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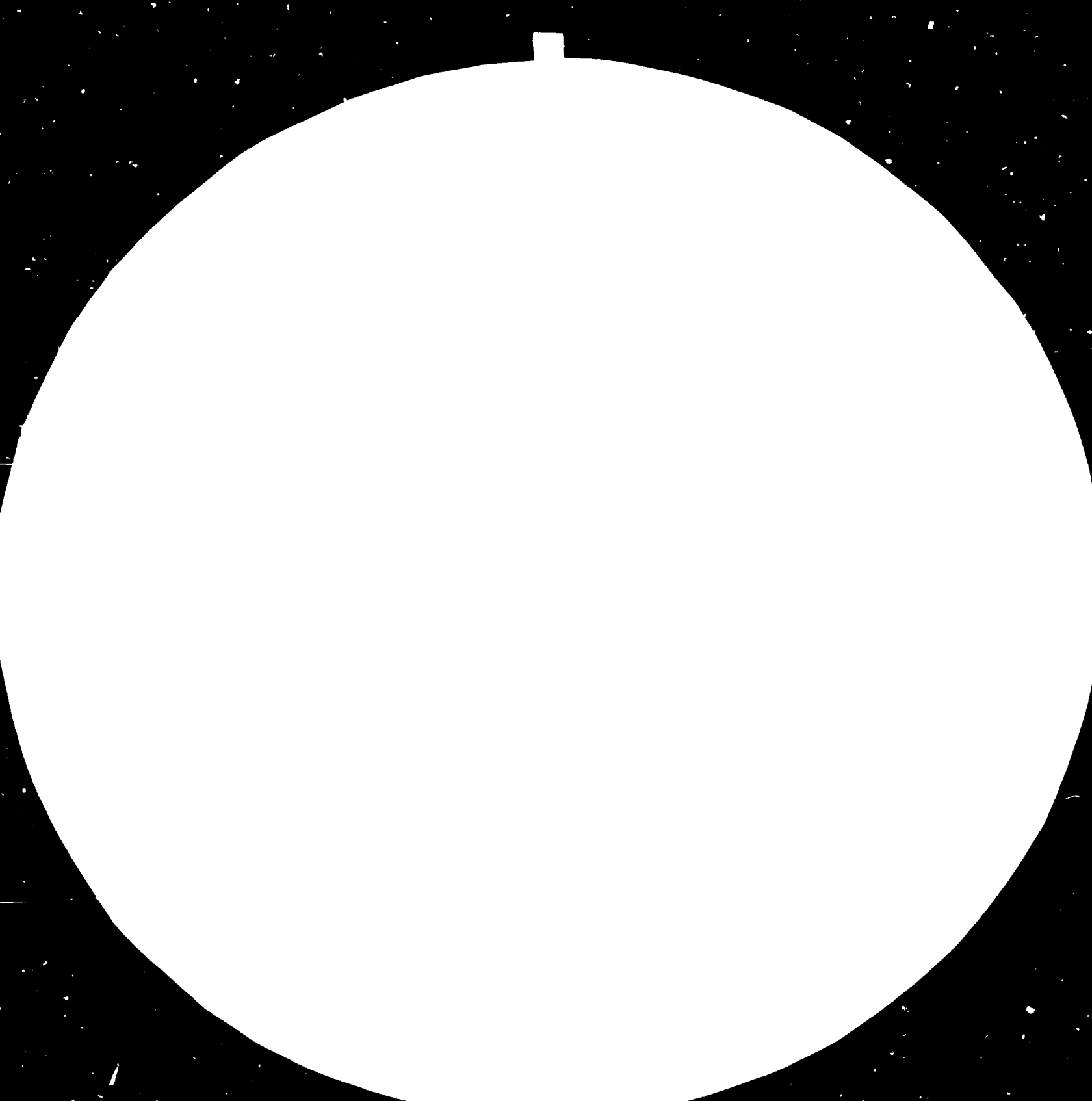

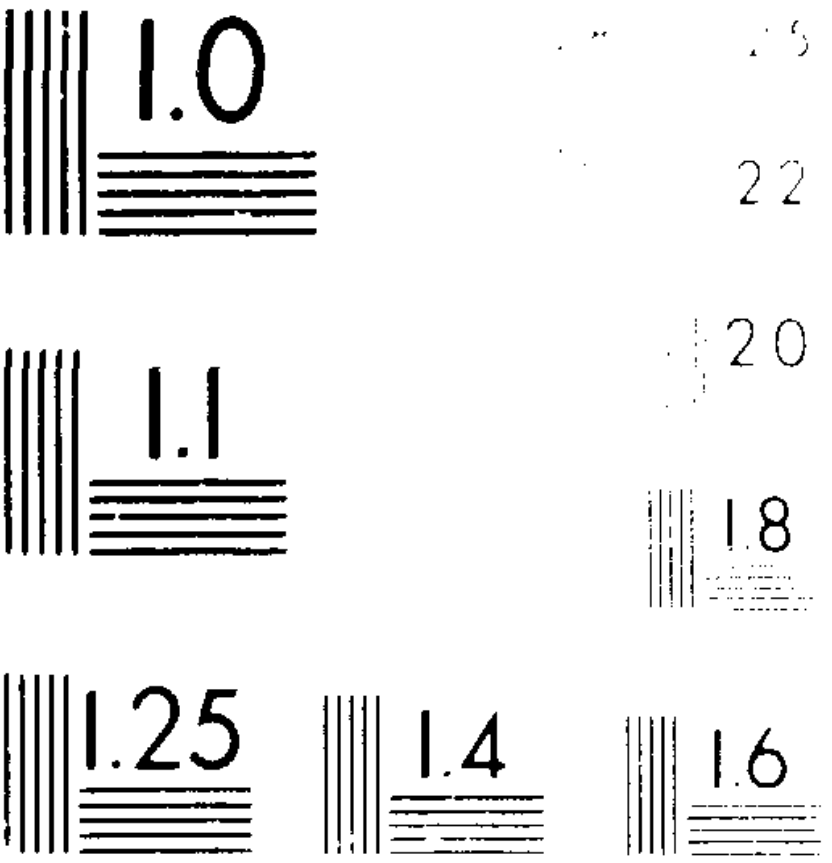
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Sri Lanka.

RESEARCH AND DEVELOPMENT FOR THE UTILIZATION OF RUBBERWOOD AND COCONUT WOOD

DP/SRL/79/053

SRI LANKA

Terminal report*

Prepared for the Government of Sri Lanka
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, Chief Technical Adviser
and K. Bergseng, Expert in Sawdoctoring

United Nations Industrial Development Organization
Vienna

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TERMINAL REPORT

1. PROJECT OBJECTIVES AND LOGIC

The stated objectives of the project were to:

(a) Aim at upgrading the existing traditional secondary wood processing industries from craft (or partly mechanized) operations to industrial (serial) production using a level of mechanization and a technology commensurate with the country's stage of development.

(b) Aim at alleviating the present shortage of raw wood material in the country through the development of technology for the processing and utilization of mature rubberwood trees and coconut palm stems.

Sri Lanka suffers from a shortage of timber, particularly of scantling and structural timbers. This is partly satisfied by the importation of Kempas and other species from Malaysia, by illegal felling and by the manufacture of traditional hand hewn coconut rafters.

There is a fairly large annual availability of mature rubberwood stems estimated at 600,000 cubic metres (21 million cubic feet). Rubberwood stems are short, only about 2.5 metres (8 feet). The logs are prone to develop tension wood, which warps during drying. It is also prone to sapstain, insect and fungus attack. Its traditional use is for firewood.

Coconut is also available to an estimated quantity of 1.2 million stems per year. If, because of poor form, only 60 per cent of these are potential sawlogs, this still represents a large potential timber resource.

Borwood Ltd. was set up by the Industrial Development Board in 1972 to process rubberwood and to manufacture furniture from it. It has successfully overcome all the problems associated with rubberwood except that of small log size. It operates a sawmill with wide band resaw, boron treatment plant, air drying sheds, pilot scale solar kiln,

wastewood fired conventional kiln, woodwork machine shop and furniture factory. Its supervisory staff are well qualified and many have attended timber industry training courses in Denmark and other countries.

While not located in the "Coconut Triangle" the Khandane factory near Horana has a fair number of coconut plantations in the vicinity and transport costs for bringing coconut logs from the Coconut Triangle are not excessive. With this reasonably readily available raw material it was decided to include coconut sawing and processing on an industrial pilot scale rather than a merely research scale in the project. This would allow use of other processing facilities existing or projected at Horana for rubberwood to be also used on coconut wood.

2. PROJECT ACTIVITIES

The project activities are broken down into four main fields, some with sub-divisions:

(a) Establishment of a structural timber manufacturing unit. The processes introduced here include:

- Fingerjointing
- Fourside planing
- Glue lamination
- Trussed rafter manufacture

(b) Establishment of a solar drying kiln

(c) Establishment of a pressure treatment plant

(d) Pilot scale sawing of coconut wood

Since it was necessary to maintain tungsten carbide-tipped (TCT) cutters, the process of diamond wheel grinding was also introduced; and a small workshop and store were installed for construction, servicing and maintenance.

3. ESTABLISHMENT OF A STRUCTURAL TIMBER MANUFACTURING UNIT

3.1 Fingerjointing

A small fingerjointer and press were installed as part of the overall Horana factory. A universal tool and cutter grinder was also installed to maintain the fingerjointing cutter and staff were trained in fingerjoint manufacture and cutter maintenance.

Full technical instructions are contained in "Technical report: Structural Fingerjointing of Timber" based on the work of Mr. C. R. Francis (DP/ID/SER.A/530).

The introduction of fingerjointing was primarily in conjunction with glulam manufacture but it now forms an important part of the general factory operations. It extends the lengths available from the short rubberwood logs and also allows the use of warped tension wood which is very common in rubberwood.

The fingerjointing team works well and rapidly and the Chief Technical Adviser congratulates the counterparts and workmen.

The equipment was purchased reconditioned ex the U.K. The press operates on air over hydraulics. The return of the clamping rams is by air and this leaks up the hydraulic cylinders and collects in the flexible hoses whence there is no provision for bleeding it. This prevents full clamping pressure from being applied. The CTA recommends that this machine should be modified by constructing an oil-filled reservoir of about 40 in^3 capacity, three quarters filled with hydraulic oil. The return air should be fed to the top of this reservoir and the oil led to the bottoms of the return cylinders. This should overcome the malfunction of this machine, which in the CTA's opinion is one of poor design. This work could readily be carried out with equipment available at the factory.

3.2 Planing

A 30 year old reconditioned Robinson six-head fourside planer was provided. This provided facilities for blanking, square dressing after fingerjointing and finishing of small glulam sections up to its capacity of 30 cm x 10 cm (12" x 4").

Planing is a routine woodworking operation familiar to all the counterparts. No technical recommendations are made.

However, the balance provided for the cutter balancing on this machine should be returned to the planer and not used in the laboratory for moisture content determination, etc. Balanced cutters run with least vibration and ensure long spindle bearing life. Failure to balance cutters results in bearing failure.

Strict discipline must be imposed on workmen always to complete a job on the planer, and not to leave it half finished. An expensive accident occurred because of a workman leaving cutter bolts un-tightened while he went for tea.

3.3 Glue lamination

The manufacture of the glue lamination (glulam) jig and associated equipment was carried out very competently on the site by local staff using welding equipment and tools supplied by UNIDO. The total cost of welding equipment, etc., plus wages, plus raw materials, was about the same as having the jig made by an engineering company and had the advantage that the equipment would then be available for any other manufacturing or maintenance work required elsewhere in the factory.

It did not prove possible to transfer one of the written-off UNDP refrigerators to the project for the purpose of glue cooling. It is recommended that the factory should try to purchase a refrigerator of about 7 cu.ft. for this purpose. Also bulk glue supplies should be stored either in a cold store or at high altitude to lengthen shelf life.

The glulam crew worked well and efficiently and quickly learned to produce good quality glulam. All detailed manufacturing and supervisory details are contained in "Technical report: Manufacture of Glued Laminated Timber" based on the work of Mr. C. R. Francis (DP/ID/SER.A/534).

There is a tendency for workmen to be over zealous in tightening the clamps. With low viscosity glues this may result in starved joints. Also with 1" timber, cauls should always be used back and front to distribute the clamping pressure and to avoid the creation of local irregularities at the clamping points.

Some of the early production beams were sent for testing to the School of Engineering, University of Peradeniya. The summary of the report of Prof. Ameratunga forms Annex I.

The CTA is entirely satisfied with the glulam manufacturing operation and congratulates the counterparts and workmen for their ability and enthusiasm.

3.4 Trussed rafter maintenance

The CTA has inspected all available scantling-sized rubberwood with a view to using it for trussed rafter manufacture. He does not recommend that this species should be used for this purpose due to:

Short average length of pieces

High proportion of severe warp caused by presence of tension wood

There are possible ways around these problems, e.g:

Jointing either by nail plates or fingerjoints

Using laminated timber

These are not recommended on the grounds of cost, and in the case of fingerjointing because of the lack of adequate guarantees against tensile failure in the absence of structural proof loading.

Coconut wood offers the possibility of reasonably long lengths of scantling, say 15 foot, which allow construction of trusses up to a 24 foot span with single member top chords and only one joint in bottom chords which is normal practice for such spans.

Coconut has an estimated stress rating of F8 for outerwood. The designs in BS CP112 - part 3* can therefore be used for tiled roofs.

For nailed or nail-on plates 18ga galvanised steel sheet is readily available in Sri Lanka. The CTA recommends that this should be cut into 4" and 6" widths by a sheet metal shop. Four inch is the width most used, and initially 8 foot x 4 foot sheets should be cut to 9 4" strips and 2 6" strips and drilled to the pattern already demonstrated. This is the same as the pattern shown in Figure 1 of the UNIDO report "A Trussed Rafter System" (DP/ID/SER.A/353).

It would be preferable if the holes were punched rather than drilled since this would be much cheaper. However, enquiries have not yet resulted in locating a firm with a suitable punch to do this work. Once drilled, the strips may be cut to lengths required with the bandsaw shears in the sawdoctor's shop.

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* Now BS 5268.

Twenty-five lbs. of nails (clouts) suitable for truss manufacture were imported. Suitable nails are not manufactured in Sri Lanka, but the initial stock should be sufficient for preliminary promotional purposes. There are various manufacturers in Sri Lanka capable of manufacturing suitable nails.

These should be 10ga x 1½" flat head. A sufficient quantity would have to be bought to warrant a manufacturer setting his machine to that size, probably 1 or 2 cwt.

The factory engineer has been instructed in the basis of trussed rafter design and should be able to cope adequately with straightforward cases.

4. ESTABLISHMENT OF A SOLAR DRYING KILN

A pilot scale solar timber drying kiln was built at Horana in 1981 with assistance from USAID and has been operating satisfactorily since then. As part of the project it was proposed to design a much larger kiln capable of holding about 4,000 fbm of timber. There were major disagreements between the executing agency and Borwood Ltd. over the administration of this component of the project.

Eventually it was agreed that, in order to sidestep these administrative problems, the solar kiln component of the budget would be extracted and made to finance a Government executed project for the same purpose. In due course an agreement was signed with the U.S. Forest Products Laboratory at Madison, Wisconsin, to undertake the design and construction supervision of this solar kiln.

The Government executed project had only just commenced when this Project terminated and no designs had been received in Sri Lanka at the time.

5. ESTABLISHMENT OF A PRESERVATION TREATMENT PLANT

5.1 Pressure treatment

It was unfortunate that the pressure treatment plant was not completed in time to be commissioned by the CTA. However he is confident that the factory staff have sufficient experience and expertise to operate this successfully.

Full operating instructions and other background material are contained in "Technical report: The pressure treatment of timber" based on the work of Mr. C. R. Francis (DP/ID/SER.A/527).

Initially the plant should be operated using about 2.5 per cent borax-boric acid solution. Not until the operators are quite familiar with the process should treatment be attempted using the rather more hazardous CCA formulations.

It was very gratifying that the preservation plant cylinder tanks and bogies were fabricated in Sri Lanka. If future plants are proposed it should be noted that considerable amounts of foreign exchange can be saved by local fabrication of these items.

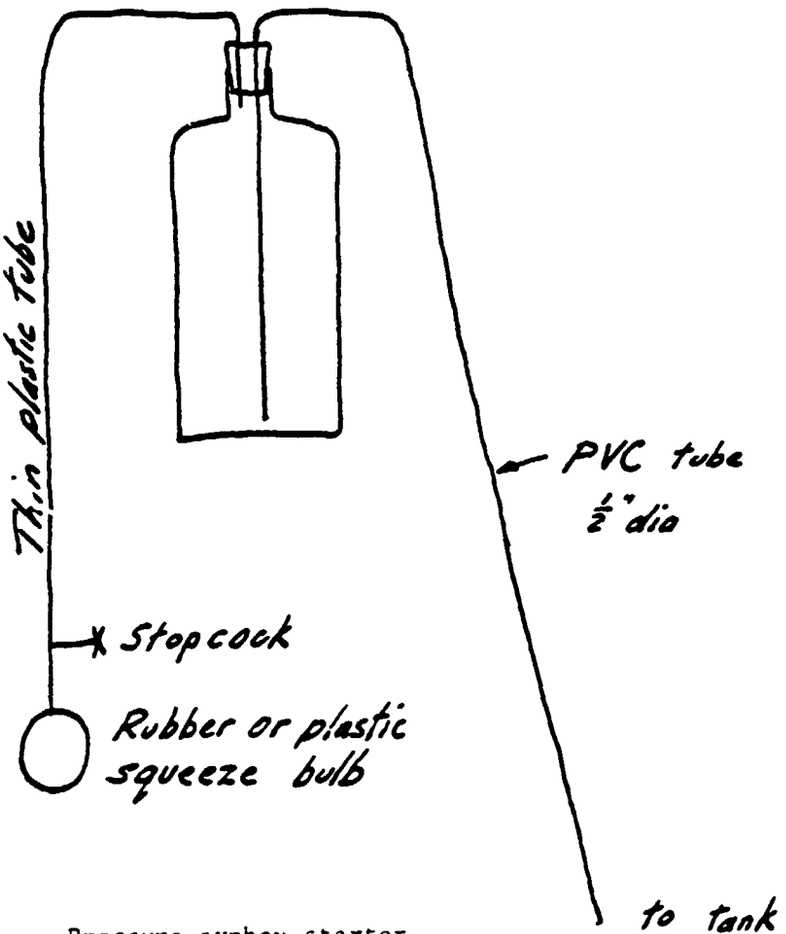
5.2 Diffusion treatment

The local climate and the diffusion properties of rubberwood are happily combined at Horana to permit simultaneous drying and diffusion. Since the diffusion process and its control are so well understood by the factory staff, the CTA recommends that the rather more protective ammoniacal copper-boron (ACB) formulation should be tried. This follows the recommendation by the eminent scientist Dr. A. J. McQuire who visited the factory in February 1984.

ACB complies with the National Project Director's requirement for non-toxic treatment chemicals. It may be applied by the diffusion process, but by immersion, not by showering. Showering would cause excessive evaporation of the ammonia and would be irritating to workers in the vicinity.

Due to the copper content, ACB is more effective against fungal decay than pure boron salts. It is recommended for use in components such as tile battens and exterior joinery.

The only caution with this mixture is that concentrated ammonia is a hazardous chemical. It should be added to the bath from an elevated bottle fitted with a pressure syphon starter of the type illustrated in the following figure. To operate, the stop cock is closed and the bulb is squeezed to start the syphon. As soon as liquid is flowing the stop-cock is opened and the bulb is slowly released. To stop the flow the stop cock is closed.



Pressure syphon starter

6. PILOT SCALE SAWING OF COCONUT WOOD

The existing equipment at the Kandane factory sawmill will presumably be used to cut coconut for a considerable period while procurement procedures are established, markets built up, and a new sawmill constructed.

The rack bench breaking down unit fitted with the new inserted tooth TCT saw is adequate for this initial work. In the interests of safety it should be fitted with a riving knife.

In order to improve saw stability it should also be fitted with ebony plug guides just behind the gullets. Fitting of this type of guide would also improve the stability of the solid plate saws and would reduce power consumption.

The screw type setworks on the bandmill are unsuitable for cutting out small logs due to their slow speed and reliance on operator judgement. The expert recommends the fitting of pneumatic stacked cylinders of various strokes working in series. If cylinders of 1", 2" and 4" were fitted, they would give sets of 1" to 8".

The expert has called for quotations for them in Auckland, New Zealand, and recommends that they should be fitted to the band resaw. Not only would they facilitate the cutting of coconut. but they would also improve the gradesawing of rubberwood.

6.1 More widespread sawing

The introduction of the tungsten carbide-tipped (TCT) inserted tooth saw opens the possibility of widespread sawing of coconut by existing sawmills with a minimum of additional investment. New equipment required for each mill would be:

Inserted tooth saw plate 8-90 guage, 36", 36 teeth
Three sets of TCT saw bits
10 spare keepers
Wrench
Total estimated CIF cost US$ 1,500

The TCT teeth would have to be sharpened at Kandane. The expert has already recommended the publicising of the availability of a sharpening service there. Such an arrangement would permit a sawmill cutting coconut to have one set of teeth in the machine, one set away being sharpened and one spare set.

The adoption of this idea by the IDB would permit the widespread sawing of coconut on a low-key basis. Since hand cut coconut rafters are already a traditional building material, there should be no problems of market acceptance by builders. Indeed the improved accuracy of a sawn over a hewn stick should be an incentive for carpenters to prefer the sawn material.

The major objection to this proposal is that the inserted tooth saws have a wide kerf of about 8-9 mm and the timber recovery suffers when such saws are used for resawing. The use of thin kerf saws is not possible on existing Sri Lanka sawmilling machinery. At the same time recovery using inserted tooth saws should be comparable with or better than recovery by hand splitting and hewing.

6.2 New sawmill

A proposal for a new sawmill is described in "Technical report: Sawing Small Coconut Logs" based on the work of Messrs. C. R. Francis and K. Bergseng (DP/ID/SER.A/528). The capital investment required for such a mill is high by Sri Lanka standards. Its potential productive capacity is far higher than any sawmill seen by the expert in Sri Lanka. Advantage has been taken of well proven modern developments in thin kerf sawing to combine the simplicity of circular saws with the recovery advantages otherwise offered only by bandsaws. The mill layout and machinery choices resulted from lengthy discussions between the CTA and the sawdoctoring expert who both have extensive experience in the types of machines recommended and of small log sawmilling.

It is hoped that preparation of the Technical Report will result in the installation of several such mills.

6.3 Sawdoctoring

The services of a sawdoctoring expert were an essential part in the coconut component of the project. It proved very difficult to recruit a sawdoctor. Finally the services of Mr. K. Bergseng, Principal of the New Zealand Timber Industry Training Centre were obtained for a one-month consultancy. He had been in Sri Lanka for only one week when the July 1983 rioting eruped and for security reasons he was repatriated. Mr. G. Alviar was then recruited and commenced work in November 1983. He had only been in Sri Lanka for one week when his wife was critically injured and he was repatriated on compassionate grounds. Finally, Mr. Bergseng was re-engaged and arrived in late January 1984 to complete three months' service.

The result of this chapter of mishaps and delays was that coconut was not sawn until March 1984 and then only on a trial basis. Sawing commenced in earnest in May 1984 when a supply of logs was arranged from the Coconut Plantation Authority, but flooding prevented delivery for several weeks.

6.4 Equipment

The sawdoctoring machinery was purchased by the CTA, who is not a sawdoctoring expert, with the advice of an FAO sawdoctoring expert who was leading a project with the State Timber Corporation. It was later discovered that the maximum pitch of the circular saw gulleter (Loroch) was too small.

The manufacturers were written to, asking if the pitch could be increased, but by the end of the project no reply had been received.

An alternative approach would be to make an auxiliary feeding plate from ½" steel plate for each large saw. Two such plates would be sufficient. They should be accurately divided on precision machinery. Suitable workshops exist in Colombo. In use the saw should be placed on the plate in the same position at every resharpening. This can be done by reference to the driving pin hole. The CTA recommends this approach as being the easiest and cheapest to implement.

6.5 Saw shop

The saw shop layout recommended by Mr. Bergseng was generally followed, but a less cramped layout was used. A new doorway into the adjacent room was constructed and the circular saw gulleters were installed there. This largely separates circular saw from band saw maintenance. Some improvement to illumination levels remains to be made.

6.6 Training

An intensive training effort was made to bring staff up to the skill levels required for techniques such as stellite tipping. The improvement in surface quality of timber before and after this training was very noticeable, and also the frequency of gullet cracking was markedly reduced.

During Mr. C. Dassanayake's fellowship in Rotorua, New Zealand, he was given concentrated training in stellite tipping. Fortunately the machine on which he was trained there was of the same type as that purchased for the project. This is not managerial work, and it will be his responsibility to train manual workers in this process.

A copy of the manual on sawdoctoring prepared under another UNIDO project by Mr. G. A. Woods, in English and Sinhala, was reproduced for use at the factory. This should be referred to constantly by both management and workmen to ensure that good practices are maintained.

The principal techniques revised or introduced included:

(a) Bandsaw levelling and tensioning. Poor techniques had crept into use over the year and these were eliminated and good practices insisted upon.

(b) Gulletting. The old Robinson gulleter was so worn that it was impossible to grind good tooth profiles. A filing clamp was provided and the filing of gullets, after grinding, was insisted upon. This practice significantly reduces the incidence of gullet cracking.

(c) Swaging, shaping and equalising. New tools and an equalising grinder were provided and workmen trained in their use. The use of swage guages was insisted on to check the accuracy of this work.

(d) Stellite tipping. A machine was provided, and also oxy-acetylene welding equipment. Mr. C. Dassanayake was given detailed training in this subject.

(e) Bandsaw welding. Previously bandsaws had been joined by scarfing and brazing, an obsolete technique for wide bandsaws. With the availability of oxy-acetylene equipment, a welding clamp was provided and workmen trained in saw welding techniques.

(f) Circular saw levelling and tensioning. A sliding centre bench was constructed for the existing anvil and staff trained in levelling and tensioning by hammer.

6.7 Future training

The range of subjects covered and the restricted time available necessarily made the degree of training rather superficial. Following the advice of the sawdoctoring expert an approach was made to the New Zealand High Commission in Singapore for bilateral aid scholarships to permit attendance by two or three trainees at the New Zealand Forest Industries Training Centre at Rotorua. The length of course and facilities

available there should continue to raise the standard of sawdoctoring. In this regard it is most encouraging that several potential candidates have started to learn English on their own initiative in anticipation of being selected.

The increase in quality of workmanship and improvement in morale in the sawshop at the end of the sawdoctoring expert's mission were most noticeable.

7. RECOMMENDATIONS

This section collects the various recommendations made in this report for further action by Borwood Ltd. and the IDB:

Fingerjointing

Modify the press by the addition of a 40 in^3 reservoir to supply oil at pneumatic pressure to the return side of the rams.

Planing

Balance cutters to prolong bearing life. Insist on a planer being left in a safe condition at all times. Make "DO NOT START" notices to hang on starting switches, with the name of the machinist. These notices to be removed only by the machinist.

Glue lamination

Arrange for resin cooling before mixing, and also for cool storage of bulk resin. Exercise strict control on clamping and always use cauls with 1" timber.

Trussed rafters

Continue search for plate punching facilities.

Arrange manufacture of 10ga x 1½" nails.

Pressure treatment

Commence treatment using 2.5 per cent borax-boric acid solution, and check results by analysis. From experience determine solution strength required to give a core retention of 0.2 per cent boric acid equivalent.

After experience is gained with innocuous boron salts, the more toxic CCA salts may be used. When these are introduced a vigourous publicity campaign should be mounted to forestall any jealous or ignorant criticism that CCA treated wood is toxic to humans.

Future plants should be fabricated in Sri Lanka, but must be designed as pressure vessels by competent professional engineers.

Diffusion treatment

Ruberwood or coconut wood to be used in frequently damp (but not ground contact) situations such as tile battens and exterior joinery should be treated with ACB using an immersion process prior to stacking.

Coconut sawing

The breaking down bench (and also the circular resaw) should be fitted with riving knives for staff safety. For improved saw stability and lower electricity consumption the fibre pads should be replaced by ebony plug guides which must be checked and adjusted on a daily basis.

The screw setworks on the bandsaw fence should be replaced with stacked cylinder pneumatic setworks using simple diode logic.

The availability of a diamond sharpening service for TCT saws and cutters should be publicised both in the interests of improved factory profits and in the interests of Sri Lanka's woodworking industry generally.

When a new coconut sawmill is installed, the production and economic advantages of modern small log circular sawing techniques should be carefully considered. In the event that these techniques are adopted, rigid discipline in preventative maintenance must be insisted on.

Sawdoctoring equipment

The Loroch gulleter should be modified to accept 3" pitch saws as described.

Saw shop

Illumination levels should be improved.

Sawdoctor training

Advantage should be taken of New Zealand bilateral aid possibilities for sawdoctor (and also mill worker) training. New Zealand is particularly recommended because of its wide association with coconut sawing in the Pacific islands and in fundamental research in coconut utilization.

ANNEX I

TESTS ON GLUED LAMINATED BEAMS MADE OF BORON TREATED RUBBERWOOD

(from report of Prof. Ameratunga,
School of Engineering, University of Peradeniya)

Introduction

This report gives detailed results of tests carried out on glued laminated timber beams, control beams and tensile specimens made of rubberwood. The laminations had been made up of short lengths of timber glued together at machine-formed "finger" joints. All test samples were supplied by Borwood Ltd.

Scope of tests

Tests were carried out primarily to determine the flexural resistance of glued laminated beams. In one test, central point loading was used; in the others, 1/3rd span loading (four-point loading) was adopted with a finger joint in the most highly stressed region in the extreme lamination in the tensile zone of the beams.

Control tests were carried out on test specimens containing a finger joint at the centre and on specimens with no joints. Direct tensile tests and centrally loaded flexural tests were carried out on air-dry specimens. Some tests on jointed specimens were carried out after immersing them in water at room temperature (about 26 degrees C.) for 24 hours immediately prior to testing.

Summary of test results

Detailed observations made during the test programme are given in tabular form; average values of the more useful results are summarized in the table on page 17.

Property	Glued laminated beams	Control specimens without joints
Average stress in direct tension		
MPa	31.4*	37.1
Lbf/in^2	4550*	5400
Flexural stress at failure		
MPa	41.2	50.2
Lbf/in^2	5950	7300
Modulus of elasticity		
MPa	9650	8270
Lbf/in^2	1.4×10^6	1.2×10^6

*Tests on finger jointed specimens

Concluding remarks

The tests on the samples of glued laminated timber beams show that these are suitable for use for structural purposes. The carrying capacity will depend on the location of joints in the laminations and their efficiency. The type of joints used in the fabrication of these laminations seem to be satisfactory, giving an efficiency of about 85 per cent compared with the strength of specimens without joints, tested under air-dry conditions. Under saturated conditions, after immersion in water for 24 hours, this figure drops to about 45 per cent. The modulus of elasticity of a glued laminated beam is of the same order of magnitude as that of a plain timber beam. It is likely that the serviceability limit state of deflection will govern the choice of beam section for a given design load and that the stresses induced will be of a low magnitude. A reduced joint efficiency might not, therefore, be of serious significance in beam design.

ANNEX II

PROJECT STAFF

International staff

Mr. C. R. Francis
Chief Technical Adviser (New Zealand)
April 1982 - July 1984

Mr. K. Bergseng
Sawdoctoring Expert (Norway)
July 1983 (1 week) and January to March 1984

National staff

National Project Director:

Mr. Hope Todd	Managing Director, Borwood Ltd.

Other project staff:

Mr. C. Dassanayake	Factory Engineer
Mr. P. Warusavithana	Production Manager
Mr. P. da Silva	Factory Manager

FELLOWSHIPS

1. Mr. Hope Todd - November 1981
   Study tour of coconut sawing and processing in Philippines and Papua, New Guinea. Cut short due to motor accident.

2 & 3. Messrs. C. Dassanayake and P. Warusavithana - August 1983.
Training course in glulam in Mt. Gambier, Australia, and in Rotorua and Auckland, New Zealand, on sawmilling and wood processing.