary importance although it is believed that the designs given in the Manual are satisfactory for general use in Kenya.

PRECUT HOUSE FRAMES

There are various degrees of prefabrication of houses possible, ranging from complete site construction (zero prefabrication) to complete factory construction as exemplified by the American mobile home industry. Lowest cost solutions to the question of where in this range the optimum degree of prefabrication lies depend on complex relationships between cost of skilled and unskilled labour capital, transport, site security and social factors. There is no one answer applicable to all situations.

The expert considers that factory precutting of wall frames may be close to an optimum for conditions in Kenya. The level of carpentry skill is obviously insufficient for reasonable quality timber buildings to be constructed on a complete in situ basis. This is borne out by the low quality of what timber framed construction there is. There are several prefabricated house factories, but the buildings are relatively expensive due to the high capital costs associated with factory operations in Kenya.

The technique of precutting with site assembly of frames concentrates the scarce skill requirements in the factory with minimum capital requirements and takes advantage of cheap semi-skilled site labour.

The key operation in precutting is the office work involved in preparing the setting out diagrams and cutting lists. This has been explained in detail to the counterpart and the steps are repeated here in summary.

(1) Prepare standard details of wall corners, both interior and exterior, wall to partition junctions, door framing details, window framing details for the standard sizes of doors and windows used. Dimension these in running dimensions from left to right, looking from the inside.

(2) Depending on whether outside sheathing sheets, if used, or interior lining sheets are more expensive, draw up running dimension series of stud spacings to suite the sheets in use.

(3) For a particular building choose a starting corner. Work round the building clockwise coding each section of wall (W) window (F) door (D) and numbering these in order. Thus a rectangular hut with a door in the front and a window in the back would have a series W1, D1, W2 (front wall); W3 (end wall); W4, F1, W5 (rear wall); W6.

(4) From the standard dimensions in 1 and 2 compile running dimension tables for top and bottom plate set outs.

(5) For each W, F and D section prepare cutting lists. Most of these are standard, calculation of lengths being mainly confined to odd length noggings.

(6) Prepare a diagrammatic plan of the W, F and D locations, giving key running dimensions of door, window and wall intersections only.

Factory operations are:

(1) Top and bottom plate set and cutting. This is the most skilled job.

(2) Cutting of standard studs, noggings, lintels, etc. Much of this can be stockpiled in advance of specific works, depending on the degree of standardisation of joinery and building practice.

(3) Cutting of special length components.

(4) Bundling and strapping of components for each W, F and D section.

Site assembly is thus restricted to:

(1) Nailing the various components into wall sections, lengths being dictated by the plate lengths supplied.

(2) Squaring and bracing these sections.

(3) Erection of these sections and connecting them together.

If prefabricated trussed rafters are also used it should be possible for four men to complete the outside skeleton of a 100 m^2 house in a week, ready for roofing and cladding.

The success of precutting depends on:

Availability of precision timber,
Standardisation of building and joinery details,
Efficient preparatory office work,
Skilled plate set-out carpenters.

Factory equipment, excluding any necessary sizing machinery is limited to set out benches, radial arm saws and a steel-strapping machine.

Office work can be speeded by making use of printed forms of cutting lists. Preprinted drawings of assembly details should be issued with each job, also the layout diagram and a cutting list which acts as a delivery docket to check complete delivery.

The lack of operating machinery did not allow demonstration of these techinques, which are applicable to houses, schools, commercial premises - in fact any timber framed building.

MARINE STRUCTURES

Kenya has a need for marine structures mainly jetties, associated with the fishing industry. This industry is being actively promoted, initially by provision of processing plants and cold stores. Most fishing is done from traditional boats such as dug-out canoes which are beached when not in use. In due course more modern boats may be introduced which will require docking facilities, but at present there are few of these.

Several sites were surveyed, but none could be found where a jetty within the Project's budgetary constraints could usefully be constructed. No other financial assistance was obtainable except for one site in a very remote location on Pate island. This jetty was being built by villagers on a self help basis and some funds were available. However, logistic problems and the remoteness of the area were such that it would not be of any use as a demonstration.

A comprehensive manual on jetty construction was prepared and widely distributed round Kenya[1/]. This contains detailed materials specifications, illustrated construction techniques and detailed drawings of typical jetty, wharf and pontoon structures suitable for small boats.

The expert recommends that the Project should maintain contact with the Fisheries Department and at suitable opportunity should construct a jetty according to the principles described in the Manual.

GLUE LAMINATION

A small volume of glued laminated timber (glulam) is manufactured in Nairobi for architectural purposes. The portal frames for the Project workshop were manufactured at the old bridge workshop using a small borrowed jig.

Manufacture of glulam components of any size must be done using

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[1/] Reproduced as DP/ID/SER.A/317.

proper equipment. This must include as a minimum a mechanical glue spreader, a full size jig and pneumatic or electric impact wrenches. The reason for this is the time limit imposed by the gelling time of the glue. This time is shortened in high temperatures. Any attempt to skimp on any of the three items above will lead to increased assembly time, probably exceeding the permissable, with consequent delamination failure.

Because of the expense of the minimum capital equipment required for even demonstration glulam manufacture, the expert deemed it advisable to search for a likely volume market. The only one with a degree of standardisation appeared to be short span highway bridges. These have been developed to a high degree in North America and have demonstrated a high level of economy and durability. In particular, the concept of clipping deck baulks on to the sides of beams with elastic fastenings accessible under the deck has eliminated the problem of deck spikes loosening under the high vertical accelerations induced by traffic.

The rural access roads programme, advised by an ILO Engineer had encountered problems with precast concrete bridges, and this engineer was enthusiastic about the possibilities of glulam bridges. The expert designed a series of single lane bridges up to 10 m span and also designed and costed a 10m x 1.2m glulam manufacturing jig. By the time the expert's proposals were complete, the ILO engineer had left Kenya, and advice on bridging was being given by an elderly expatriate engineer who appeared to be completely ignorant of post war developments in timber engineering. The expert's suggestions were rejected out of hand.

The expert considers that glulam highway bridges have a definite future in Kenya, the more so as imported fuel costs for cement manufacture inevitably continue to rise. Admittedly, at present, the import content of glue for glulam manufacture mitigates against the use of glulam, but with the possibility of tannin formaldehyde glue

manufacture from locally produced wattle bark, glulam should show significant advantages in terms of overall imported content.

The expert recommends that contact should be maintained with the MoTC with a view to agreeing to the supply of, say, two short span bridges to the designs prepared by him. This would justify to a fair degree the cost of the necessary manufacturing equipment. Also, at any time that Forest Department officers are travelling in industrialized wood-using countries, opportunities should be taken to visit glulam plants, preferably old fashioned ones, whose technology is more appropriate to Kenyan requirements than highly automated high production units.

A technical report "Glulam Bridges for Developing Countries" (DP/ID/Ser.A/322) was prepared which describes the manufacture, design, erection and costing of a glulam bridge factory for a programme of the size required in Kenya. This report has been written in quite general terms, but in fact the labour and materials costs used are approximately those prevailing in Kenya and the report is thus directly relevant to Kenyan conditions.

TANNIN FORMALDEHYDE

It was suggested in the Project Document that the Project should investigate the manufacture of adhesives from cashew nut shell oil. The expert is acquainted with the idea of manufacturing natural phenolic formaldehyde adhesives, but is also aware that investigations of this nature are the province of skilled polymer chemists which he certainly is not. Also, there was no one on the staff of the Forest Department who had any qualification of this type. This item was therefore deleted from Project activities.

Some time later, a paper appeared in Forest Products Journal describing the manufacturing of phenolic adhesives from wattle (acacia) bark. This interested the expert to the extent that a

partial survey of urea formaldehyde consumption in the plywood industry was undertaken, also the production volume and prices of wattle bark extract were ascertained. A necessarily rough calculation showed that:

(1) It appears possible to manufacture tannin formaldehyde (TF) glue at the same cost to the consumer as imported urea formaldehyde (UF) glue.

(2) The present wattle bark extract industry has ample capacity to supply the plywood industry's requirements for TF.

(3) By diverting wattle bark into TF manufacture, the loss of export sales would be more than balanced by savings in imports of UF.

A chemist has recently been attached to the Utilisation Section at Karura. It is recommended that he should research TF manufactured from locally produced wattle bark and check its suitability for the manufacture of plywood, particleboard and glulam, in that order.

SOLAR KILN

A major handicap to the furniture industry of Kenya is the non availability of dry timber. This problem was investigated by the expert with various contacts with the furniture manufacturers. There appeared to be two reasons for the low use of dry timber in furniture manufacture.

(1) No premium is paid for furniture made from dry timber. It is purely a matter of whether it looks satisfactory as a sample at the point of sale. Caveat emptor.

(2) Timber producers or millers cannot recoup their drying costs from purchasers. Quite apart from this there is no source of working capital for producers to be able to even try and offer dry timber,

charging the storage and handling costs to their eventual customers. This is particularly the case of small pit sawyers who do the initial conversion of native hardwoods and who traditionally sell flitches to city resaw mills at disadvantageous prices. Quite apart from kiln drying, even air drying to which the climate in Kenya is admirably suited is not practised.

A memorandum on this subject has been sent by the expert to the Assistant Minister who oversees the Forest Department in late 1979. The major point made in this memorandum was that if the Government wished to promote furniture manufacture for export from dry timber, the cheapest way was to guarantee working capital charges, with a corresponding inspection system to ensure that no cheating was done by dryers. At a personal interview with the Assistant Minister he had no recollection of ever having seen this memorandum.

The expert recommends that his memorandum should be found in the Ministry files and presented to the Assistant Minister for his consideration.

Air drying even in the best climatic circumstances is slow and generally in Kenya leads to case hardening. A kiln where relative humidity can be controlled is preferable and in most cases quicker. The expert had considerable experience of low temperature diesel fired kilns and combined this with current solar technology to produce detailed designs for an industrial scale kiln. It was apparent from the available literature and from correspondence with experts in the field that the main problem was not absolute efficiency but cost effectiveness. Also there is wealth of experience with pilot sized kilns of 1 or 2 cubic metres capacity but almost none of kilns of a commercial scale. The expert accordingly designed a kiln of commercial size with a gross charge volume of 1.8m x 12, - net capacity approximately 16 - 20m^3. Since this was a commercial sized kiln, the expert decided that it should be in an area where:

(1) A fair volume of timber required to be dried continually.

(2) Forest Department personnel were available for operation.

(3) With the workshop experience of no electricity or water, these services were easily available.

(4) A reasonable amount of sunlight was available, free from shade trees or other obstruction.

(5) Flat land and heavy vehicle access existed.

The only site which met all these requirements was Karura Forest Station. A site was selected, with the general approval of the Chief Conservator of Forests but when pegged out was vetoed by the officer in control of the area as it might have conflicted with vague future expansion plans. An alternative site was offered by this officer which was totally unsuitable for a kiln of any description, consisting of a 2 - 3m deep bank on the edge of unconsolidated fill without suitable vehicular access for loading and unloading large volumes of timber.

During these site negotiations a considerable quantity of expensive "Tedlar" film was purchased by UNIDO for the solar collector. This is in store.

It is recommended that if the Forest Department is genuinely interested in the construction of a solar kiln, that a suitable site should be selected according to points 1 to 5 above, and materials corresponding to the detailed drawings prepared by the expert should be stockpiled. Then a further approach might be made to UNIDO for expert assistance in actually constructing and operating a kiln without lengthy periods being wasted in awaiting inter-departmental decisions.

GYPSUM BOARD

The only wall and ceiling lining boards available in Kenya are wood based. All are inflammable. The inflammability of timber framed buildings lined with these boards is a major factor against their wider use.

Paper faced gypsum board has been imported for use in prestige buildings but is not produced in Kenya. In ary case, the minimum capital and production levels for this material are far above Kenya's capacity.

Gypsum is fairly widespread in Kenya, and one geological opinion expressed to the expert was that no one knows just how extensive the deposits are. Gypsum will also be a by-product of the proposed fuel alcohol plant.

A lining board composed of plaster of Paris reinforced with sisal fibres has been in use in Australia and New Zealand for 60 or 70 years and is still the preferred material for ceilings. The manufacturing process is simple, low in capital requirements and can be undertaken on a small scale. It is moderately labour intensive.

A report on the manufacture of fibrous plaster board was prepared and distributed round various Ministries, including those of Environment and Natural Resources (Mines Department) and Industry. Pilot manufacture of 8ft x 4ft and 4ft x 4ft sheets was started at the Project workshop. Satisfactory casting procedures were worked out, but further development of transfer from casting table to drying rack, and refinement of the drying racks themselves is required.

It is recommended that this work should be continued. Then fire demonstrations should be carried out before officers of the Ministry of Works, Nairobi City Council and Architectural Association of Kenya. These demonstrations should take the form of huts 8ft cube with door and window spaces, lined with fibrous plaster

board, and softboard/hardboard combinations. Ignition should be by rags soaked with several litres of kerosene. A fire resistance rating of about half an hour should be expected with 12.7mm board.

It should be noted that use of this material is not confined to timber framed buildings but should also be used in ceilings of masonry buildings and office partitioning systems on the grounds of quality, fire resistance and durability. A manufacturer can therefore commence operations with an existing market awaiting penetration.

SUMMARY OF RECOMMENDATIONS

Preservation

Work should proceed in the Kenya Bureau of Standards on the preparation of a Code of Practice based on the expert's draft. The preservation industry should then be policed by the Forest Department so as to raise standards of preservation. Diffusion treatment as described in the draft code should be promoted amongst small sawmillers cutting plantation softwoods. To generate consumer interest a publicity campaign funded by preservative salt suppliers and wood preservers should be instituted.

Prefabricated/Precut Buildings and Components

The project should construct several buildings on a "precut" basis. These could be any of a variety of buildings required by the Forest Department building programme. They should be provided with prefabricated trussed rafters.

After some experience has been gained both with the manufacture and marking of kitsets and their erection, publicity should be given to the speed and precision of erection.

Only planer gauged timber should be used. The Forest Department should work in collaboration with the Ministry of Works to obtain

mutual experience in trussed rafter construction. The ultimate aim should be the setting up of small factories in various provincial locations.

Marine Structures

The Project should maintain contact with the Fisheries Department so that good advance notice of any proposed jetties is obtained. This will allow time for survey, felling peeling and drying of poles for pressure treatment. The project should construct a jetty, using a maximum of factory cut pieces for the Fisheries Department.

Glulam

The project should maintain contact with the Ministry of Transport and Communications in the hope that their present conservative thinking will change to a more rational and modern approach.

Tannin Formaldehyde

The chemist at the Utilisation section at Karura should include research into this material in his work plan.

Solar Kiln

A site should be selected bearing in mind the factors described in the report. A kiln of the cross section shown in the project drawings and at least 6m long should be built using the Tedlar film supplied by UNIDO.

Gypsum Board

Manufacture of board to the formula given by F. Sorensen should continue. A handling trolley and better drying rick should be made. Fire resistance demonstrations should be performed (after an initial private exploratory test). Gypsum board should be used in all timber framed buildings built by the project. Firing and finishing should be in accoreance with the instruction booklets provided by H. Bradley Pty. Ltd.