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17251

DP/ID/SER.A/1103
29 December 1988
ORIGINAL: ENGLISH

ASSISTANCE IN CONSTRUCTION OF PREFABRICATED WOODEN HOUSING

SI/BHU/87/801

BHUTAN

Technical report: Timber seasoning at Gedu Wood Manufacturing Corporation and aspects of timber research and development in Bhutan*

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

Based on the work of D. K. Gough
Consultant in timber drying

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Industrial Management and Rehabilitation Branch

United Nations Industrial Development Organization
Vienna

* This document has not been edited.

V.88 31835

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INTRODUCTION

In January 1987, the Royal Government of Bhutan requested UNIDO assistance in the construction of prefabricated wooden housing. The project foresaw the services of a timber engineer as well as foreman carpenter to produce the prototype houses. Because of problems that the Gedu Wood Manufacturing Corporation (GWMC) had in wood drying, a six week mission by a wood drying consultant was also included.

Mr. D. K. Gough, consultant in wood drying undertook this mission from 5 March to 16 April 1988.

His terms of reference were:

Part A - With respect to the Gedu Wood Manufacturing Corporation, as per the job description of 16 July 1987:

1. Assess the state of the four 70 m3 kilns and all auxiliary equipment, and, if necessary, make the required adjustments and calibrations.

2. Obtain information on the species likely to be dried and recommend drying schedules.

3. Train laborers and kiln operators on the correct stacking and operation of the kilns.

4. Conduct a short course for the operators and for the technicians in the Gedu complex to cover:

   - basic wood anatomy,
   - air humidity/moisture content relations,
   - defects of drying (case hardening, honeycombing, checks, warping, etc.),
   - kiln drying (what happens in the kiln),
   - kiln design

Part B - General, as per (a) the job description of 16 July 1987, (b) discussions in Vienna at the time of briefing, 7 and 8 March 1988, and (c) request made by Forest Department in Bhutan.

1. Compile the teaching aids, materials and handouts used in the courses into a 'Manual on kiln drying of timber' for future use as a textbook and by the staff at Gedu and in technical schools (and future wood processing plants in Bhutan).

2. Evaluate the potential for using seasoned timber for particular applications in Bhutan following discussions with specifiers and timber users.

3. Assess the requirements for a solar kiln installation at the PWD Wooden Bridge Project at Gaylegphug.

4. Assess the requirements for a solar kiln installation at the Ramtokta Depot of the Bhutan Logging Corporation.

4. Give advice to the Bhutan Logging Corporation on the procedures for undertaking sawmill recovery studies.

6. Inspect and give advice on the roofing shingle treatment project, operated by the Forest Department at Punakha.

ACKNOWLEDGEMENTS

This consultancy was of six weeks duration from 5 March to 16 April 1989. Of this period 20 working days were completed at Gedu. The remaining time was spent in travel, briefings at Vienna and Thimphu, inspections of timber processing facilities and building construction sites in Bhutan, and discussions with the following:

Mr. Sangay	Deputy Director, Department of Industry
Mr. Adahikari	Assistant Director, National Urban Development Commission
Mr. Sangay Thinley	Director, Department of Forests
Mr. Tara Giri	Managing Director, Bhutan Logging Corporation
Mr. Sangay Wangchuck	Management Officer, Department of Forests
Mr. Sherab Wangchuck	Deputy Director, Bhutan Logging Corporation
Mr. Dorji Dupka	District Forester, Thimphu
Mr. Tobgay Tshering	O/C Forest Research, Department of Forests
Mr. Matthias Ladurner	Chief Technical Adviser, FAO/Bhutan Forest Management Project
Mr. Marc Dujarcin	Architect, Public Works Department
Mr. Robert Fielding	Architect, Department of Education
Mr. Denis Lee	Principal, Royal Technical Institute, Kharbandi
Mr. Dawa Gyaltshen	Building and Construction RTIK
Mr. M. D. Rajadnya	Architect, SAARC Conference Center
Mr. Vyas	Project Officer, SAARC Conference Center
Mr. Lionel Jayanetti	Consultant, FAO Preservation Project

These discussions were invaluable and the time and assistance given by these people is gratefully acknowledged. All of the management and staff at Gedu Wood Manufacturing Corporation willingly gave advice and assistance whenever it was sought and grateful appreciation is extended to them. Mention is made in particular of:

Mr. Nawang Gyetse	General Manager
Mr. Rakesh Chhetri	Deputy General Manager
Mr. P. K. Sharma	Production Manager
Mr. Tsering Wangdi	Logging Manager
Mr. Ugen Tshering	Deputy Logging Manager
Mr. Kinza Namgey	Manager, Joinery Plant
Mr. Tanka Nath Sharma	Kiln Supervisor
Mr. Aita Sing Alley	Assistant Kiln Supervisor
Mr. Hank Wensley	Plant Engineer, FAO
Mr. Pema Norbu	Chief Maintenance Engineer

Finally, the guidance and help given in Vienna by Messrs. A. V. Bassili and R. Hallett and in Thimphu by the UNDP Resident Representative, Mr. P. Matthews and Programme Officers Messrs. Neil Buhne and Jens Toyberg-Frandzen is gratefully acknowledged.

Part A - Gedu Wood Manufacturing Corporation

1. Introduction

The sawmill at Gedu Wood Manufacturing Corporation (GWMC) produces sawn timber for

(a) blockboard, manufactured at GWMC.
(b) joinery, furniture and prefabricated housing, manufactured at GWMC,
(c) sale to the private sector or for Government building projects.

Sawn timber for sale is usually sold unseasoned but the timber used by GWMC for blockboard, joinery, etc, is all seasoned.

The capacity of the blockboard plant is quite high, as also is the potential timber requirements for the joinery plant. With both plants in full operation, the full ability of GWMC to produce timber for sale will be severely limited except for some low grade products which cannot be used 'in-house'.

Apart from the possibility of doing some custom sawing or seasoning, of logs or sawn timber supplied by others, both the sawmill and the seasoning kilns should be regarded primarily s supplying the needs of the blockboard plant and the joinery, which are certainly the major clients.

Four identical 'Hildebrand' kilns were commissioned for service in September, 1986. The brief of Part A of the consultancy was essentially:

- to evaluate the operation of the kilns;
- to determine the drying characteristics of the species involves;
- to develop an efficient operational programme for seasoning at GWMC;
- to train staff in timber seasoning.

2. The influence of other factors at GWMC on timber seasoning.

GWMC is an integrated wood processing complex where the various sections: logging, plywood, blockboard, sawmilling, seasoning and joinery are dependent on one another to varying degrees.

The seasoning section is influenced by other sections and for this reason it is necessary to examine all sections to some extent, to improve overall integration.

2.1 Log resources

The log resources are principally temperate rainforest hardwoods and although up to 60 species are represented in the forest, most logs are from

about 30 species. GkMC commenced operations in some sections in 1982 and production rates are gradually climbing towards anticipated targets. It is difficult to determine the level of current log production, however, it does exceed current veneering and sawmilling production rates and a considerable surplus of logs is available for export to India. By most standards, the size and form of logs is poor. Log diameter ranges from about 1 m to 0.3 m (40" to 12") with most logs less than 0.6 m (24"). The forest management regime is changing from selection logging, to clear felling in strips but this should have no significant effect on log quality.

2.2 Veneer and plywood

Veneer and plywood production requires logs of better than average size and form (straightness). It is a capital intensive operation and only the better logs of preferred species are diverted to the plywood plant. The length of veneer logs is restricted to about 27. m (9') and the practice is to dock all logs to that length in the bush and haul them to Gecu where they are classified as either veneer logs or sawlogs.

2.3 Sawmilling

Given the sawmill equipment, the sawing of logs in 2.7 m lengths is satisfactory. Diversion of the better logs to the veneer mill is accepted. However, sawmill production and the subsequent seasoned quality is currently at a very low level, mainly because the sawmill is taking the difficult species and the small and misshapen logs. Not all logs going to the sawmill are difficult, bendy, etc. but those that are often cause breakdowns, they are difficult to handle, they produce low sawn and seasoned recovery and they reduce production rates.

In general, the high density species such as buk (oak) and katus (chestnut) are the difficult species to saw. Bandsaws in particular, should be prepared (sharpened and tensioned, for a certain class of logs and it is bad practice to be sawing a mixture of species covering a wide range of density.

In addition, the sawmilling machinery is relatively light for processing heavy hardwoods. The bendy misshapen logs are very difficult to handle and they put unacceptable stress on the log loading gear and the carriage.

It is strongly recommended that the difficult species and the bendy, misshapen logs be sold at auction. Priority must be given first to the veneer mill, then to the sawmill, with export quality coming third.

Further observations about the sawmill are:

(a) All logs should be debarked to protect the sawblades from stones embedded in the bark. This should be done just before sawing.

(b) Specialist assistance of an expert sawdoctor is required to help overcome the all too frequent incidence of gullet cracking. (Four headsaw blades snapped in a period of two weeks during the consultancy.) This could be due to the high density logs. The sawdoctor and his assistant are quite skilled at their job but additional tuition under an experienced expert at Gecu would be timely, and would certainly be of great benefit.

(c) Comments have been made in the past about the absence of a green chain (sorting table) in the sawmill. Given the limited range of product sizes it is felt that this is not a major problem at present.

(d) Sizing of sawn material is often erratic. This is probably due in part to sawing high density logs and bendy logs with a lot of tension wood. However, because the sawn size is often variable, a rather generous oversize allowance is made. This, of course, reduces recovery, increases seasoning time and requires more power for machining.

2.4 Joinery

An important prerequisite for a profitable joinery operation is a supply of high grade, well seasoned timber. There is little scope for using low grades which have excessive distortion due to tension wood from bent logs. There is also little scope for using high density timber in joinery, furniture or prefabricated housing, especially when internal checking and collapse has occurred in seasoning. Oak and chestnut are particularly susceptible to collapse.

2.5 Blockboard

Because of problems that have arisen in the past, the following specification for blockboard material is already in place:

(a) Dense species (oak and chestnut) are not permitted.
(b) Pieces less than 100 mm wide are not permitted.
(c) Moisture content of 8 - 9 percent is required.

'(a)' is understandable because the dense species are difficult to rip and they rapidly blunt the saws.

'(b)' is unfortunate because blockboard is really a good means of using small sizes. However, small sizes produce a lot of waste and they also reduce production rates.

'(c)' means that blockboard and joinery have to be seasoned in separate charges because joinery should only be dried to about 12 percent moisture content. In fact the 8 to 9 percent moisture content requirement was probably set because a higher average, say 12 percent does, under current

seasoning condition, produce a wide range of values and often contains some pieces of 20 percent moisture content and more. With the removal of dense species from the log intake and an improvement in seasoning practice, it should be possible to increase the average moisture content for blockboard to the saw as that for joinery.

Flexibility in the seasoning operation is impaired due to the differing requirements of blockboard and joinery, for final moisture content and for thickness. A rationalization is certainly required here so that boards from the sawmill can be stacked and seasoned in the same charge and then graded for either blockboard or joinery use, as the stacks are broken down. The tallying could also be done at the same time instead of the current practice, which is to tally before seasoning when the stack is being built.

The most significant factor from the above is that the dense species and the bendy and misshapen logs should be sold at auction. It is not profitable to process them or to attempt to use their sawn product at GWMC, for either blockboard or joinery.

Note: The current stock-pile of logs at the sawmill is extremely large and contains a high proportion of these unsuitable logs. The stock pile should also be culled and only the suitable logs selected for sawing. At the same time, the stock pile of logs for auction could also be checked and the better logs taken out for processing by GWMC.

3. The kiln seasoning installation at GWMC

Four identical 'Hildebrand' kilns were commissioned for service in September 1986.

Each kiln has two tracks and each track can take a stack 7.3 m (24') long x 2.4 m (8') wide x 4.0 m (13') high. The volume of 32 mm (1 1/4") thick timber in such a stack using 25 mm (1") stickers is about 28 to 30 cubic meters (990 to 1060 cubic feet).

The kiln buildings are constructed of insulated aluminum panels. Each has a single access door, the full width of the kiln (7.9 m (26')).

Finned steam coils are used for heating.

A water spray line with atomizing nozzles is used to increase humidity.

Each kiln is fitted with two pairs of automatically operated vents controlled by the EMC set point. Four, 75 cm (30") reversible fans each powered by 3 kW (4HP) integrally mounted electric motors set at 26 degrees pitch and running at 1450 rpm., provide air circulation. Infinitely variable time clocks permit fan reversal at any interval up to six hours.

Kiln control is automatic, based on temperature and equilibrium moisture content (EMC). Temperature, EMC of the kiln atmosphere and moisture content (m.c.) of sample boards via resistance electrodes, are recorded on roll chart recorders.

A lift truck and transfer system is used for loading the kilns.

These kilns do have a number of limitations and it has been the aim of this consultancy to define the limitations and to develop a programme of operation to work within them to optimum efficiency.

3.1 Limitations of the kiln installation

3.1.1 The lift truck is 6 m long. This limits the length of a stack to 6m and the volume of each stack to about 23m3 for 32 mm thick timber and about 30 m3 for 57 mm. Good working figures for these sizes are 20 m3 (700 cft) and 27 m3 (950 cft) respectively, for stacks 2.1 m (7') wide. With a stack length of 6 m it is necessary to install baffles at one end to prevent the air flow by-passing the stacks. Combinations of two short stacks, eg. 2 x 3.6 m or 2.4 and 4.8 m stacks could be considered as an alternative, but in practice this would not be feasible while 2.7 m is the predominant length of logs processed at the sawmill.

3.1.2 The kiln size is quite large, the stacks are wide and they are very high, making stack construction time consuming and labor intensive. The stacks being built are very good but under the circumstances it is impossible to use a stacking guide and there is no hydraulic lift to assist with stacking. Destacking is also difficult from this height (4 m (13')). Consideration should be given to installing a hydraulic lift platform for constructing stacks. A stacking guide could be fitted to the platform and this would ensure that well made stacks were constructed. The number of laborers used for stacking could be reduced and further reductions could be made by using a forklift to transfer timber from the sawmill to the lift platforms.

3.1.3 The kiln buildings are well sealed and insulated. However, the doors are extremely large and at least three men are required to open and close them.

3.1.4 The finned heating coils are located in the roof space and are in good condition. There are no re-heat coils between the stacks, but this is not a problem. Kiln heat-up time is quite acceptable.

3.1.5 The water spray can generally maintain high enough humidity to prevent degrade during drying but it is not able to produce a high enough humidity to undertake a high humidity treatment (HHT) at the end of drying.

An HHT is of great benefit at the end of drying and should be run at a temperature of 80oC with a relative humidity approaching 100 percent (EMC of 18%+), for up to four hours.

The effect of an HHT is to reduce drying stresses, to reduce moisture gradients, and to reduce case hardening. All of this helps to reduce any movement in the timber after drying and it makes the timber much easier to process with planing machines and splitting saws, etc.

With the water spray however, it is not possible to attain a high temperature and a high humidity at the same time, because the heat demand to vaporize the water spray is too high. It is possible to reach about 85% RH and 55oC (EMC about 16%) but this is not sufficient to provide an adequate steaming treatment.

It is recommended that, in the first instance, the water spray in two of the kilns be replaced by a steam spray. The water spray nozzle should be removed and holes drilled in the spray line at about 500 mm spacing. It may be necessary to replace the control valves with steam valves. This could be determined by the plant engineer.

The steaming treatment will be of most benefit to the denser species and to the thicker timber. The second two kilns could also be converted to steam, depending on the result achieved with the first two.

3.1.6 The temperature and humidity conditions in the kilns are measured and controlled using resistance sensors for temperature and an EMC sensor to obtain a resistance derived value for EMC of the kiln atmosphere.

Kiln temperatures and EMC were checked using thermocouple and a thermocouple wet bulb.

The dry-bulb and wet-bulb readings were applied to psychometric tables to obtain the corresponding EMC values.

Each kiln was checked and a summary of the results is as follows:

Kiln No.	Temperature	E.M.C.
1	Readings are close. Auto control not working	Readings are seriously out
2	Indicated temp is about 1-2^{o} high	Indicated E.M.C. is about 1% low
3	Indicated temp about 1-2^{o} high	Indicated E.M.C. is about 1% high
4	Temp appears to be controlled by sensor on the air exit side of the stack	As with kiln 1. Readings are very low. This signals for the spray line to be on continuously.

All of the control units need a thorough overhaul. Many of the function indicator lights do not work. It is recommended that a remote reading temperature indicator be obtained, similar to the digital reading thermocouple unit used in the above tests (Leeds and Northrup Model 933, Numatron). Such a unit could also be used for testing the veneer kilns.

A point to note is that there is a temperature sensor on either side of each kiln and they alternate to control kiln temperature, depending on the direction of air flow. (See fig. 1.)

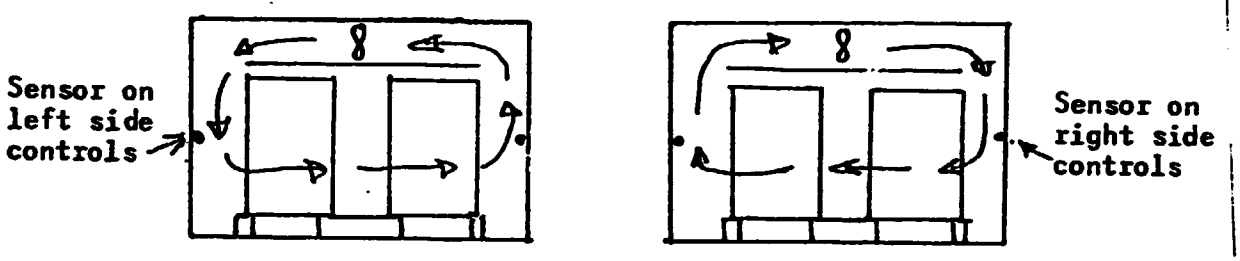


Fig. 1: Showing change of sensor control with change in fan direction (end elevation).

It is most important that the fan change is synchronized with the correct temperature sensor.

Under the remote circumstances at Gedu a wet bulb temperature sensor would be preferred for both indicating and controlling the humidity conditions in these kilns.

3.1.7 The air circulation equipment (fans, vents and fan reversal equipment) is basically good and in good working order, however the fans are considered to be too small for the task at hand. Air speed between the sticker spaces was measured on the exist side of the stack using an 'Alnor' hot-wire anemometer. The testing was extensive, with measurements being taken at every fifth sticker space down the stack at four positions along the stack (see fig. 2). Only one kiln was tested but readings were taken on both stacks with the sir flowing in both directions. The results are listed below. In he first series of tests, there was no baffling in place and both stacks were located centrally along the rails with a gap of approximately 0.75 m (30") at each end. These results (see pages 15 and 16) show that the overall average is higher through the first stack, 1(b), but the uniformity of air flow is very poor with hardly any air passing through the top third. Total air flow through the second stack, 1(a) and 2(a), is very low at 0.2 meters per second (mps) and uniformity of flow is still very patchy.

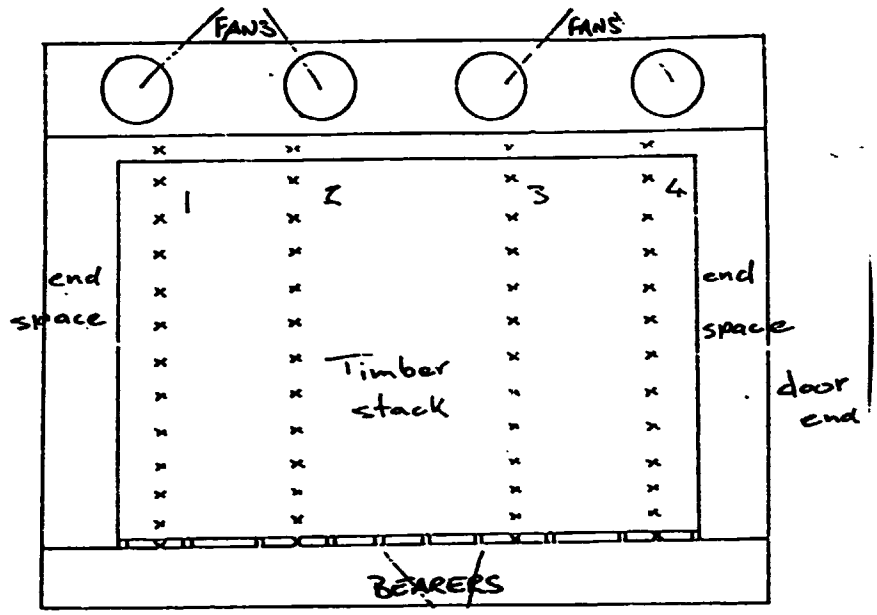


Fig. 2: Side view of kiln and a stack showing the points at which air speed readings were taken, i.e. every fifth stick spacing at four positions along the stack.

The air flow through the end spaces is quite high (up to 2.6 mps) through spaces about 0.75 m wide) and it is quite clear that a large volume of air by-passes the stacks. As mentioned, the lift truck is only 6 m long. This limits the stack length to 6 m in a kiln which is 7.5 m deep.

In the second series of tests (pages 17 and 18), the stacks were moved to alternate ends, i.e. stack 1 was left near the door and stack 2 was moved right in to the rear wall. The overall average figures improved to some extent (averages 0.4 to 0.75 mps) but the results were still not uniform from top to bottom, or along the length, particularly for stack 2 (3(b) and 4(a)), which had thinner timber and more stick spaces than stack 1.

In the third series of tests (pages 19 and 20) two plywood baffles 1.2 m wide, from the floor to the false ceiling, were installed in the rear of the kiln. The average air flow was from 0.8 to 1.1 mps and the uniformity along the stack, and from top to bottom, was improved considerably. The air flow at the top was consistently lower than that at the bottom, however, this result is acceptable and similar baffles are strongly recommended for all kilns.

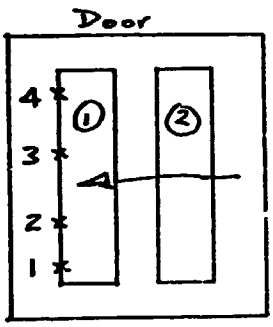
Note: In this third series, both stacks were actually of 32 mm thick timber. A higher air flow would be expected through 57 mm timber.

2.0 mps through the stack is the figure generally recommended for conventional kiln drying, and larger fans, eg. 1.1 m diameter with 5 kW motors, would be recommended for kilns the size of those at Gedu. It would be impossible to make such a change now, but this does emphasize the need to take care with closing off all air gaps around the stack.

Practice at GWMC has been to set the air flow reversal at one hourly intervals. With the relatively long drying times involves, it is recommended that four hourly intervals be adopted.

Exit side stack 1

1.6 end space



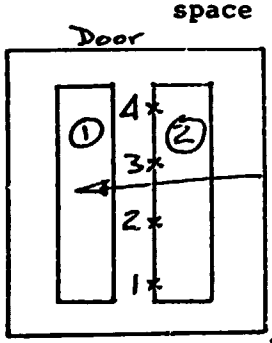
	1	2	3	4	
Above Stack	0.8	0.3	0.7	0.4	Av(a)
	0.3	0.2	0.4	-	0.25
	-	0.2	0.4	-	0.15
	-	0.5	0.3	-	0.2
	0.2	-	0.1	-	0.1
	0.3	-	0.1	-	0.1
	0.4	0.1	-	0.1	0.15
	0.5	-	0.1	-	0.15
	0.6	0.2	0.3	0.6	0.4
Bearers	1.0	0.3	0.9	1.0	
Av(b)	0.3	0.15	0.2	0.1	

2.0 end space

Overall Av 0.2 mps 1(a)

Exit side stack 2

2.0 end space



Above Stack	-	-	-	-	Av(a)
	0.2	-	-	-	0.05
	-	-	-	-	-
	-	-	-	-	-
	1.1	-	-	-	0.3
	0.2	0.1	0.4	-	0.2
	0.8	0.2	0.3	-	0.3
	0.9	0.3	0.4	0.2	0.45
	1.1	0.5	0.6	0.5	0.7
	1.2	0.5	0.7	0.7	0.8
	1.3	0.5	0.3	1.0	0.8
	1.2	0.7	0.8	0.9	0.9
	1.0	0.8	0.7	0.9	0.85
Bearers	0.9	0.9	0.7	1.0	
Av(b)	0.75	0.3	0.35	0.35	

1.2 end space

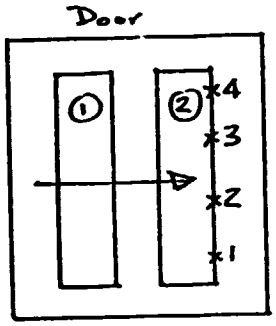
Overall Av 0.45 mps 1(b)

Measurements are in metres per second (mps).
Av(a) gives the average measurement for each position down the stack.
Av(b) gives the average measurement along the stack.
Diagrams (plan view) show measurement positions and direction of air flow.
Stack 1, Walnut mixed thickness. Gap of 2' at top of stack.
Stack 2, Mixed hardwoods 1½" thick. Gap of 1' at top of stack.

Air Speed in m/sec

Exit Side stack 2

2.0 end space

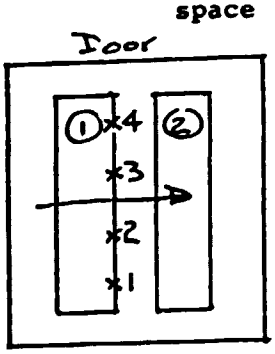


	1	2	3	4	Av (a)	
Above Stack	2.2	0.5	0.4	1.2		
	0.3	0.1	0.1	0.7	0.3	
	0.4	0.1	0.2	0.3	0.25	
	0.2	0.1	0.3	0.3	0.3	2.6 end space
	-	0.1	-	1.6 (gap)	0.1	
	0.1	0.6	0.1	0.2	0.25	
	0.1	0.5	-	0.2	0.2	
	0.1	0.1	-	0.3	0.1	
	0.1	-	-	0.1	0.05	
	0.2	-	-	0.1	0.05	
	0.2	0.1	0.1	0.2	0.15	
	0.2	0.2	0.2	0.3	0.25	
	0.5	0.4	0.2	0.2	0.3	
	0.7	0.5	0.2	0.3	0.4	
Bearers	0.9	0.5	0.7	0.9		
Av(b)	0.25	0.2	0.1	0.3		

Overall Av 0.2 mps 2(a)

Exit Side Stack 1

2.4 end space



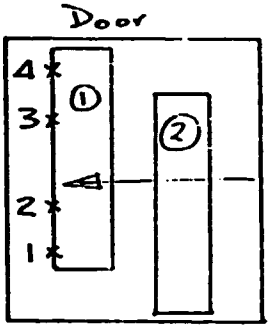
Above Stack	0.2	0.2	0.1	0.3	Av(a)
	-	-	-	-	0.0
	-	-	-	-	0.0
	-	-	-	0.3	0.1
	0.5	-	0.1	0.3	0.2
	0.8	0.4	0.5	0.8	0.6
	0.5	0.4	0.5	0.9	0.6
	1.1	0.9	0.5	1.1	0.9
	1.2	1.1	0.5	1.2	1.0
	1.6	1.8	0.8	1.4	1.4
	1.7	2.0	0.8	1.4	1.5
Bearers	2.3	2.5	2.2	1.9	
Av(b)	0.75	0.65	0.35	0.75	

2.6 end space

Overall Av 0.6 mps 2(b)

Exit Side
Stack 1

1.7
end
space

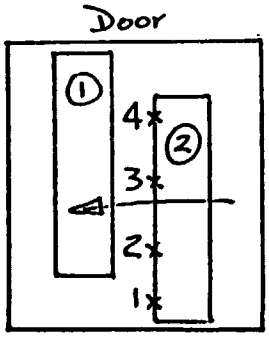


	1	2	3	4		
Above Stack	1.0	0.3	0.5	1.7	Av (a)	
	0.4	0.2	0.2	0.1	0.2	
	0.3	0.2	0.3	0.4	0.3	
	0.5	0.5	0.4	0.6	0.5	2.8 end space
	0.5	0.6	1.0	1.1	0.8	
	0.5	0.4	0.9	1.2	0.75	
	0.9	0.6	1.0	1.1	0.9	
	0.7	0.6	1.0	0.6	0.7	
	0.9	0.6	1.3	1.3	1.0	
Bearers	1.5	1.4	1.9	1.5		
Av(b)	0.6	0.45	0.75	0.8		

Overall Av 0.65 mps 3(a)

Exit Side
Stack 2

2.8
end
space



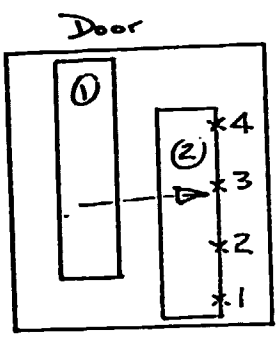
Above Stack	0.7	-	-	-	Av (a)	
	0.5	0.2	0.5	0.1	0.3	
	0.5	0.3	0.3	-	0.3	
	0.9	0.6	0.5	-	0.5	2.0 end space
	0.6	0.6	0.7	-	0.5	
	0.9	0.7	0.7	-	0.6	
	1.4	0.8	0.8	0.2	0.8	
	1.4	0.6	0.8	0.5	0.8	
	1.1	0.7	0.9	0.7	0.85	
	1.3	0.6	1.0	0.8	0.9	
	1.3	1.2	0.9	1.0	1.1	
	1.2	1.0	1.1	0.8	1.0	
	1.5	1.1	1.2	1.0	1.2	
Bearers	2.8	1.6	1.7	1.2		
Av(b)	1.05	0.7	0.8	0.4		

Overall Av 0.75 mps 3(b)

Second series - stacks moved to alternate ends

Exit Side
Stack 2

1.4
end
space

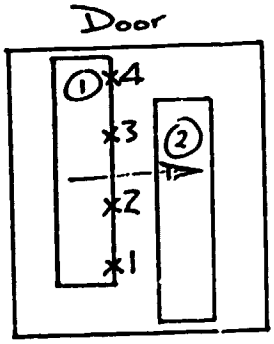


	1	2	3	4	Av(a)	
Above Stack	0.4	-	-	-		
	0.6	-	0.2	0.4	0.3	
	0.5	-	0.3	0.4	0.3	
	0.6	0.3	0.5	-	0.35	1.7 end space
	0.6	0.3	0.4	-	0.35	
	0.5	0.4	0.3	-	0.3	
	0.7	0.3	0.4	-	0.35	
	0.9	0.2	0.3	-	0.35	
	1.0	0.3	0.1	-	0.35	
	1.0	0.3	-	0.2	0.35	
	0.9	0.3	0.3	0.3	0.45	
	0.9	0.3	0.3	0.3	0.45	
	1.8	0.4	0.4	0.4	0.75	
	1.4	0.6	0.5	0.5	0.75	
Bearers	2.0	1.1	0.9	0.5		
Av(b)	0.9	0.3	0.3	0.2		

Overall Av 0.4 mps 4(a)

Exit Side
Stack 1

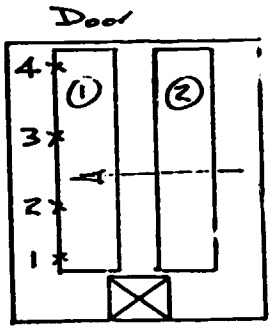
2.4
end
space



					Av(a)	
Above Stack	0.3	0.5	-	-		
	0.3	0.1	-	-	0.1	
	0.1	-	0.3	0.3	0.2	
	0.2	0.3	-	0.5	0.25	3.0 end space
	0.4	-	0.9	0.9	0.55	
	0.5	0.3	1.0	1.5	0.8	
	1.2	0.9	1.0	1.4	1.1	
	1.4	0.7	1.6	1.1	1.2	
	1.9	1.6	1.9	1.7	1.8	
Bearers	1.6	2.6	2.5	2.8		
Av(b)	0.75	0.5	0.85	0.9		

Overall Av 0.75 mps 4(b)

Exit Side
Stack 1

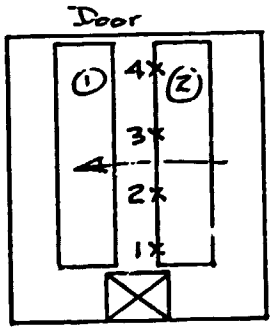


	1	2	3	4	Av (a)	
Above Stack	1.2	1.4	0.9	1.5		
	0.8	0.6	0.7	0.6	0.7	
	0.7	0.5	0.6	0.7	0.6	
	0.6	0.5	0.8	0.7	0.65	3.5 end space
	0.6	0.7	0.9	0.7	0.7	
	0.5	0.7	0.7	0.8	0.7	
	0.5	0.7	0.7	0.7	0.65	
	0.9	0.5	0.7	0.7	0.7	
	0.8	0.6	0.9	0.8	0.8	
	0.9	0.6	0.9	0.8	0.8	
	1.3	1.2	0.9	1.4	1.2	
	1.2	1.1	0.8	1.3	1.1	
	0.7	0.9	1.2	1.1	1.0	
Bearer	Spaces Blocked					
Av(b)	0.8	0.7	0.8	0.85		

Overall Av 0.8 mps 5(a)

Exit Side
Stack 2

2.6
end
space

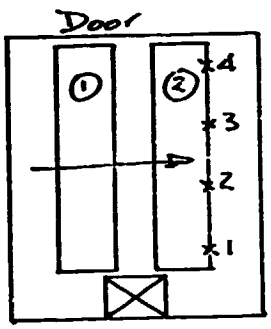


					Av(a)	
Above Stack	0.6	0.8	1.7	1.5		
	1.2	0.6	0.5	0.5	0.7	
	1.1	0.6	0.3	0.7	0.7	
	1.0	0.5	0.4	0.7	0.65	3.1 end space
	1.2	0.7	0.5	0.6	0.75	
	1.4	0.6	0.5	0.9	0.85	
	1.4	0.9	0.8	1.0	1.0	
	1.7	0.9	0.9	1.5	1.25	
	1.6	1.6	1.2	2.1	1.6	
	1.8	1.2	1.3	1.5	1.45	
	1.7	0.7	1.2	1.7	1.3	
	1.8	1.3	1.3	2.1	1.6	
	2.0	1.8	1.3	1.8	1.7	
Bearers	1.7	2.4	2.3	1.9		
Av(b)	1.5	0.95	0.85	1.25		

Overall Av 1.1 mps 5(b)

Third series - end baffle in place. End spaces now about 20 cm (10") wide

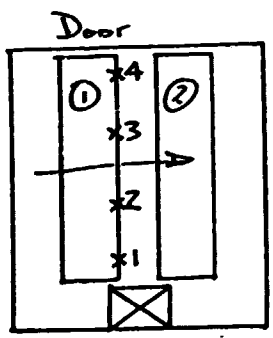
Exit Side
Stack 2



	1	2	3	4	
Above Stack	0.5	0.5	0.6	1.1	Av (a)
	0.6	0.6	0.7	0.9	0.7
	0.8	0.7	0.8	0.9	0.8
	0.7	0.8	0.8	0.9	0.8
	0.8	0.8	0.9	0.9	0.85
	0.6	0.7	0.9	0.8	0.75
	0.6	0.8	0.5	1.0	0.75
	1.0	0.9	1.0	1.3	1.05
	1.4	1.2	0.9	0.8	1.1
	1.2	1.2	0.7	1.4	1.1
	1.2	1.3	0.8	1.3	1.15
Bearer	Spaces Blocked				
Av(b)	0.9	1.0	0.8	1.0	

Overall Av 0.9 mps 6(a)

Exit Side
Stack 1



Above Stack	1.2	1.3	1.2	1.3	Av(a)	
	0.9	1.0	0.7	0.7	0.8	
	1.3	0.9	0.7	0.7	0.9	
	1.0	0.8	1.0	0.8	0.9	2.8 end space
	1.4	0.8	1.0	0.6	0.95	
	1.4	0.9	1.0	1.0	1.1	
	1.7	1.0	1.0	0.9	1.15	
	1.5	1.0	1.2	1.1	1.2	
	2.0	0.9	1.2	1.0	1.25	
	1.8	1.0	0.9	1.2	1.2	
	1.7	1.0	0.8	1.2	1.2	
	1.8	1.3	1.0	1.4	1.4	
	1.7	1.5	1.0	1.3	1.4	
Bearers	1.8	1.2	1.8	2.2		
Av(b)	1.5	1.0	0.95	1.0		

Overall Av 1.1 mps 6(b)

3.1.8 Kiln operation and monitoring moisture content is done using sophisticated electronic equipment which, in the circumstances, is considered both inappropriate and inadequate.

It is inappropriate because in any isolated situation such as Bhutan, it is difficult to get replacement parts readily and it is also difficult to obtain the services of experienced electronics experts who can diagnose faults and rectify them. It is inadequate because kilns 1 and 2 are fitted with three pairs of moisture content resistance probes and kilns 3 and 4 have two. Practice has been to have two pairs of probes in two stacks and one pair in each of the remaining six stacks. These probes are driven into any board of any species on the outside of the stacks, and the information obtained is used in the process of deciding how well a whole stack is drying, and when the stack is finally dried. Information on the EMC of the kiln atmosphere may also be used in the decision but as with the moisture content probes, it is not always reliable.

A system using sample boards based on over dry weight moisture content determination has now been introduced. This system is both simple and instructive and it addresses the problem at the species level. It is more time consuming than the electronic method, but it involves the kiln operator at a more basic level and provides both operator and management with information that can be usefully assessed.

Figure 3 illustrates the steps involved in preparing and using sample boards.

Four sample boards are being used per stack. Where mixed species are being dried, the four are chosen from different species and they are placed within the outside row of boards, on the side of the stack in the center of the kiln (see figure 4).

The control panel of each kiln is fitted with a roll chart recorder as mentioned earlier but there are no charts in stock and the value of keeping such records is questioned. Currently the night time operator records temperature, EMC and moisture content at four hourly intervals. A check of these records is considered adequate for picking up any faults.

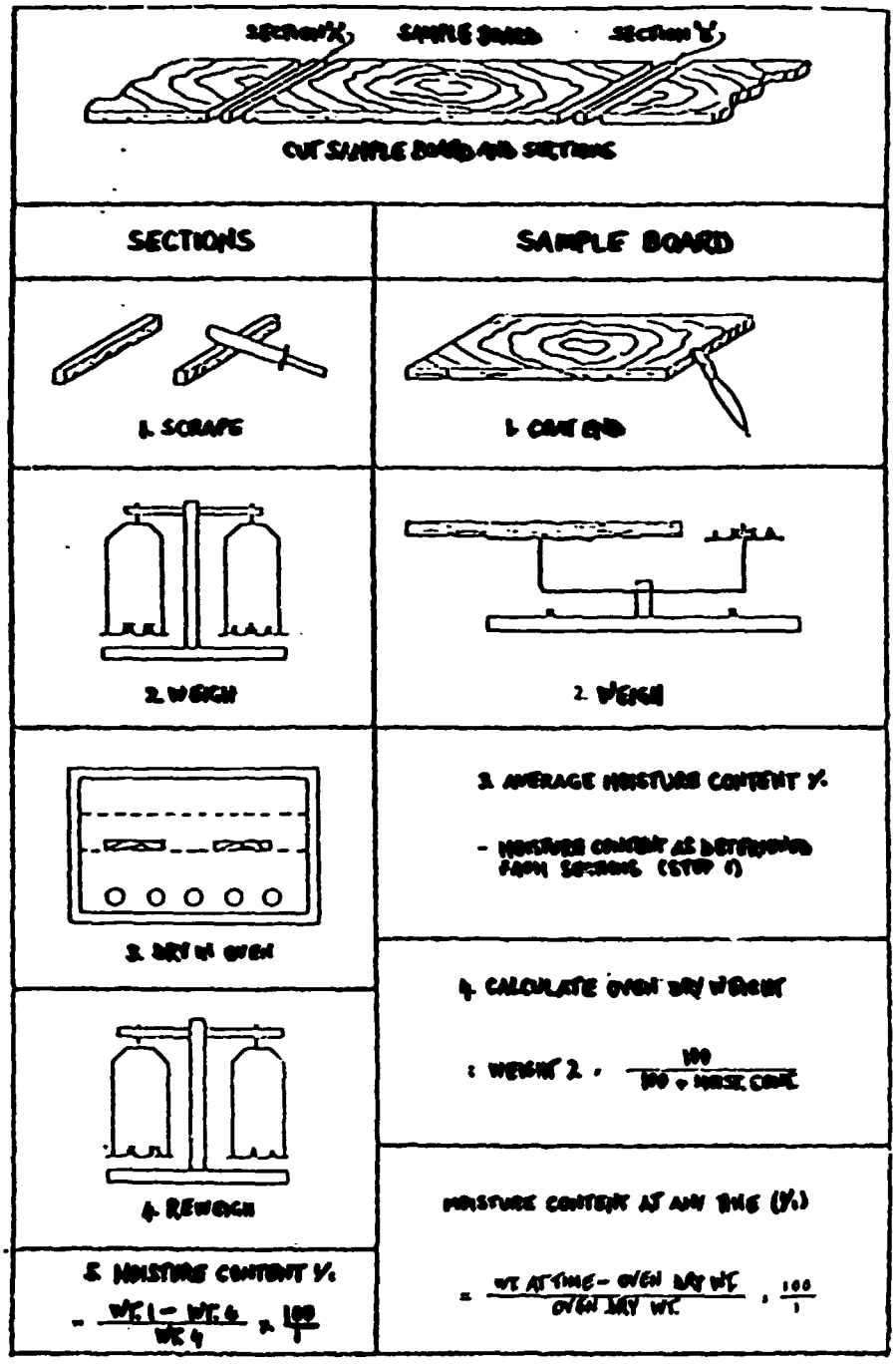


Fig. 3. The preparation of sample boards.

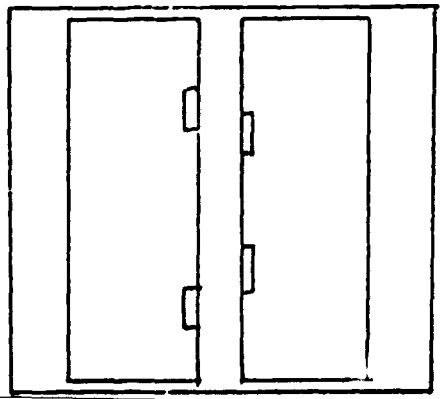


Fig. 4. Showing the location of sample boards on the inside of stacks. (plan view)

3.2 Summary of limitations and recommended action

(a) Lift truck length of 6m (and log length of 2.7 m) means that the kiln cannot be stacked to its full length of 7.2 m and kiln capacity is reduced accordingly. Kiln capacity of each kiln is approximately 40 m3 (1400 cft) for 32 mm thick timber and 54 m3 (1900 cft) for 57 mm thick. It is understood the kilns were installed in the belief that kiln capacity would be 70m3 each. In view of this reduced capacity, kiln through-put must be increased by air drying prior to kiln drying (see section 5.0) and by drying only the less dense species which are easier to dry.

(b) Individual stack size is quite large (4 m high) and stack construction is difficult and labor intensive. This situation could be improved by installing a hydraulic lift platform for use in stack construction. A small feasibility study is recommended.

(c) High temperature (80o) and high humidity (95-100%) are required for post-seasoning stress relief. With the water spray system for increasing humidity, it is not possible to obtain a high enough temperature and a high humidity at the same time. It is recommended the water spray be modified and connected to the steam supply.

(d) The fans are barely large enough to give adequate air flow through the stacks, and with the stack length of 6 m in a kiln 7.5 m long, most of the air flow will by-pass the stacks if the large air gap is not baffled off. Top priority must be given to constructing plywood baffles in all kilns, to close off the gap at the end of the stacks. In addition all stacks should be built to their full height. If they are not, a temporary baffle should be used to block off the space at the top.

(e) The electronic system supplied for determining the end point of drying is neither adequate nor reliable. The system of sample boards based on the oven dry weight determination of moisture content, which was introduced during the consultancy is strongly recommended.

4. Stacking

There are three significant factors in obtaining good seasoned quality and good seasoned recovery.

(a) Good stacking practice,
(b) The correct kiln schedule,
(c) Good and well maintained kilns and equipment.

Good stacking prevents warp and other distortion, whereas poor stacking with overhanging and unsupported ends encourages drying degrade. As mentioned earlier (3.1.2), the large kiln size requires very large stacks which are difficult to construct. Despite this the stacking at GWMC is quite reasonable and improvements have been made to standardize the distance between sticks and to make all stacks, box ended at both ends. As time goes on, the short length sticks, which are currently used in tandem, should be replaced by single sticks the full width of the stack, plus approximately 50 mm at either side, i.e. total stick length 2.2 m for a 2.1 m wide stack.

The stack length of 6 m is quite suitable for the short logs generally processed by the sawmill. However, the conifer logs are often longer in length and consideration could be given to making separate stack 3.6 m long, when conifers are processed.

5. Proposed air drying

In most timber seasoning operations the usual practice is to air dry prior to kiln drying. This is not done at Gecu because there are not enough sets of stack foundations (ramps) available and there is no forklift at the sawmill large enough to carry the very large stacks. Also, the demand for seasoned timber is so high that stacks are usually run into the kiln as soon as the timber arrives from the mill and the stacks are built.

When sawmill production is increased, as intended by management, the kiln capacity will not be sufficient to meet requirements. It is proposed that a combination of air drying, followed by kiln drying, would help overcome this problem and Fig. 5 is a plan of the kilns and the four existing stacking ramps with an additional seven ramps for air drying. These additional ramps could quite easily be serviced by the existing lift truck and transfer system.

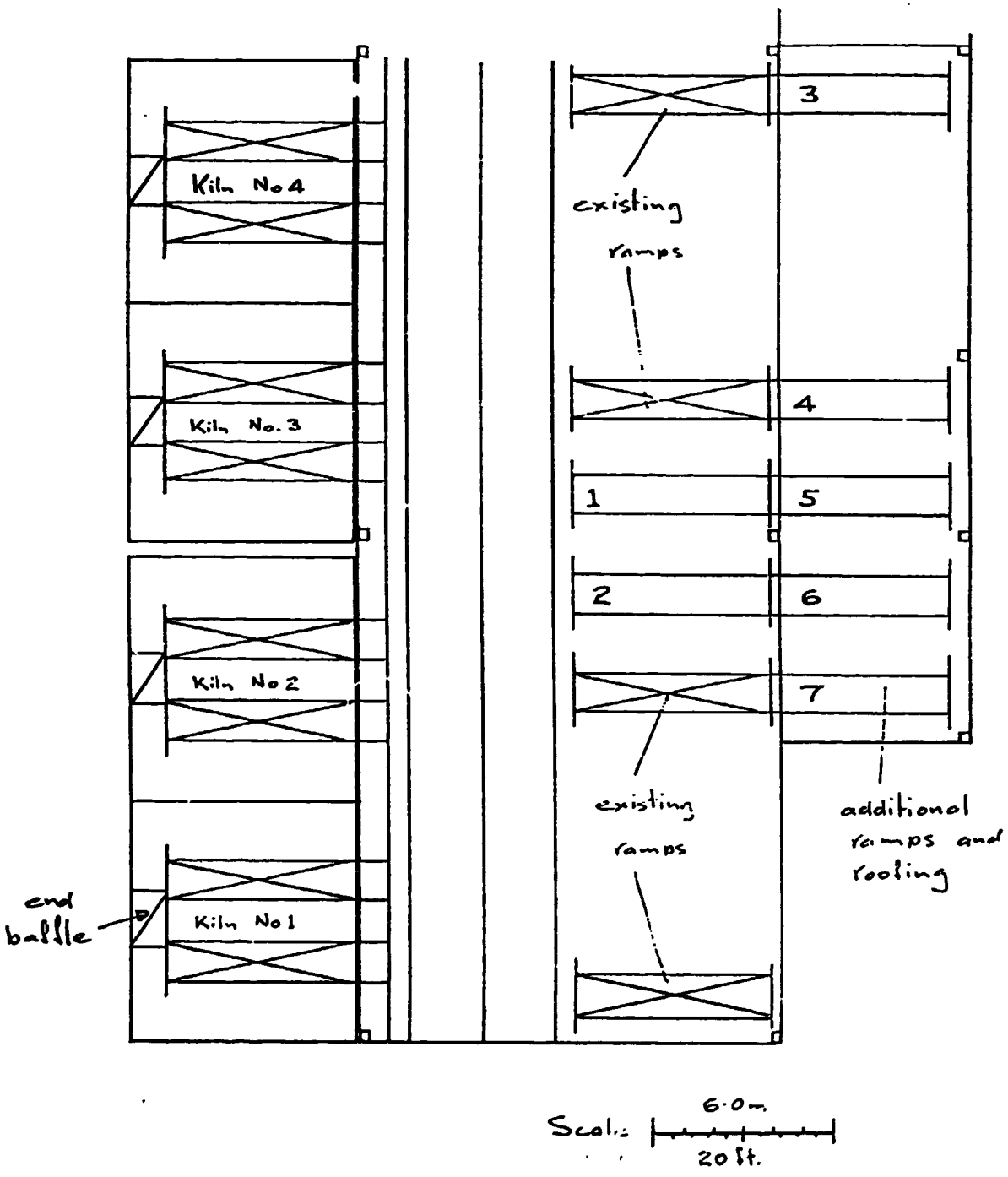


Fig. 5: Plan of GWMC seasoning kilns (with end baffles installed) showing four existing stacking ramps and seven additional ramps and roofing, for air seasoning.

In a stack of mixed hardwood, allowed to air dry for six days, the moisture content of sample boards fell from an average initial figure of 79% to 53.5%. Admittedly, the weather at the time was especially fine for Gedu, but even under wet, humid conditions, air drying is still effective in removing the early moisture (free moisture) from timber, thereby reducing the kiln residence time. Covered air drying is strongly recommended and an extension to the roofed area is also shown in Fig. 5.

It is estimated that for 32 mm timber, two weeks of air drying should, on average, be able to reduce kiln time to around 10 to 14 days. Current time is about 20 days kiln drying from green.

Provision of these additional ramps would also permit flexibility of operation. For example, difficult species which collapse, could be air dried for longer periods down to about 30% moisture content before being kiln dried. Improved quality should result. Also the extra ramps would allow kiln priorities to be altered, should urgent orders for a particular size or species group arise.

It is recommended that construction of the seven additional ramps be given top priority.

c. Kiln schedule development

The main objective in seasoning is to dry the timber in as short a time as possible with a minimum of degrade. "Schedules" are usually developed to do this, for various species and for various thicknesses, depending on how difficult the species is to dry. At GWMC, with all species mixed in together, it is only possible to apply a fairly mild schedule.

About 30 species of hardwood logs are represented in the Gedu logyard in significant numbers. Logs of other species may also be present from time to time. With the exception of walnut and the conifers, none of the others are sorted. They are sawn together, as they come, and the seasoning stacks are made up accordingly.

It is strongly suggested that species be allocated to a seasoning group according to their seasoning performance and that these groups be sorted in the logyard so they can be sawn and seasoned separately. Three groups should be adequate and the initial basis for grouping should be density classes.

The key to all of this, however, is species identification and at present no attempt is being made to identify any species, in either its log form or as sawn timber. Expertise in identification appears to be limited to just a few people, and it is recommended that this be fostered in many more of the staff in the logyard, the sawmill and the seasoning kilns.

A start has been made now to develop species information from the boards selected for sample boards. At present, the various boards chosen are only being given a number and a local name, in the hope that in the near future an expert in identification will be able to confirm their identity. The information being obtained is:

Green density, Basic Density, Air Dry Density
Shrinkage from green to 12%
Moisture meter corrections
Seasoning characteristics

It is proposed that logs be sorted, sawn and seasoned as per the three groups listed in Table 1. This grouping is based on limited air dry density information. The appropriate kiln seasoning schedules for each group are also listed in Table 1. These three groups should be added to and amended, depending on the information obtained from sample boards which have been through the seasoning process. For example, if Schedule I is found to be too severe for a certain species in Group I, the list should be amended to include that species in Group II.

As stressed in section 2, it is strongly recommended that certain species and certain logs which are difficult to dry, should be offered at auction rather than being sawn.

Buk (Oak) is a very difficult species to dry and there are others such as Katus (chestnut) which collapse and develop internal checking. If these species are sawn, they should be sawn to no thicker than 32 mm boards because boards present less problems in drying than framing sizes.

In addition, many of the rain forest logs have quite bad form (severe bends) and tension wood is always associated with this poor form. Tension wood has abnormal longitudinal shrinkage which results in bow and spring. While the demand from India for logs of any description remains high, there is no point in attempting to saw and season the difficult species and the difficult logs at GWMC.

Table 1: Species groups for seasoning purposes at GWMC, based on air dry density where available.

Group I - up to 500 kgs/m3

Local name	Botanical name
Arupatey	Prunus nepaliensis
Aldev (Utish)	Alnus nepaliensis
Rani Champ	Michelia champaca
Spruce	Picea spinelosa
Blue pine	Pinus wallichiana
Badrasi	Eleocarpus varuna

Group II - 500 to 600 kg/m3

Saur (Birch)	Betula alnoides
Kwala	Machilus gammiena
Kapasi (Maple)	Acer campbelli
Pipli	Bucklandia populnea
Toon	Cedrella spp.
Okhar (Walnut)	Juglans regia
Leck chilaune	Nyssa javanica
Tarsing	Beilschmeidia sikimensis
Bhale sissi	Neolitsea foliosa
Pahale	Litsea spp.
Lalchandan	Daphiniphylum himalayanensis
Kholme	Symplocos spicata
Gobray	Echinocarpus decicarpus

Group III - greater than 650 kg/m3

Buk (Oak)	Quercus lamellosa
Kharane (Ash)	Symplocos theifolia
Tita Champ	Michelia cathcarti
Aul chilaune	Schima wallichii
Katus	Castanopsis hystrix
Pathi sissi	Cuinnamomum impresnervum
Bholay putli	Acer oblongus
Famfal	Machilus edulis

SCHEDULES FOR GROUP I SPECIES

Air dry density up to 500kg/m³

M.C. Change Points %	Up to 35mm thick			Greater than 35mm		
	Dry Bulb °C	E.M.C. %	Wet B.D.* °C	Dry Bulb °C	E.M.C. %	Wet B.D. °C
Green	55	13.0	5	55	14.0	4
60	55	10.0	8	55	13.0	5
40	60	8.5	10	60	10.0	8
35	60	6.5	15	60	10.0	8
30	65	5.0	20	65	8.5	10
25	65	5.0	20	65	6.5	15
20	70	5.0	20	70	5.0	20
15	70	5.0	20	70	5.0	20

For Group I species a high humidity (steaming) treatment is recommended at the end of drying. This can be achieved by installing a live steam spray, to get 80°C and 18% E.M.C. for 3 hours for up to 35 mm thickness and 4 hours for thickness greater than 35 mm.

* Wet Bulb Depression

SCHEDULES FOR GROUP II SPECIES

Air dry density 500 to 650 kg/mm³

M.C. Change Points %	Up to 35mm thick			Greater than 35mm		
	Dry Bulb °C	E.M.C. %	Wet B.D. °C	Dry Bulb °C	E.M.C. %	Wet B.D. °C
Green	50	14.0	4	45	16.0	3
60	50	13.0	5	50	14.0	4
40	55	11.0	7	50	13.0	6
35	55	10.0	8	55	10.0	8
30	60	8.5	10	55	8.5	10
25	60	6.5	15	60	7.5	12
20	70	5.0	20	65	6.5	15
15	70	5.0	20	70	5.0	20

A high humidity treatment is recommended for Group II species as per that for Group I species.

SCHEDULES FOR GROUP III SPECIES

Air dry density greater than 650kg/m³ and for any other species prove to collapse. Same schedule for all sizes

M.C. Change Points %	Dry Bulb °C	E.M.C. %	Wet B.D. °C
Green	45	16.0	3
60	45	16.0	3
40	50	14.0	4
35	50	12.0	6
30	55	10.0	8
25	55	8.5	10
20	65	6.5	15
15	70	5.0	20

Note: For these species air drying down to about 35% is recommended before kiln drying. A reconditioning treatment is also recommended at 20% M/C. This is similar to a high humidity treatment. Temperature should be 90°C with maximum E.M.C. attainable for 4 hours.

For all species,

Schedule changes should be made when sample board with the highest M.C. has reached the M.C. change points.

When a stack has been air drying, the kiln should be set for the conditions applying to the previous change point, eg. if a stack is air dried to 35% M.C., apply the kiln conditions listed for

7. Quality assurance

There is a definite distinction between quality control and quality assurance.

Quality control extends to the end of kiln drying. It rests with the kiln operator and consists of decisions being made by him to control the drying of a kiln charge, based on information received from sample boards, about the progress of drying of that charge.

Quality assurance is a formal feed-back system where information about the final moisture content of a charge is presented to the kiln operator after the stack has been broken down.

He can then check this information against his information for the particular charge and adjust the drying times or conditions for subsequent charges accordingly.

A quality assurance system was instituted for GWMC as part of the consultancy. It consists of taking moisture meter readings on a sample of about 30 boards per stack as the stacks are broken down. Moisture meters have limited accuracy, but they are useful for providing an indication of dried quality, i.e. the average moisture content and the range.

A moisture meter with long nails and a sliding hammer electrodes should be used so the nails reach to the center of the board. Sample selection should be as per the format developed, i.e. about every third board, in every tenth layer. The readings should be entered to indicate the approximate position of the samples in the stack. Stack details such as stack number, seasoning group and thickness should also be recorded. Allowance should be made on each record for the production supervisor and the kiln supervisor to sign, indicating that they have sighted the results. In addition to this, the foreman in charge of the blockboard section and the joinery manager should also be encouraged to offer feed-back on seasoned quality.

8. Training

A timber seasoning course as detailed in Annex I was held over four days for seven participants. Each received a complete copy of the course notes. Attendance was good and feedback during the course was most encouraging. Participants were the Production Manager, two from the kilns, two from the sawmill, the Joinery Manager and the Assistant Logging Manager. As discussed in Section 2, timber seasoning cannot be considered in isolation. It is processing in joinery or blockboard manufacture. It must be considered as an integral part in the whole organization and it was pleasing that the management level from these other sections was well represented.

Extensive on-the-job training was given to the kiln supervisor and his assistant. This involved stack construction, sample board preparation, measurement techniques, kiln testing, record keeping and the interpretation of results.

It is recommended that the kiln supervisor undertake further training overseas, and arrangements will be pursued for him to be attached to the Division of Technical Services of the Department of Forestry, Queensland, Australia. The Division has a comprehensive seasoning research section and a period of three weeks working with the research staff would be an invaluable experience.

9. Forest Products Research

It is considered that the Department of Forests has a responsibility to ensure that forest products research is being addressed in the same way that forest research is, and it is strongly recommended that an appointment in forest products research be made in the Department of Forests as soon as possible. The initial role of the appointee should be to extract all species information relevant to Bhutan, from the Dehra Dun information. This could then be confirmed, and the missing information provided by local research. Although the appointee should be from the Department of Forests, he should be based at Gedu with an office at GWMC, where basic laboratory and sample preparation facilities are available. GWMC is the largest wood processing plant in Bhutan and the wide range of temperate rain forest species being logged makes it extremely difficult to attain high product standards. Expanding the expertise in species recognition, backed up by basic wood property information would certainly lead to more efficient utilization of the various species, to improved product quality, and to higher profits. This proposal was discussed with the Officer in Charge of Forest Research at Tava, Thimphu and will be further considered under Part B of this report.

10. Recommendations and action proposed for timber seasoning, GWMC

Section	Recommendation	Action Officer
2	Difficult species, bendy and misshapen logs be sold instead of being processed	Policy: General Manager Action: Logging Manager
2.3	Debark logs prior to sawing	Sawmill Manager
2.3	Obtain consultancy for expert Sawdoctor	General Manager UNDP
2.4	Feasibility study to rationalize seasoned requirements for blockboard and joinery (sizes and moisture content)	Production Manager
3.1.2	Feasibility study for hydraulic lift platform for stack construction	Production Manager Plant Engineer

3.1.5	Connect steam to the water spray	Plant Engineer
3.1.6	Obtain a thermocouple temperature indicator	Production Manager
3.1.7	Construct plywood baffles in all kilns	Kiln Supervisor
3.1.7	Adopt four-hourly intervals for fan reversal	Kiln Supervisor
3.1.8	Adopt sample board system of moisture content monitoring	Kiln Supervisor
4	Replace short length sticks with single length sticks	Kiln Supervisor
5	Construct air drying ramps	Policy: General Manager, Action: Production Manager
6	Sort logs into seasoning groups	Logging Manager
7	Develop and implement a regular Inspection/Maintenance schedule	Production Manager Plant Engineer, Kiln Supervisor
7	Replace fan motors in kilns 3 and 4	Plant Engineer
7	Calibrate and repair all electronic equipment	Plant Engineer
8	Undertake Quality Assurance testing for attention Production Manager and Kiln Supervisor	Assistant Kiln Supervisor
9	Organize overseas training for kiln Supervisor	Consultant, General Manager
10	Obtain forest products research technician for GWMC	General Manager Director of Forests, O/C Forest Research

Part B - Aspects of timber research and development in Bhutan

1. Introduction

An analysis of the situation at Gedu reveals that for the foreseeable future the sawmilling and seasoning facilities at GWMC will be almost totally occupied in meeting the Corporation's own requirements for blockboard, joinery and prefabricated buildings. There will be little excess capacity to provide seasoned timber for the general market or to undertake custom seasoning.

In Bhutan at present there is a limited appreciation of the desirability for using seasoned timber. An understanding of shrinkage and what happens when timber dries is essential to improving both initial and long term performance of timber products, particularly as more machines are used in construction, and the factory fabrication of timber articles and components continues to grow. Not all timber needs to be seasoned, but, where it is required, it is important that certain requirements are met.

Two quite separate areas of building can be defined:

1. Tradition housing, where in many respects the builders manage to accommodate the action of shrinkage by allowing for it in their design.
2. Institutional buildings (hotels, government offices, schools and public buildings), which are usually built to a time schedule by contractors, where joinery items can be factory products off-site, and where there is no time to adequately season timber for flooring and panelling, etc. on site, prior to use.

The design and construction of traditional housing has reached a high level of sophistication and skill, and the incentives offered by government to ensure that this continues are to be commended. A greater awareness of the use of seasoned timber, the use of preservative treated timber, and of the basics of wood technology would be of some benefit in tradition building. In institutional building, it is essential.

These aspects were pursued in the limited time available and reports and recommendations are made in the following sections.

2. Timber seasoning teaching aids

As mentioned under training, Part A, Section 9, a comprehensive timber seasoning course was run at GWMC for seven of the management and supervisory staff.

The course content, detailed in Annex I, covered aspects of timber seasoning such as wood/water relationships, air seasoning, stacking, drying stresses, etc., which are all necessary to an understanding of kiln drying.

Each participant received a copy of the course notes. A further copy of the notes, together with all the overhead projector transparencies, was left with the Principal of the Royal Technical Institute at Kharbandi (RTIK).

This institute runs a building and construction course which includes carpentry and joinery (C&J) and discussions were held with the Principal and the C&J staff, with the view to introducing additional relevant information on timber and its properties.

The C&J staff members were invited to attend the seasoning course at Gedu, but unfortunately their teaching commitments prevented this.

2.1 Pilot scale solar timber kiln for RTIK

The Principal expressed interest in building a small solar timber drying kiln at the Institute so that timber for their own requirements could be seasoned. Details on solar kiln design were left with him. The proposal is strongly supported as it would also serve as a valuable teaching aid to introduce some of the basics of wood technology.

2.2 Carpentry workshop equipment, RTIK

While at the Institute it was noted that the equipment available in the carpentry workshop is quite old and extremely limited. It is recommended that the possibility of new equipment being provided under an aid project be investigated.

The education system can play a large part in developing an awareness of the technical properties of timber. It is desirable that this be introduced at the upper primary level or thereabouts. However, at this stage, as a start to improving the efficiency of the wood using sector, it is most desirable that relevant information on timber and its properties be given to the building and construction students at RTIK. Provision of a small solar kiln and new workshop equipment would help to lift the effectiveness of this important area.

3. The potential for using seasoned timber in Bhutan

As discussed in the introduction to Part B, it is in the construction of institutional type buildings that the use of seasoned timber has its greatest potential.

A short course-cum-discussion was organized for architects and draughtsmen from the following specifying/building organizations:

Public Works Department (PWD)
South Asian Association for Regional Cooperation (SAARC)
Department of Education.

Unfortunately only the Education Department was represented by seven attenders and there was also an architect from the private sector.

The discussion was structured around 'Timber specifiers' Notes', prepared by the Department of Forestry, Queensland. Contents are detailed in Appendix II. Emphasis was placed on taking care to determine what is required of timber building materials, taking care to specify correctly and precisely and taking care to check that the material received meets the specifications in terms of species, durability, moisture content and grade.

At present there are no standard timber grading rules in Bhutan but this is of no great consequence. Relevant rules from India could be used, or it may be sufficient not to use standard rules but simply to adopt certain specifications which limit the size of knots, the size of gum veins, etc.

Seasoned timber is not readily available from any sawmill except for Gedu but this is largely because there has been no demand for it. Seasoned timber can be provided, if it is clearly specified and ordered as such, even if it is air dried. It will not be until the demand grows that suppliers can be expected to install timber seasoning kilns.

A small dehumidifier kiln has been installed in Thimphu by SAARC to season the timber being used for joinery and panelling in the new Conference Center. This kiln is also available to do custom seasoning but it will not get much use until specifiers order seasoned timber.

The potential is there to improve the standard of building and of furniture, etc. by using seasoned timber as appropriate. It is considered that those designing public buildings for the Government should take the lead in specifying seasoned timber for particular uses.

4. Solar kiln for the Public Works Department (PWD) bridge project at Gaylegphug

Although arrangements had been made to visit the wooden bridge project at Gaylegphug, the trip was not made because the project carpenter was not on site. In addition reports were received that PWD were not ready at the time to develop the project any further.

5. Solar kiln for Bhutan Logging Corporation (BLC) at Ramtokta

The BLC log depot at Ramtokta was inspected with the view to installing a demonstrations solar kiln in site. The site would be satisfactory, however BLC is reviewing its operation. At present BLC provides logs to privately owned sawmills who, for a fee, convert them to sawn timber and then they (BLC) arrange for the sale of the sawn timber. This is likely to change, whereby the sawmills will purchase the logs from BLC and will then sell the sawn timber to consumers.

Most of the country mills are expected to be selling their sawn product in the green condition to India. The mill at Ramtokta is a country mill and therefore would not be wanting to sell seasoned timber.

As mentioned, there is a dehumidifier kiln run in Thimphu by SAARC, and it is understood that this unit is being given to the Forest Department (BLC) to operate when the Conference Center Project has been completed. At this stage, while the demand for seasoned timber is just developing, it is considered the dehumidifier kiln should be operated instead of installing a solar kiln. Electricity is quite inexpensive in Bhutan, at Ng. 0.4 per kWh, which makes operating a dehumidifier much more reasonable than it would be in other countries.

It is recommended the local specifiers and sawmillers be encouraged to use the dehumidifier kiln now, and the proposal to instal a solar kiln be reviewed once market acceptance of seasoned timber has been developed. Copies of a paper by D. Gough 'Timber seasoning in a solar kiln' (see annex III for abstract) were left with BLC and also with RTIK.

6. Sawmill recovery studies for BLC

Information was forwarded to BLC on the methodology for undertaking sawmill recovery studies. The information is in the form of a field report by Gough, Williams, Sydney Chan and Chan Hing Hon, 1982, 'Procedure and computer tabulation for graded recovery studies of sawn timber' (see annex IV for abstract).

As BLC is responsible for selling logs, it is important that they are able to determine the true value of various log size and quality classes, based on the value of the timber obtainable from those logs.

The above filed report establishes the principles involved in sawmill recovery studies. It sets procedures which allow studies done at different times to be readily compared, one with the other. Computers are not essential for data analysis, but they certainly help. The computer programme listed in this report is perhaps not as elegant as it could be and there are programme packages available which could no doubt be easily adapted for use; nonetheless it does work and could be used either for separate logs/stems or for batches of logs sorted,for example into diameter classes.

7. Timber preservation

7.1 Roofing shingle project - Punakha

A project involving the creosote treatment of softwood roofing shingles for a major renovation of the Punakha Dzong was inspected at the request of the District Forester, Thimphu.

This was a hot and cold treatment in 50/50 creosote and oil. The shingles were held in a tank maintained at about 80oC for one hour and were then transferred to a tank of cold creosote and oil. Penetration, even in the sapwood, was minimal and it is considered that immersion for 2 to 3 hours, at about 90o-100oC would give a better result. The treated shingles are being stored for one to two years before they will be used. This should reduce any risk of contamination to rain water run-off from the roof.

The treatment would be expected to extend the life of the shingles by reducing physical weathering and by preventing decay in the penetrated timbers. It is recommended that a foam-type fire extinguisher be kept on hand at the treatment site and that the storage of treated and untreated timber be in separate sheds from the treatment tanks, in case a fire occurs.

7.2 Poles for power and telephone transmission

In general, only the sapwood of any species can be successfully treated with preservatives. Some penetration can be achieved in the heartwood of some species but this is usually low level and quite variable.

Fortunately, the conifers of pole size have relatively wide sapwood and can be most successfully treated for power and telephone transmission poles. It is recommended that this aspect be further examined as a means of providing an alternative to the imported steel poles currently in use. It could also develop into an exportable product.

7.3 Lyctus immunization

A low level of treatment is desirable to immunize the sapwood of certain hardwoods against the Lyctus borer. Lyctus attack has been observed at Gedu and it has been reported in some of the plywood and blockboard coming from Gedu. The extent of the problem is not known and research work is required to determine which species have Lyctus susceptible sapwood.

7.4 CCA treatment at GWMC

There is a large Vacuum Pressure Impregnation plant for CCA treatment at Gedu, but to date this plant has not been used. Many of the rain forest species processed by GWMC have wide sapwood and would accept treatment quite readily. However, a large amount of research is required to develop an effective treatment programme.

A medium level of treatment is desirable to treat the sapwood of all timber used in above ground situations, exposed to the weather. Higher levels are required when the timber is used in the ground, to give protection against decay. In addition, species with low natural durability should not be used in the ground because their heartwood cannot be treated and will still be subject to decay.

Course notes for a Timber Preservation Operators course, presented by the Queensland Timber Industry Training Council were left with the Production Manager at GWMC. The need to use this plant should be reviewed.

7.5 Termites

Termites present a difficult problem because they will still destroy the untreated heartwood in a building. Timber houses, including prefabricated buildings, located in termite prone areas are best protected by treating the soil around all foundations with an organochlorine or organophosphorus insecticide, by placing 'ant caps' under the main bearers, and by undertaking annual inspections for termite tunnels leading into the building. Information is derived from Australian Standard Code for Practice, AS 2057-1986, giving recommended practice for installing effective chemically treated soil barriers and listing recommended chemicals and their concentrations is given in Appendix V.

8. Recommendations and conclusions for part B

- A greater emphasis on basic wood technology and the use of seasoned timber and preservative treated timber is recommended to enhance the building and construction course at RTIK. This is essential to improve the long term use of timber in Bhutan.

- A pilot scale solar timber kiln should be installed at RTIK.

- New equipment and machines are recommended for the carpentry workshop at RTIK.

- The construction of institutional buildings (public buildings, schools, etc.) should be targeted initially for the use of seasoned timber. Architects and builders must be encouraged to specify accordingly.

- The proposal for a solar kiln installation at Gaylegphug should be held in abeyance.

- Due to operational changes in BLC the depot at Ramtokta is not considered suitable for a solar kiln installation.

- Encouragement should be given to using the SAARC dehumidifier kiln in Thimphu for custom seasoning and the proposal for a solar kiln should be reviewed when market acceptance for seasoned timber has been developed.

- The principles and procedures documented in the paper given to BLC (Annex IV) are recommended for sawn timber recovery studies.

- A creosote/oil temperature of 90-100oC with immersion for two to three hours would improve preservative penetration in the treatment of roofing shingles.

- A foam type fire extinguisher should be on hand when the hot and cold process for creosote treatment is being used to treat roofing shingles, and the treatment and storage areas should be kept separate.

- Priority should be given to CCA treatment of softwood transmission poles.

- Priority should be given to identifying species which have Lyctus susceptible sapwood.

- Soil poisoning and the use of ant caps is recommended to prevent termite attack in problem areas.

Further consideration of the various aspects discussed in Part B reinforces the recommendation in item 10, part A, which is for Forest Products Research to be addressed by the Forests Department in the same way that Forest research is being addressed.

The first priority is for an officer to be stationed at Gedu, but this should be placed in the overall context of a forest product research and extension function, with headquarters at Tava (or Thimphu). The dehumidifier kiln and the mobile treatment plant at Thimphu could be used as the initiation of a research facility. A solar kiln could be added. In the long run, it may be a better proposition to locate all of this equipment at Tava. Consideration should be given to this alternative.

All of this however, required a commitment on the part of the Forestry Department to provide suitably trained staff, which at present is quite difficult, in view of the demands for staff presented by the current FAO Forest Management Project.

Species property evaluation is being undertaken at present by Dehra Dun. This is a fairly long term project and it will be of considerable help, but at this stage, there is little scope for making use of that information in Bhutan and for raising the standards of timber utilization in the broad sense.

It is strongly recommended that urgent consideration be given to the planning of a Forest Products research and extension function in Bhutan and that staff be selected now for appropriate wood science/wood technology training.

9. <u>Recommendation and action proposed with respect to aspects of timber utilization in Bhutan.</u>

Section	Recommendation	Action Officer
2	Give more emphasis to basic wood technology and use of seasoned and treated timber in building course at RTIK.	Principal and Head of Building and Construction RTIK

2.1	Construct pilot scale solar kiln at RTIK	Principal and Head of Building and Construction
2.2	Obtain new workshop equipment for carpentry at RTIK	Principal, RTIK, UNDP
3	Specify seasoned timber as appropriate for institutional buildings	Architects, engineers and builders.
4.	Reassess need for solar kiln at Gaylegphug	PWD, UNIDO
5	Operate the dehumidifier kiln at Thimphu and review the need for a solar kiln as demand for seasoned timber increases	Deputy Director, BLC UNIDO
6	Publication on sawmill recovery studies be used for log valuation by BLC	Deputy Director BLC
7.1	Shingle treatment be tried at 90-100oC for two to three hours. Obtain foam type fire extinguisher and separate storage from treatment	DFO, Thimphu
7.2	Examine use of treated pine poles for telephone and electricity lines	Deputy Director, BLC
7.3	Obtain information on Lyctus susceptibility of hardwood species	General Manager, GWMC O/C Forest Research
7.4	Review the need to use CCA treatment plant at GWMC	General Manager, GWMC O/C Forest Research
7.5	Use soil poisoning and ant caps to overcome termite problems	Specifiers, PWD Education Department, etc.
8.	Develop a forest products research and extension function in Bhutan	General Manager, GWMC Director of Forests O/C Forest Research

ANNEX I

TIMBER SEASONING COURSE

CONTENTS

Note: This course was prepared originally for the Timber Industry Training Council, Queensland, Australia. Presentation of the course at G.W.M.C. was adapted for the specific conditions in Bhutan and reference to chapters 9 and 10 was omitted.

ANNEX II

The Queensland Department of Forestry

TIMBER SPECIFIER'S NOTES

Containing information to help Architects, Engineers and Builders prepare specifications which will assist both themselves and timber suppliers to arrive at the most effective, most satisfactory and the most attractive use of timber.

CONTENTS

NO. 24 TECHNICAL PAPER 1981

TIMBER SEASONING IN A SOLAR KILN

BY

D. K. GOUGH

ABSTRACT

A solar kiln of 15 cu m capacity has been built for demonstration and research purposes in Brisbane, Queensland. Details of design and construction, capital and operating costs are given together with drying rates for a range of species dried in the solar kiln and for matching air dried stacks. On a fine day the maximum temperature in the kiln is about 18°C to 24°C above the maximum outside temperature. The kiln is effective and can dry timber to below equilibrium moisture content in a relatively short time. The most effective system of operation is to air-dry the timber to about 20 to 25 per cent moisture content before moving it into the kiln.

ANNEX IV

FAO/UNDP-MAL/78/004
Field Document No.3

DEVELOPMENT OF SAWMILLING, KILN DRYING AND PRESERVATION RESEARCH IN SABAH

PROCEDURE AND COMPUTER TABULATION FOR GRADED RECOVERY STUDIES OF SAWN TIMBER

A Technical Report to
the Government of Malaysia

by

D K Gough	Project Team Leader
J St J Williams	CUSO Volunteer
Sydney Chan	Systems Analyst
Chan Hing Hon	Utilization Officer

UNITED NATIONS DEVELOPMENT PROGRAMME
FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

Forest Research Centre, Sandakan, August 1982

FAO. Development of Sawmilling, Kiln Drying and Preservation Research in Sabah. Procedure and Computer Tabulation for Graded Recovery Studies of Sawn Timber by D K Gough, J St J Williams, Sydney Chan and Chan Hing Hon, Sandakan 1982, 28 p. FAO/UNDP-MAL/78/004. Field Document No.3.

ABSTRACT

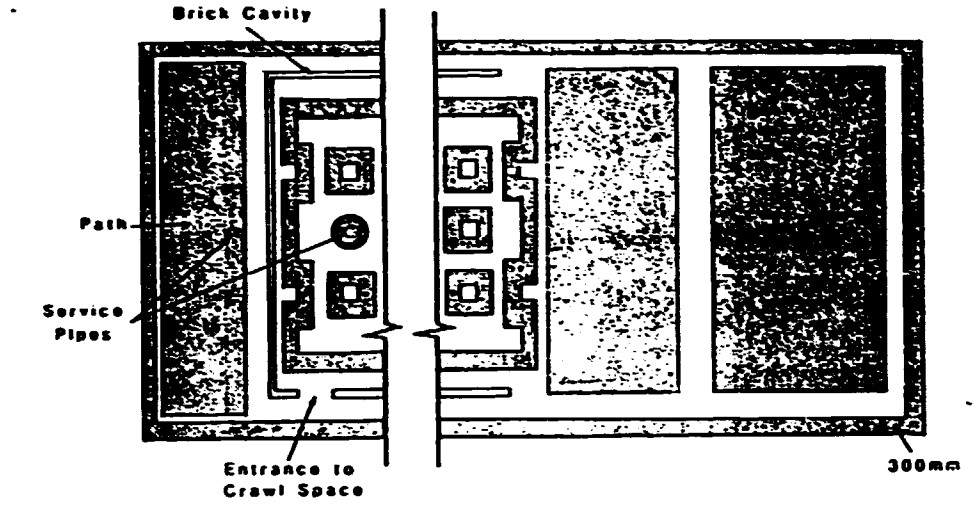
This paper was prepared as part of the project started in 1981 by the government of Malaysia, the United Nations Development Programme and the Food and Agriculture Organisation of the United Nations, to ensure the optimal utilisation of timber and wood products in the State of Sabah.

A major objective of the project is to provide information on the various timber properties of the lesser-known species (those species not being extracted and used because of lack of information on their properties).

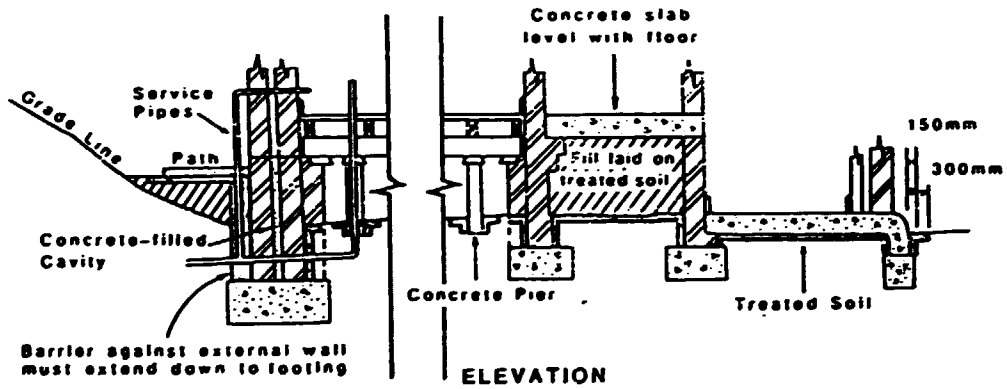
The paper documents the procedure developed for doing recovery studies on the graded timber sawn from logs of these species. Such studies provide quantitative information to show whether their exploitation is an economic proposition or not. Procedures for log collection and measurement, sawing, grading and computer tabulation of the data are given. Examples of the forms used, a summary of the grading rules used, a listing of the computer programmes and an example of the computer output are given in the Appendices.

The results from individual studies are not given. There is a discussion, suggesting how graded recovery information may be used. The application of this procedure to species grown in plantations and to currently accepted species for re-valuation purposes, is also mentioned.

ANNEX F



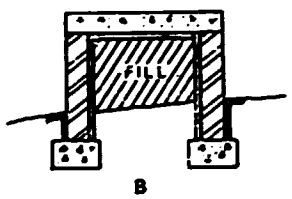
PLAN



ELEVATION

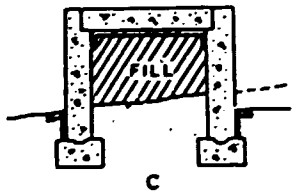
KEY

- Fill
- Pier
- Brickwork
- Concrete
- Treated areas



B

BRICK SUBSTRUCTURE AND RETAINING WALLS. Vertical barriers must be continuous with and meet the barriers external to the retaining wall.



C

CAST CONCRETE SUBSTRUCTURE AND RETAINING WALLS (or other materials impenetrable to termites). The barrier must seal any junctions between retaining walls and floor slab and be continuous under the slab.

Recommended practice for the installation of effective chemically treated soil barriers against termites.

Note: Diagrams B and C are alternatives for the slab on fill situation.

Chemicals currently recommended for soil treatment against subterranean termites

Any one of the following chemical emulsions is effective when applied in accordance with the Australian Standard Codes of Practice AS2057-1986 as appropriate.

Chemical	Dilution
Organochlorine Insecticides	
Aldrin	An aqueous emulsion containing 5g/L of aldrin
Chlordane	An aqueous emulsion containing 10g/L of technical chlordane
Dieldrin	An aqueous emulsion containing 5g/L of dieldrin
Heptachlor	An aqueous emulsion containing 5g/L of heptachlor
Chlordane/ Heptachlor	An aqueous emultion containing 5g/L of technical chlordane and 2.5g/L of heptachlor
Organophosphorus Insecticide	
Chlorpyrifos	An aqueous emulsion containing 10g/L or 20g/L or chlorpyrifos (see product label for details).

Prescribed application rates:

- for soil profile - 100L/m^3
- for soil surface treatment - 5L/m^2

These chemicals are poisonous. Read and observe label directions and safety precautions.