PROCEEDINGS

Of

The International Workshop

On

Introducing Myanmar's Lesser-Used Timber Species to the World Market

29 - 30 March 2000

Yangon , Myanmar

ITTO Project PD 31/96
Rev.2 (M.F.I)

FORESTS

ITTO

CONTENTS

PART I

INTERNATIONAL WORKSHOP & EXHIBITION

ON

INTRODUCING MYANMAR'S LESSER - USED

TIMBER SPECIES TO THE WORLD MARKET

ITTO Project PD 31/96 Rev. 2 (M.F.I)

SUMMARY

1. The International Workshop and Exhibition (2000) on Introducing Myanmar's Lesser Used Timber Species to the World Market was held in Yangon, Myanmar on 29 & 30 March, 2000 under co-sponsorship of ITTO Project PD 31/96 Rev.2 (M.F.I) and Forest Department, Myanmar.

2. The Workshop was convened to discuss the following (4) major subject areas.

(1) Developing Sustainable Forest Management System in Harvesting LUS.
(2) Research Findings of the Properties of LUS.
(3) Improved Utilization of LUS.
(4) Trade Promotion of LUS.

3. His Excellency Colonel Thaik Tun, Deputy Minister, Ministry of Forestry, officially opened the workshop. In this welcoming speech, he noted that it is the first project of ITTO in Myanmar with the development objective to increase the economic contribution of Myanmar's forest resources by emphasizing the introduction of under utilized timber species. He also expressed that he believed this workshop is of National as well as International significance by virtue of new initiative in promoting the utilization of LUS in line with the present situation of the world market.

4. Dr. Hwan Ok Ma, Projects Manager, Forest Industry, ITTO in his speech expressed that Myanmar has the potential to improve the economic value of tropical forests, to increase the capacity of the forest for sustained production of timber products, to develop value added product technologies, and to open up marketing opportunities for these products in both the domestic and international markets. He noted that, the current ITTO project in Myanmar may help to identify opportunities based on the use of lesser-used timber species, to contribute to improve forest management practices and forest ecosystem conservation, and sustainable development of timber industry.

5. Nine papers were presented by the resource persons in the field of forest Management, Timber Harvesting, Wood properties, wood Industries and Marketing regarding on improved utilization lesser - used timber species.

6. A video film on Timber Processing in Myanmar was shown to the participants on 30^{th} March 2000.

7. CD-ROM on Properties of Some Myanmar's Lesser- Used Timber Species was also demonstrated at the workshop.

8. The Exhibition (2000) was held along with the workshop on "Introducing Myanmar's Lesser - Used Timber Species to the world Market". In that exhibition the products of LUS such as internal materials, furniture and furniture components were shown impressively.

9. A plenary section on Introducing Myanmar's Lesser-Used Timber Species to the world Market was convened on 30^{th} March, 2000. The following persons have been selected as Panel of Chairman in the Plenary Session.

U Myat Thin	Advisor, Ministry of Forestry
Dr. Hwan Ok Ma	Projects Manager, ITTO
Mr. Songsak Vitayaudom	Chief of Planning Division, Royal Forest Department, Thailand
U Htein Win	Deputy Managing Director, Myanmar Forest Products and Timber Merchants' Association

10. The plenary session was convened to discuss four major subject areas as:

(1) Forestry aspect.
(2) Research on LUS promotion.
(3) Timber harvesting and processing.
(4) Strengthening marketing effort.

14. In the closing Address, Dr. Kyaw Tint, Director - General of Forest Department stated that the International Workshop and Exhibition marked the successful completion of the project. He also stated that Myanmar Forest Department is deeply indebted to ITTO for its financial and technical assistance. He thanked Dr. Hwan Ok Ma, the Projects Manager for his relentless support and encouragement through out the three year period of the project.

15. He also thanked to resource persons Dr. Emmanuel D Bello, Retired Director of Forest Products Research and Development Institute, Philippines, Dr. Lionel Jayanetti, Head (TRADA) UK, Dr. Yoji Kikata, Professor of Nagoya University, Japan, and Dr. R.H Leicester, Chief Research Scientist, Common Wealth Scientific and Industrial Research Organization (CSIRO), Australia and others participants for their excellent contribution and participation to the workshop. He also thanked to wood industrialists and staff of FRI for their relentless efforts and spent many nights to make the International workshop and Exhibition a successful one.

16. On behalf of ITTO Dr. Hwan Ok Ma, Projects Manager, stated in his closing remarks, he said that the International workshop was very successfully conducted. He hopes that the workshop produced some very special to the advance of

utilization of LUS and the recommendations can be followed by the Forest Department and Ministry of Forestry.

17. He thanked to resource persons, all the participants for their valuable recommendations and opinions. He also thanked to the delegates from Thailand Royal Forest Department.

18. Dr. Hwan Ok Ma thanked to FRI staff, National Project Manager U Win Kyi, and secretariat who assisted this workshop to be completed.

19. The Workshop ended at (17:30) pm on 30th March, 2000 with greeting to all participants by the Director-General of Forest Department.

20. On the 31st March 2000, the excursion tour was arranged to explore wood based industry factories and Hlaw Ga wild life park led by Dr. Hwan Ok Ma.

INAUGURAL ADDRESS

by

His Excellency Colonel Thaik Tun
Deputy Minister
Ministry of Forestry

- Distinguished Guests,
- Participants,
- Ladies and Gentlemen,

It is indeed a great pleasure for me to welcome you all to the opening session of the International Workshop and Exhibition (2000) of the ITTO project entitled Introducing Myanmar's Lesser-Used Timber Species to the World Market. This Workshop and Exhibition jointly organized by the Forest Department of Myanmar and ITTO, marks the accomplishments realized up to the end of the third and last year of the 3 year project.

We are most fortunate to have among us Dr. Hwan Ok Ma, the distinguished projects Manager of ITTO, who is one of the leading personnel of the project and the main driving force behind its implementation. I would like to welcome him to Myanmar and also to this assembly at the Taw Win Convention hall. Also among the resource persons, I find experts and scientists who have expertise and International experience related to the utilization and management of Lesser Used Species. I am pleased to see Dr. E.D. Bello from the Philippines, Dr. Yoji Kikata from Japan, Dr. Jayanetti from UK and Dr. R.H. Leicester from Australia. We are very much obliged that they are here to share their experience with us. I am also very glad to see many of our Myanmar scientists and researchers who represent their contribution in the effort to introduce Myanmar's Lesser - Used Timber Species to the International Market.

If I may briefly touch upon the background of Myanmar Forestry, about half of the total land area of the country is still covered with forests amounting to 344,237 square kilometers in extent. It is, therefore, not an exaggeration to state that the country is relatively in good shape in terms of forest resources as well as biodiversity richness. This can be attributed to the systematic and sustainable management of the natural forest in Myanmar since the adoption of the Myanmar Selection System which dates back to 1856. The system is the best and only way of working the heterogeneous forests, as it does not only lend itself well to work in a forest where there are so many species with only a few extracted, but also achieve environmental harmony without causing ecological damage.

However, Myanmar's natural forests are of high heterogeneity and the number of tree species, large and small, recorded so far amounts to over 2000 out of these about 700 species are known to attain merchantable size, but only 85 species, or 4 percent of the total, have been accepted as having capability to produce multi-use timbers of good quality. Consequently, the pressure on premier species in the natural forests are increasingly mounting. One approach to deviate from creaming the forests of commercially high – value species is to alleviate the pressure on these species by developing market for Lesser - Used ones. This strategy implies that the natural forests can better be managed sustainably by adopting a more intensive management regime that fully utilizes the timber species. It would also be an effort to realize the imperatives of Myanmar Forestry Policy, especially, in promoting the efficiency in harnessing the full economic potential of the forest through increased productivity while controlling the socio-economically and environmentally unacceptable side effects.

- Distinguished Guests, ladies and Gentlemen,

As an initiative to promote the utilization and marketing of Lesser-Used timber species, the Forest Department, in collaboration with ITTO, has launched the project " Introducing Myanmar's Lesser-Used Timber Species to the World Market " since 1997. It is the first project funded by ITTO in Myanmar with the development objective to increase the economic contribution of Myanmar's forest resources by emphasizing on the introduction of under-utilized timber species. Today, at the end of the 3 years project period, all anticipated outputs have been achieved, the final accomplishment being this International Workshop and Exhibition.

In fact, Myanmar's relationship and commitment to ITTO commenced much earlier when it became the 51st member country in November, 1993. I would like to take the opportunity of this occasion to welcome more collaborations with ITTO in order to achieve the ultimate goal of sustainable forest development and overall balance of the ecosystem to ensure the perpetuity of mankind.

Turning back to the workshop, I believe it is fair to say that this workshop is of national as well as international significance by virtue of the new initiative in promoting the utilization of Lesser-Used Species in line with the present situation of the world market. I understand that planning and preparation to hold this workshop have taken many months. It is most heartening to observe this wonderful turnout of keen participants and enthusiasts. It makes me more confident that this workshop will bring about fruitful results in introducing the essence and importance of utilization of lesser-used species for sustainable forest management. I would sincerely and strongly urge all participants to take every opportunity of this occasion to absorb, as much as possible, new findings and identify areas in which they would be most applicable. Although the duration of the workshop is very short, I am well convinced that it will be fruitful and rewarding and that the participants from the various units will respond very positively and build up on what have been already achieved with follow-up activities.

The initiative taken by ITTO to hold this workshop is very much appreciated indeed. It is not only appropriate but obligatory to thank, personally, Dr. Hwan Ok Ma, the very distinguished representative of ITTO, without whose assistance this workshop would not have been materialized. It is also my privilege and pleasure to commend the staff and personnel of the ITTO project and also staff members of the Forest Department who have been instrumental in organizing this event. I would also like to express deep gratitude to the resource persons from the various organizations for their invaluable contributions. I wish you all great success and achievement in your deliberations.

- Distinguished Guests,
- Participants,
- Ladies and Gentlemen,

Allow me to bring my statement to a close by thanking all of you again for gracing this ceremony.

Thank You.

OPENING STATEMENT

by

Dr. Hwan Ok Ma
Projects Manager, Forest Industry,
International Tropical Timber Organization

- His Excellency, Colonel Thaik Tun, Deputy Minister, Ministry of Forestry,
- Dr. Kyaw Tint, Director-General of the Forest Department,
- U Soe Tint, Director-General of the Planning and Statistics Department,
- U Win Htun, Managing Director of the Myanma Timber Enterprise,
- Delegates from Thailand,
- Distinguished Guests,
- Ladies and Gentlemen,

It is a great pleasure and honour for me to salute and welcome all of you on behalf of the Executive Director of ITTO Dr. Manoel Sobral Filho to this opening ceremony of the International Workshop on Introducing Myanmar's LUS to the World Market along with LUS Products Exhibition. I would like to extend ITTO's best wishes for a successful workshop.

On behalf of ITTO, I would also like to tell you many officials in the Ministry of Forestry how grateful we are for their continued strong support for ITTO project and this workshop. We are indeed honored by Vice Minister's presence among us this morning to preside this Opening Ceremony for this workshop. Through you I would like to express our sincere thanks and infinite gratitude to the Myanmar Ministry of Forestry, for its excellent arrangements of this important workshop and LUS products exhibition.

- Ladies and Gentlemen,

Let me use this privilege to start with mutual exchange of information by presenting to you about ITTO. The International Tropical Timber Organization (ITTO) was established in 1986 and it is an intergovernmental organization, which brings together countries produce and consume tropical timber and develops policies on all aspects of the world tropical timber economy. It is headquartered in Yokohama, Japan and as January 2000, it has 53 member countries comprising 29 producer member countries and 23 consumer member countries. Among the producer countries as you know Brazil, Indonesia, Malaysia and Ghana are important countries. Among the consumer countries Japan, China, Republic of Korea and United States are also important in terms of their number of votes.

ITTO mission is to facilitate discussion, consultation and international co-operation on issues relating to the international trade and utilization of tropical timber and the sustainable management of its resource base. The member countries in the ITTO have committed to target 2000. Our activities are now geared towards promoting international trade in tropical timber from sustainably managed forest resources.

The Organization works towards its objective on a consensus basis through two types of activities; policy works and related project works. On the policy side, for example, as one measure to assist our member countries in achieving the year 2000 Objective, ITTO has recently published two manuals for the application of criteria and indicators for sustainable management of natural tropical forests at both national and forest management unit levels. These manuals will provide practical guidance to countries in implementing sustainable management of tropical forests.

On the other hand, project work is an important aspect of the Organization's activities and a primary means of assisting our member countries to implement policy initiatives. Members may submit project proposals to the International Tropical Timber Council for review and financing. All projects are funded by voluntary contributions from member countries. Since 1986, the ITTO has supported more than 400 projects amounting to about one hundred and seventy million dollars spread over Asia-Pacific, Africa and Latin America Caribbean regions. This is one of the key activities of the Organization, which has made ITTO a leader in the field of sustainable management of tropical forests and sustainable development of the tropical forest industry.

The sponsorship of this workshop through the kindness of the Government of Japan is one of the examples for project work in ITTO. With regard to the promotion of LUS, ITTO has supported many projects in tropical regions. The following are on-going projects relating to the promotion of LUS:

- Industrial Utilization and Improved Marketing of Some Ghanaian Lesser-used Timber Species from Sustainable Managed Forests which is implementing in Ghana.
- Industrial Utilization of Lesser-Known Forest Species in Sustainably Managed Forests which is being implemented in Honduras.
- Impact of Increased Utilization of Lesser-Used Species which is implementing in Ghana.
- The Establishment of the Database of Tropical Industrial Lesser-Used Wood Species which is implementing in the ITTO Secretariat through the Nagoya University. I am very pleased to see our project leader here also.

- Ladies and Gentlemen,

In Myanmar, in fact, it is clear that the utilization of Lesser-Used timber species is significant because it has the potential to improve the economic value of tropical forests to increase the capacity of the forest for the sustained production of timber products, to develop value added product technologies and to open up marketing opportunities for these products both for the domestic and international market. In this connection, it is anticipated that the current ITTO project may help to identify tropical forestry opportunities based on the use of Lesser-Used species, thus contributing to improved forest management practices and forest ecosystem conservation and sustainable development of the forest industry.

At the first meeting of the PSC for the project, Honorable Minister, U Aung Phone, the Chairman of the project steering committee said that Myanmar has more than 2,000 timber species and till now only some species are being utilized. He emphasized that this ITTO project will help reduce pressure on demand for teak and other valuable hardwoods and increase export earning in brining up the LUS for both domestic and international markets with socio-economic viability and ecological acceptability.

- Ladies and Gentlemen,

The convening of this workshop at this time, when Asia is completely out of the financial and economic crisis, provides timely opportunity to consider further development of the timber industry in Myanmar and potential contribution of the timber industry to the national economy. The timber industry is not only an important for economic activity but also a major source of valuable foreign exchange earning, and providing employment opportunities to the population.

I believe that this workshop has two important tasks:

i. to review the achievements of the project PD 31/96 with demonstration of LUS products.
ii. to identify feasible strategies to promote LUS in the domestic and the international market.

The workshop will address important issues such as (1) availability of the LUS and the dynamic of the resources base, (2) processing technologies of selected promising LUS for product development and (3) marketing for LUS products which I believe could be critical importance and could provide the right direction to promote the utilization of the LUS.

In the coming two days, the distinguished scientists, respected resource persons, and members of the Myanmar Forest Products and Timber Merchants' Association, who have real hand-on experience, will deliver the issues and I hope, at the end, we would have covered the problems of the industry and then to submit a final technical report to the ITTO. I hope Yangon workshop recommendations will be made based on specific need of the timber industry sector in a collective way to promote sustainable supply and management of LUS, efficient utilization and processing of LUS and better economic information on the international trade in tropical timber.

Today, I am happy to be with Dr. Yoji Kikata from Nagoya University, Japan, Dr. Lionel Jayanetti from the Timber Research and Development Association UK, Dr. Emmanuel D. Bello, the former Director of the Forest Product Research

Institute, now the professor of University of Philippines at Los Baños and Dr. Robert H. Leicester, Common Wealth Scientific and Industrial Research Organization, Australia, respectful four international experts. I believe that they have taken great effort to be with us this morning.

- Your Excellency, Distinguish Guests, Ladies and Gentlemen,

I wish thanks again to the Ministry of Forestry for the enthusiastic arrangements made for this workshop and products exhibition. Particularly, I would like to express my sincere appreciation to Honorable Minister, U Aung Phone, for his strong support and effective guidance for the implementation of the ITTO project. Perhaps we could never have this workshop without his strong support.

I feel confident that the outcome of this workshop and demonstration of LUS products will generate feasible national strategy for promoting LUS in domestic and international market and further development of Myanma Timber Enterprise also in the new millennium.

I again wish you all the success for this important workshop and a pleasant stay in Yangon.

I thank you for your kind attention.

PART II

Technical Session 1

CONTENTS

POTENTIAL PRODUCTION AND DISTRIBUTION OF LESSER USED SPECIES IN MYANMAR
(Sustainable Forest Management Perspective)
ITTO PROJECT PD 31/96 REV. 2 (M.F.I.)

U MYINT SWE, U THEIN WIN, AND U KYAW HTUN
Deputy Directors and Assistant Director
Planning and Statistics Division, Forest Department

SUMMARY

The present total annual allowable cut (AAC) fixed for Teak (*Tectona grandis*) and non-teak other hardwoods are 409,062 m^3 and 3,236,071 m^3 in volume respectively. The total volume of the remaining other non-teak hardwood species available annually on sustained basis amounts to about 2.6 million m^3 in volume from Myanmar's forests. The potential AACs of 55 designated Lesser Used Species (LUS) are estimated for 11 States and Divisions based on forest inventory data conducted in different years. The present study indicates that AAC of 4.95 million m^3 in volume of designated LUS can be obtained from the 11states and divisions. Among the states and divisions under investigation, Sagaing Division is the most abundant in terms of AAC in volume (1.6 million m^3) followed by Kachin State (0.9 million m^3) and Bago Division (0.8 million m^3). Chin State is the least abundant in terms of AAC (0.04 million m^3). Sagaing, Bago, and Magway Divisions are the most accessible and they together contribute about 2.95 million m^3 in volume, which can redeem the annual deficit of 2.6 million m^3 in volume of non-teak hardwoods.

Acknowledgements

The authors would like to thank Dr. Kyaw Tint, Director-General of the Forest Department, Ministry of Forestry, for his kind permission to present this paper. We are indebted to U Win Kyi (2), Director of the Forest Research Institute and National Project Manager of the ITTO PROJECT PD 31/96 Rev.2 (M.F.I.), for providing an excellent opportunity to take part in the International Workshop and Exhibition on INTRODUCING MYANMAR'S LESSER USED TIMBER SPECIES TO THE WORLD MARKET. Special thanks go to U Saw Win, former Deputy Director of the Forest Department, for his critical comments on the manuscript. His questions and discussions have been stimulating and challenging. We wish to acknowledge U Phone Htut, Junior Computer Programmer, for his tireless enthusiasm in producing stand and stock tables for all inventoried areas. We fully understand that words cannot adequately express our appreciation for their kindness.

POTENTIAL PRODUCTION AND DISTRIBUTION OF LESSER USED SPECIES IN MYANMAR
(Sustainable Forest Management Perspective)
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U MYINT SWE, U THEIN WIN, AND U KYAW HTUN
Deputy Directors and Assistant Director
Planning and Statistics Division, Forest Department

1. INTRODUCTION

Since the inception of the Forest Department (FD) in 1856, Myanma Selection System (MSS) has been a principal silvicultural system in natural forests. Selection felling within the confines of Annual Allowable Cut (AAC) and extraction of timber by means of the least impact logging system are the most significant features among others of the MSS. Thanks to the consistent exercise of MSS, which well accords with Myanmar situations and sound forest management practices, about half of the total land area of Myanmar is still covered by forests amounting to 344,237 km^2 in extent.

The present total annual allowable cut potential fixed for Teak (*Tectona grandis*) and other non-teak hardwoods are 409,062 m^3 and 3,236,071 m^3 respectively (Anon, 1999). Of the latter, Pyinkado (*Xylia dolarbriformis*), Padauk (*Pterocarpus macrocarpus*) and Gurjan (*Dipterocarpus spp.*) form hardly about 20%. Therefore, the total volume of the remaining other non-teak hardwood species available annually on sustained basis is about 2.6 million m^3. Recorded number of tree species, big and small, amounts to 2088 (Anon, 1999), out of which only 85 species (4.07%) have been recognized and accepted as producing multi-use timber of good quality. Myanma Timber Enterprise (MTE), a sole institution responsible for timber harvesting in Myanmar, is harvesting about 30 species compulsorily. ITTO Project PD 31/96 has recognized a total of 55 species as potential LUS in Myanmar. These LUS make up about 30% in composition of the total growing stock in Myanmar's forests. A list of 55 species designated by ITTO Project PD 31/96 as the LUS is provided in Appendix 1.

2. OBJECTIVES

(a) To study the current status of growing stock of potential LUS by region (i.e. state and division);

(b) To estimate the AAC potential for all designated LUS for the whole country based on available inventory data; and

(c) To analyse the sustainable production capacity of the most abundant LUS in terms of AAC for commercial production and to investigate their distribution patterns by region.

3. LITERATURE REVIEW

Although several species - sometimes may be several hundred species per hectare - are observed in tropical rainforests, only a handful of timber species are valued at the international market. The rest, so-called lesser used species, are either extracted for local markets or mostly left in the forests. Increasing the use of such lesser used species and market promotion of them is seen as a way of making natural forest management more viable. The following two arguments regarding the promotion of LUS are rather controversial. First, more volume per unit area from less area will be produced, leading to the possibility that less forest should be logged. Second, and perhaps, more importantly, generation of more revenue from a given area of forest will increase the value of the forest, attracting as a long-term land use option. Rietbergen and Poore (1995) pointed out that the ecological effects of increasing the range of species harvested were yet to be found out. The damage to soil and vegetation in the remaining stands will be increased due to the felling and extraction of more trees while all other factors - such as site, planning and operational skills - being equal. They suggested that adequate planning, execution and supervision of forestry operations are essential for minimising the risks. Increased production means increased costs of extraction. Therefore, marketing attempts for LUS must be made. At least, costs must be offset by the existence of remunerative prices. The economics of increasing the range of species used are also yet to be proven.

There are pros and cons of increasing the range of species harvested. Gresham (1995) commented that harvesting more species would leave less tree cover and a less viable forest. Although it is true that less area will be logged for a given volume of cubic metres extracted, it may be a trivial argument. It is well to note that because demand for timber remains high, greater volume extracted per hectare is unlikely to mean less area logged.

According to Rietbergen and Poore (1995), the increased harvesting of LUS seems to be a two-edged sword. There may be a positive or negative impact on the benefits derived from any tropical forests, depending on site characteristics, the management objectives opted and the standard of forest management. In Malaysia, of 2900 species, 408 species have been harvested and marketed commercially using the Malaysian Grading Rules (Thang 1988). Lesser used species continue to play a significant role in the local timber processing and manufacturing industry and also figure prominently in exports. Since the silviculture of many commercial species was still unknown, ensuring that lesser used species are exploited without jeopardising the integrity of the forest ecosystem remains a challenge to foresters and conservationists.

4. SOURCES OF DATA AND DATA ANALYSIS

The Government of Myanmar in collaboration with FAO had conducted an inventory project in order to obtain a reliable data and up-to-date information on the forest resources. The National Forest Survey and Inventory Project (BUR/79/011) funded by UNDP/FAO was initiated in August 1981. At the termination of that project in May 1986, the second phase, the

National Forest Management and Inventory (MYA/85/003) became operational to run for another five years. During the projects' period (1981-82 to 1994-95), a decade long forest inventory was launched at three levels: Pre-investment level, Reconnaissance level and Management level.

Pre-investment level surveys with a sampling intensity of about 0.1%, were conducted for the forests which are commercially significant. Reconnaissance level surveys were carried out in the forests of less commercial importance with the sampling intensity of less than 0.1%. Management level surveys, with a sampling intensity of 1.0% were specifically meant for more detailed and precise data which were to be used in developing management plans in selected forest areas.

The design of the inventory at the pre-investment level was a systematic sampling with plots located on a square grid of 3 km x 3 km. At the pre-investment level, the basis for sampling was 'sampling with partial replacement' in the continuous inventory: one quarter of the sampling units was made permanent in a grid of 6 km x 6 km. The sampling design of the reconnaissance inventory was a stratified random cluster sampling while for the management inventory, it was exactly the same design as that of the pre-investment inventory except that it was more intensified with more information collected on each sampling unit.

During the project period, nearly 12 million ha of forest had been inventoried at pre-investment level. It covers the most commercially important forests of Myanmar and accounts for more than 40% of the country's forests.

Since the termination of the project in 1993, Government of Myanmar has been conducting forest inventory, covering about 2.0 million ha each year, with its own resources. Some of the areas left out during the project period are being surveyed, depending on favorable security conditions. Types of inventory, areas covered, and years of inventory conducted in the states and divisions are provided in Appendix 2. The three states, namely, Kayah, Kayin, and Mon, are not included in the present study due to the absence of inventory data in the states.

The inventory data were processed and analysed at the initial stage. The stand and stock tables for the divisions/states were generated and sampling errors were calculated during the later stages. The whole process was undertaken using a package of programmes written in BASIC programming language on a COMPAQ DESKPRO PC at the Forest Department Computer Center.

4.1 Annual Allowable Cuts (AACs) for LUS

AACs for LUS are calculated by using the following Yield_Regulation formula.

$$AAC = ARR + \frac{WS - \frac{1}{2} FC.\ ARR}{LP}$$

where:

AAC = annual allowable cut (number of trees)

ARR = annual rate of recruitment (number of trees)

$$= \frac{\text{number of trees within 1' below girth limit}}{\text{time of passage (tp)}}$$

FC = felling cycle (years)

LP = liquidation period (years)

WS = working stock (number of trees)

= number of trees of girth limit and over

Recognizing the mortality of the trees, the survival percentages of WS and ARR are assumed to be 95% and 90% respectively.

5. RESULT

5.1 Kachin State

Total number of LUS enumerated over the total inventoried area of about 16,069 km^2 is estimated to be 41,576,150 trees based on the data obtained from pre-investment type of inventories conducted in 9 townships in different years (1994-95, 1996-97 & 1997-98) within Kachin State. The average LUS stem no per hectare is 25.87. The AAC potentials for all designated 55 LUS from Kachin State are estimated and 28 abundant LUS representing 97.59% of the total designated LUS are regarded as potential LUS for the state in terms of AAC (at least 1,000 trees or 39,00 m^3 per species). A list of 28 potential LUS in Kachin State is provided in Appendix 3.

5.2 Chin State

Total number of LUS enumerated over the total inventoried area of about 8,896 km^2 is estimated to be 7,879,730 trees based on the data obtained from reconnaissance type of inventories conducted in 7 townships in different years (1996-97 & 1997-98) within Chin State. The average LUS stem no per hectare is 8.86. The AAC potentials for all designated 55 LUS from Chin State were estimated and 19 abundant LUS representing 89.21% of the total designated LUS are regarded as potential LUS for the state in terms of AAC (about 500 trees or 1,650 m^3 per species). A list of 19 potential LUS in Chin State is provided in Appendix 4.

5.3 Sagaing Division

Total number of LUS enumerated over the total inventoried area of about 29,380 km^2 is estimated to be 61,469,750 trees based on the data obtained from pre-investment type of inventories conducted in 21 townships in different years (1995-96 & 1998-99) within the Sagaing Division. The average LUS stem no per hectare is 20.92. The AAC potentials for all designated 55 LUS from the Sagaing Division are estimated and 31 abundant LUS representing 97.80% of the total designated LUS are regarded as potential LUS for the state in terms of AAC (at least 1,000 trees or 4,200 m^3

per species). A list of 31 potential LUS in Sagaing Division is provided in Appendix 5.

5.4 Tanintharyi Division

Total number of LUS enumerated over the total inventoried area of about 355 km^2 is estimated to be 758,379 trees based on the data obtained from pre-investment type of inventory conducted in 1 township in 1994-95 within Tanintharyi Division. The average LUS stem no per hectare is 21.35. The AAC potentials for all designated 55 LUS from Tanintharyi Division were estimated and only one LUS representing 64.13% of the total designated LUS is regarded as potential LUS for the state in terms of AAC (about 500 trees or 2,500 m^3 per species). A list of potential LUS in Tanintharyi Division is provided in Appendix 6.

5.5 Bago Division

Total number of LUS enumerated over the total inventoried area of about 13,407 km^2 is estimated to be 25,285,887 trees based on the data obtained from pre-investment type of inventories conducted in 18 townships in different years (1992-93, 1993-94 & 1994-95) within Bago Division. The average LUS stem no per hectare is 18.86. The AAC potentials for all designated 55 LUS from Bago Division are estimated and 34 abundant LUS representing 94.92% of the total designated LUS are regarded as potential LUS for the state in terms of AAC (at least 1,000 trees or 3,600 m^3 per species). A list of 34 potential LUS in Bago Division is provided in Appendix 7.

5.6 Magway Division

Total number of LUS enumerated over the total inventoried area of 13,467 km^2 is estimated to be 26,996,460 trees based on the data obtained from pre-investment type of inventories conducted in 17 different townships in different years ranging from 1992-93 to 1998-99 within Magway Division. The average LUS stem no per hectare is 20.05. The AAC potentials for all designated 55 LUS from Magway Division are estimated and 32 abundant LUS representing 94.95% of the total designated LUS are regarded as potential LUS for Magway Division in terms of AAC (at least 1,000 trees or 3,660 m^3 per species). A list of 32 potential LUS is provided in Appendix 8.

5.7 Mandalay Division

Total number of LUS enumerated over the total inventoried area of 12,019 km^2 is estimated to be 18,058,044 trees based on the data obtained from pre-investment type of inventories conducted in 15 townships in 1994-95 within Mandalay Division. The average LUS stem no per hectare is 15.02. The AAC potentials for all designated 55 LUS from Mandalay Division are estimated and 25 abundant LUS representing 90.51% of the total designated LUS are regarded as potential LUS for Mandalay Division in terms of AAC (at least 1,000 trees or 3,950 m^3 per species). A list of 25 potential LUS is provided in Appendix 9.

5.8 Rakhine State

Total number of LUS enumerated over the total inventoried area of 6,165 km^2 is estimated to be 8,210,120 trees based on the data obtained from pre-investment type of inventories conducted in 3 townships in different years (1981-82 & 1986-87) within Rakhine State. The average LUS stem no per hectare is 13.32. The AAC potentials for all designated 55 LUS from Rakhine State are estimated and 12 abundant LUS representing 87.26% of the total designated LUS are regarded as potential LUS for Rakhine State in terms of AAC (at least 500 trees or 1,700 m^3 per species). A list of 12 potential LUS is provided in Appendix 10.

5.9 Yangon Division

Total number of LUS enumerated over the total inventoried area of 1,377 km^2 is estimated to be 2,178,790 trees based on the data obtained from pre-investment type of inventory conducted in 2 townships in 1982-83 within Yangon Division. The average LUS stem no per hectare is 15.82. The AAC potentials for all designated 55 LUS from Yangon Division are estimated and 13 abundant LUS representing 66.60% of the total designated LUS are regarded as potential LUS for Yangon Division in terms of AAC (at least 500 trees or 1,840 m^3 per species). A list of 13 potential LUS is provided in Appendix 11.

5.10 Shan State

Total number of LUS enumerated over the total inventoried area of 23,837 km^2 is estimated to be 38,683,630 trees based on the data obtained from pre-investment type of inventories conducted in 13 townships in different years (1995-96, 1996-97, 1997-98 & 1998-99) within Shan State. The average LUS stem no per hectare is 16.29. The AAC potentials for all designated 55 LUS from Shan State are estimated and 27 abundant LUS representing 94.37% of the total designated LUS are regarded as potential LUS for Shan State in terms of AAC (at least 1,000 trees or 3,540 m^3 per species). A list of 27 potential LUS is provided in Appendix 12.

5.11 Ayeyawady Division

Total number of LUS enumerated over the total inventoried area of 2,220 km^2 is estimated to be 3,131,710 trees based on the data obtained from pre-investment type of inventory conducted in 4 townships in 1994-95 within Ayeyawady Division. The average LUS stem no per hectare is 14.10. The AAC potentials for all designated 55 LUS from Ayeyawady Division are estimated and 6 abundant LUS representing 85.89% of the total designated LUS are regarded as potential LUS for Ayeyawady Division in terms of AAC (about 500 trees or 1,710 m^3 per species). A list of 6 potential LUS is provided in Appendix 13.

6. DISCUSSION AND CONCLUSIONS

Myanmar's climate and soil are suitable for growing quality timber. The timber qualities of the designated LUS are suitable for various uses including plywood, furniture, turnery, carving, construction, cart shaft and axle. Most LUS possesses colors and constitutional properties, which will meet the requirements of the end uses. Some of the Myanmar's LUS have already established markets in the main export markets such as Japan, Korea, and Taiwan. Many of them are already known to neighboring export markets in Thailand, India, People's Republic of China, and Bangladesh.

The supply of timber from tropical forests are rapidly decreasing due to reduced growing stock and increased demand in the producer countries. Many exporters in the 80's became importers in the 90's. Most countries in the tropics such as Philippines, Thailand, and Indonesia had already banned the export of logs. In this context, Myanmar has to promote the utilization of LUS to reduce the pressure on other presently commercial species. In addition, promotion of utility of LUS could help take care not to cream the forests of commercially valuable species and degrade the existing natural forests. Taking the advantage of Myanmar's monopoly in teak export as another source of potentials, market opportunities can also be promoted for LUS.

Potential production or AAC of the abundant LUS from the whole country is estimated for all states and divisions in which inventories were already carried out. They are provided in Appendix 3 to 13. The number of abundant LUS are observed to be as many as 34 in Bago Division and 31 in Sagaing Division while as few as one species in Tanintharyi Division.The top three most abundant LUS are given by state and division in Appendix 14. Their distribution by state and division is shown in Appendix 15. Potential AACs of abundant LUS are calculated based on the effective areas of Hardwood Selection Working Circle (HSWC) in states and divisions and potential volume (m^3) per hectare estimated based on the available forests inventory data from respective states and divisions. They are illustrated in Appendix 16. Due to the validity of inventory data and disforestation of some reserved forests, Yangon Division is not included in the calculation of potential AACs of abundant LUS. Total potential AAC of designated LUS in Myanmar is estimated to be 4.9 million m^3 in volume. Among the states and divisions, Sagaing Division is the most abundant in terms of AAC in volume followed by Kachin State and Bago Division. Chin State is the least abundant in terms of AAC. Sagaing, Bago, and Magway Divisions are the most accessible and they together contribute about 2.95 million m^3 in volume, which can redeem the annual deficit of 2.6 million m^3 in volume of non-teak hardwood for the whole country. All LUS are not available uniformly in the country. Some are more dominant in some states and divisions than others. The LUS, which were available in small quantity in terms of AAC were excluded in AAC calculation due to the following three reasons: conservation of species diversity, conservation of natural habitat and feed (fruit trees) for wildlife and economic feasibility in extraction.

Exploitation of LUS is desirable for the following reasons.

- Most LUS are moderate to high quality timber suitable for various uses. Colour and constitutional properties in most LUS could fulfil the requirements for most end-uses.

- Myanmar's LUS could be easily accepted in the markets by all timber-deficit and timber-importing countries.

- LUS of Myanmar are already known to neighbouring countries which share common borders with Myanmar since they have been using many Myanmar's LUS under various local names.

- In addition, exploitation of LUS can fetch two important gains and they are:

Economic gain: Yield of both teak and other tropical hardwoods are steadily declining due to reduced growing stock and increased domestic demand. Exploitation of LUS will not only increase yield but minimize pressure on a few commercial species as well.

Silvicultural gains: Felling of LUS could provide room to other important species for growth as well as regeneration. Extraction of LUS will contribute to Improvement Felling (IF) which is an important operation in MSS.

With careful planning and proper execution of forest operations followed by continuous monitoring and evaluation, increased production of LUS in Myanmar will significantly contribute to the national economic development and provide the alternatives of timber uses, without disintegrating the integrity of forest ecosystems.

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Appendix 1

List of Myanmar's LUS examined for wood properties and its potential end-uses

Sr. No.	Local Name	Botanical Name	Species Code
1	Baing	*Tetrameles nudiflora*	445
2	Binga	*Mitragyna rotundifolia*	291
3	Bonmeza	*Albizzia chinensis*	17
4	Chinyok	*Garuga pinnata*	190
5	Didu	*Salmalia insignis*	377
6	Dwabok	*Kydia calcina*	226
7	Dwani	*Eriolaena candollei*	160
8	Gwe	*Spondias pinnata*	412
9	Gyo	*Schleichera oleosa*	393
10	Hmya-seik	*Antiaris toxicaria*	36
11	Hnaw	*Adina cordifolia*	11
12	Kokko	*Albizzia lebbek*	18
13	Kuthan	*Hymenodictyon excelsum*	220
14	Kyetyo	*Vitex pubescens*	460
15	Lein	*Terminalia pyrifolia*	442
16	Letpan	*Salmalia malabarica*	378
17	Leza	*Lagerstroemia tomentosa*	233
18	Ma-u-lettan-she	*Anthocephalus cadamba*	35
19	Myaukchaw	*Homalium tomentosum*	215
20	Myauk-ngo	*Duabanga grandiflora*	148
21	Myauk-thwegyi		
22	Myauk-thwenge	*Myristica angustifolia*	
23	Nabe	*Lennea grandis*	236
24	Panga	*Terminalia chebula*	437
25	Petthan	*Haplophragma adenophyllum*	203
26	Pyaukseik	*Holoptelea integrifolia*	214
27	Pyinma	*Lagerstroemia speciosa*	232
28	Sawbya	*Pterocymbium tinctorium*	345
29	Seikchi	*Bridelia retusa*	63
30	Shaw	*Sterculia spp.*	414
31	Sit	*Albizzia procera*	21
32	Taukkyan	*Terminalia tomentosa*	443

Sr. No.	Local Name	Botanical Name	Species Code
33	Taung-meoak	*Alstonia scholaris*	24
34	Taung-petwun	*Pterospermum acerifolium*	347
35	Taung-pinnae	*Artocarpus calophyla*	42
36	Taung-thayet	*Swintonia floribunda*	424
37	Taw-thayet	*Mangifera caloneura*	257
38	Thabye	*Eugenia spp.*	166
39	Thadi	*Protium serrata*	339
40	Thakutpo	*Stereospermum fimbriatum*	415
41	Thande	*Stereospermum personatum*	417
42	Thapan	*Ficus glomerata*	175
43	Thingadu	*Parashorea stellata*	312
44	Thitka	*Pentace burmanica*	317
45	Thitkado	*Cedrela toona*	92
46	Thit-magyi	*Albizzia odoratissima*	20
47	Thit-pagan	*Millettia brandisiana*	282
48	Thit-payaung	*Neonauclea excelsa*	300
49	Thitsein	*Terminalia belerica*	434
50	Yemane	*Gmelina arborea*	195
51	Yindaik	*Dalbergia cultrata*	118
52	Yinma	*Chukrasia tabularis*	98
53	Yinzat	*Dalbergia fusca*	119
54	Yon	*Anogeissus acuminata*	30
55	Zaungbale	*Legerstroemia villosa*	235

Appendix 2

Areas Covered by Forest Inventory by Year and Type of Inventory

Sr. No.	State/Division (No. of township)	Year	Type of inventory	Area (ha.)
1	Kachin State (9)	1994-95,1996-97 & 1997-98	Pre-investment	1,606,972
2	Chin State (7)	1996-97 & 1997-98	Reconnaissance	889,627
3	Sagaing Division (21)	1995-96 & 1998-99	Pre-investment	2,938,083
4	Tanintharyi Division (1)	1994-95	Pre-investment	35,511
5	Bago Division (18)	1992-93, 1993-94 & 1994-95	Pre-investment	1,340,733
6	Magway Division (17)	1994-95	Pre-investment	1,346,722
7	Mandalay Division (15)	1994-95	Pre-investment	1,201,942
8	Rakhine State (3)	1981-82 & 1986-87	Pre-investment	616544
9	Yangon Division (2)	1982-83	Pre-investment	137,717
10	Shan State (13)	1995-96, 1996-97, 1997-98 & 1998-99	Pre-investment	2,383,723
11	Ayeyawady Division (4)	1994-95	Pre-investment	222,074
	Total			**12,719,648**

Appendix 3.

Potential LUS in Kachin State				
Spp. Code	Myanmar Name	Botanical Name	*AAC (No. of Tree)	Volume (m^3)
(1)	(2)	(3)	(4)	(5)
445	Baing	*Tetrameles nudiflora*	49,941	179,936
17	Bonmeza	*Albizza chinensis*	4,287	16,248
190	Chinyok	*Garuga pinnata*	3,674	13,926
377	Didu	*Salmalia insignis*	3,929	14,156
412	Gwe	*Spondias pinnata*	6,000	21,619
393	Gyo	*Schlelchera oleosa*	6,657	25,232
11	Hnaw	*Adina cordifolia*	6,224	24,063
378	Letpan	*Salmalia malabarica*	9,382	33,802
35	Ma-u-lettan-she	*Anthocephalus cadamba*	15,261	57,845
215	Myaukchaw	*Homalium tomentosum*	1,714	6,495
148	Myauk-ngo	*Duabanga grandiflora*	9,621	36,466
236	Nabe	*Lanea grandis*	8,956	33,949
437	Panga	*Terminalia chebula*	3,507	13,293
232	Pyinma	*Lagerstroemia speciosa*	3,479	13,449
414	Shaw	*Sterculia spp*	2,065	7,827
443	Taukkyan	*Terminalia tomentosa*	12,112	45,710
424	Taung-theyet	*Swintonia floribunda*	11,702	44,354
257	Taw-theyet	*Mangifera caloneura*	10,778	40,854
166	Thabye	*Eugenia spp*	8,159	30,928
339	Thadi	*Protium serrata*	15,783	61,018
417	Thande	*Stereospermum personatum*	4,302	16,308
175	Thapan	*Ficus glomerata*	15,936	60,404
92	Thitkado	*Cedrela toona*	1,064	3,921
20	Thit-magyi	*Albizzia odoratissima*	1,286	4,738
434	Thitsein	*Terminalia beletica*	6,277	23,792
195	Yemane	*Gmelina arborea*	17,473	64,405
98	Yinma	*Chukrasia tabularis*	16,804	61,940
30	Yon	*Anogeissus acuminata*	3,729	14,134

* Girth limit for AAC is 6 feet in girth or 58 cm in diameter at breast height.

Appendix 4.

Potential LUS in Chin State				
Spp. Code	Myanmar Name	Botanical Name	*AAC (No. of Tree)	Volume (m3)
(1)	(2)	(3)	(4)	(5)
445	Baing	*Tetrameles nudiflora*	512	1,843
17	Bonmeza	*Albizza chinensis*	1,840	6,976
377	Didu	*Salmalia insignis*	1,122	4,044
393	Gyo	*Schlelchera oleosa*	548	2,077
11	Hnaw	*Adina cordifolia*	1,495	5,778
460	Kyetyo	*Vitex pubescens*	659	2,499
378	Letpan	*Salmalia malabarica*	2,918	10,515
35	Ma-u-lettan-she	*Anthocephalus cadamba*	526	1,993
148	Myauk-ngo	*Duabanga grandiflora*	825	3,128
236	Myaukchaw	*Homalium tomentosum*	467	1,771
232	Pyinma	*Lagerstroemia speciosa*	548	2,119
414	Shaw	*Sterculia spp*	471	1,786
443	Taukkyan	*Terminalia tomentosa*	5,647	21,404
424	Taung-theyet	*Swintonia floribunda*	2,152	8,157
257	Taw-theyet	*Mangifera caloneura*	487	1,847
166	Thabye	*Eugenia spp*	653	2,478
339	Thadi	*Protium serrata*	1,116	4,316
175	Thapan	*Ficus glomerata*	475	1,801
434	Thitsein	*Terminalia belerica*	487	1,847

* Girth limit for AAC is 6 feet in girth or 58 cm in diameter at breast height.

Appendix 5.

Potential LUS in Sagaing Division				
Spp. Code	Myanmar Name	Botanical Name	*AAC (No. of Tree)	Volume (m^3)
(1)	(2)	(3)	(4)	(5)
445	Baing	*Tetrameles nudiflora*	5,954	21,452
291	Binga	*Mitragyna rotundifolia*	2,364	9,140
17	Bonmeza	*Albizzia chinensis*	1,537	5,828
190	Chinyok	*Garuga pinnata*	4,772	18,087
377	Didu	*Salmalia insignis*	4,785	17,239
412	Gwe	*Spondias pinnata*	2,984	10,751
393	Gyo	*Schleichera oleosa*	21,281	80,663
11	Hnaw	*Adina cordifolia*	7,103	27,460
460	Kyetyo	*Vitex pubescens*	1,126	4,267
378	Letpan	*Salmalia malabarica*	8,207	29,569
35	Ma-u-lettan-she	*Anthocephalus cadamba*	5,986	22,688
215	Myaukchaw	*Homalium tomentosum*	3,355	12,719
148	Myauk-ngo	*Duabanga grandiflora*	3,864	14,647
236	Nabe	*Lanea grandis*	8,805	33,376
437	Panga	*Terminalia chebula*	5,315	20,146
232	Pyinma	*Lagerstroemia speciosa*	7,883	30,478
414	Shaw	*Sterculia spp.*	5,652	21,424
443	Taukkyan	*Terminalia tomentosa*	80,026	303,334
424	Taung-thayet	*Swintonia floribunda*	2,822	10,697
257	Taw-thayat	*Mangifera caloneura*	3,074	11,651
166	Thabye	*Eugenia spp.*	20,549	77,891
339	Thadi	*Protium serrata*	21,149	81,767
417	Thande	*Stereospermum personatum*	1,504	5,702
175	Thapan	*Ficus glomerata*	2,176	8,249
300	Thit-payaung	*Neonauclea excelsa*	1,425	5,401
434	Thitsein	*Terminalia belerica*	6,348	24,063
195	Yemane	*Gmelina arborea*	6,156	22,691
118	Yindaik	*Dalbergia cultrata*	1,016	3,744
98	Yinma	*Chukrasia tabularis*	1,922	7,084
30	Yon	*Anogeissus acuminata*	6,519	24,710
235	Zaungbale	*Lagerstroemia villosa*	4,011	15,205
* Girth limit for AAC is 6 feet in girth or 58 cm in diameter at breast height.				

Appendix 8.

Potential LUS in Magway Division				
Spp. Code	Myanmar Name	Botanical Name	*AAC (No. of Tree)	Volume (m^3)
(1)	(2)	(3)	(4)	(5)
291	Binga	*Mitragyna rotundifolia*	2,431	9,397
190	Chinyok	*Garuga pinnata*	6,100	23,122
377	Didu	*Salmalia insignis*	17,854	64,329
412	Gwe	*Spondias pinnata*	3,984	14,355
393	Gyo	*Schleichera oleosa*	3,481	13,195
11	Hnaw	*Adina cordifolia*	4,551	17,594
220	Kuthan	*Hymenodictyon excelsum*	1,173	4,448
460	Kyetyo	*Vitex pubescens*	1,058	4,009
442	Lein	*Terminalia pyrifolia*	1,283	4,864
378	Letpan	*Salmalia malabarica*	6,230	22,447
233	Leza	*Lagersrtroemia tomentosa*	3,098	11,744
35	Ma-u-lettan-she	*Anthocephalus cadamba*	1,077	4,081
215	Myaukchaw	*Homalium tomentosum*	1,351	5,122
148	Myauk-ngo	*Duabanga grandiflora*	1,658	6,283
236	Nabe	*Lanea grandis*	9,337	35,393
437	Panga	*Terminalia chebula*	1,322	5,012
214	Pyaukseik	*Holoptelea integrifolia*	1,235	4,683
232	Pyinma	*Lagerstroemia speciosa*	2,844	10,995
414	Shaw	*Sterculia spp.*	3,191	12,094
443	Taukkyan	*Terminalia tomentosa*	20,369	77,208
424	Taung-thayet	*Swintonia floribunda*	4,573	17,332
257	Taw-thayet	*Mangifera caloneura*	2,344	8,885
166	Thabye	*Eugenia spp.*	6,046	22,919
339	Thadi	*Protium serrata*	2,393	9,252
175	Thapan	*Ficus glomerata*	2,072	7,855
282	Thit-pagan	*Millettia brandisiana*	1,410	5,346
300	Thit-payaung	*Neonauclea excelsa*	936	3,549
434	Thitsein	*Terminalia belerica*	5,319	20,163
195	Yemane	*Gmelina arborea*	993	3,659
118	Yindaik	*Dalbergia cultrata*	1,468	5,412
30	Yon	*Anogeissus acuminata*	9,937	37,666
235	Zaungbale	*Lagerstroemia villosa*	1,676	6,354

* Girth limit for AAC is 6 feet in girth or 58 cm in diameter at breast height.

Appendix 9.

Potential LUS in Mandalay Division				
Spp. Code	Myanmar Name	Botanical Name	*AAC (No. of Tree)	Volume (m^3)
(1)	(2)	(3)	(4)	(5)
445	Baing	*Tetrameles nudiflora*	2,126	7,659
190	Chinyok	*Garuga pinnata*	3,000	11,371
377	Didu	*Salmalia insignis*	8,733	31,466
412	Gwe	*Spondias pinnata*	1,659	5,977
393	Gyo	*Schleichera oleosa*	7,038	26,677
11	Hnaw	*Adina cordifolia*	3,088	11,939
460	Kyetyo	*Vitex pubescens*	2,026	7,680
378	Letpan	*Salmalia malabarica*	1,341	4,831
233	Leza	*Lagersrtroemia tomentosa*	2,730	10,347
148	Myauk-ngo	*Duabanga grandiflora*	2,382	9,027
236	Nabe	*Lanea grandis*	2,977	11,284
437	Panga	*Terminalia chebula*	1,042	3,949
443	Taukkyan	*Terminalia tomentosa*	7,201	27,295
166	Thabye	*Eugenia spp.*	2,835	10,747
339	Thadi	*Protium serrata*	6,114	23,639
417	Thande	*Stereospermum personatu*	4,233	16,044
175	Thapan	*Ficus glomerata*	1,103	4,179
282	Thit-pagan	*Millettia brandisiana*	2,486	9,422
434	Thitsein	*Terminalia belerica*	2,451	9,290
195	Yemane	*Gmelina arborea*	1,068	3,936
118	Yindaik	*Dalbergia cultrata*	1,601	5,901
98	Yinma	*Chukrasia tabularis*	1,189	4,383
119	Yinzat	*Dalbergia fusca*	1,143	4,333
30	Yon	*Anogeissus acuminata*	4,324	16,389
235	Zaungbale	*Lagerstroemia villosa*	1,606	6,096
* Girth limit for AAC is 6 feet in girth or 58 cm in diameter at breast height.				

Appendix 10.

Potential LUS in Rakhine State				
Spp. Code	Myanmar Name	Botanical Name	*AAC (No. of Tree)	Volume (m^3)
(1)	(2)	(3)	(4)	(5)
377	Didu	*Salmalia insignis*	474	1,708
460	Kyetyo	*Vitex pubescens*	844	3,199
148	Myauk-ngo	*Duabanga grandiflora*	1,392	5,275
236	Nabe	*Lanea grandis*	1,308	4,958
232	Pyinma	*Lagerstroemia speciosa*	2,691	10,404
42	Taung-pinnae	*Artocarpus calophyla*	2,075	7,867
424	Taung-thayet	*Swintonia floribunda*	17,371	65,844
257	Taw-thayet	*Mangifera caloneura*	798	3,024
166	Thabye	*Eugenia spp.*	6,527	24,740
175	Thapan	*Ficus glomerata*	497	1,884
317	Thitka	*Pentace burmanica*	646	2,381
434	Thitsein	*Terminalia belerica*	1,173	4,448
* Girth limit for AAC is 6 feet in girth or 58 cm in diameter at breast height.				

Appendix 11.

Potential LUS in Yangon Division				
Spp. Code	Myanmar Name	Botanical Name	*AAC (No. of Tree)	Volume (m^3)
(1)	(2)	(3)	(4)	(5)
190	Chinyok	*Garuga pinnata*	864	3,276
412	Gwe	*Spondias pinnata*	637	2,296
233	Leza	*Lagersrtroemia tomentosa*	908	3,440
215	Myaukchaw	*Homalium tomentosum*	790	2,996
148	Myauk-ngo	*Duabanga grandiflora*	681	2,580
214	Pyaukseik	*Holoptelea integrifolia*	602	2,283
232	Pyinma	*Lagerstroemia speciosa*	3,144	12,153
42	Taung-pinnae	*Artocarpus calophyla*	1,369	5,189
424	Taung-thayat	*Swintonia floribunda*	1,000	3,790
166	Thabye	*Eugenia spp.*	723	2,739
417	Thande	*Stereospermum personatum*	1,505	5,705
312	Thingadu	*Parashorea stellata*	1,039	4,018
282	Thit-pagan	*Millettia brandisiana*	835	3,166

* Girth limit for AAC is 6 feet in girth or 58 cm in diameter at breast height.

Appendix 12.

Potential LUS in Shan State				
Spp. Code	Myanmar Name	Botanical Name	*AAC (No. of Tree)	Volume (m^3)*
(1)	(2)	(3)	(4)	(5)
445	Baing	*Tetrameles nudiflora*	5,151	18,559
377	Didu	*Salmalia insignis*	2,685	9,674
412	Gwe	*Spondias pinnata*	2,711	9,768
393	Gyo	*Schleichera oleosa*	8,226	31,181
11	Hnaw	*Adina cordifolia*	3,012	11,644
460	Kyetyo	*Vitex pubescens*	1,301	4,930
378	Letpan	*Salmalia malabarica*	5,026	18,109
233	Leza	*Lagersrtroemia tomentosa*	2,179	8,260
35	Ma-u-lettan-she	*Anthocephalus cadamba*	2,325	8,813
148	Myauk-ngo	*Duabanga grandiflora*	1,254	4,754
236	Nabe	*Lanea grandis*	4,299	16,296
437	Panga	*Terminalia chebula*	2,413	9,148
232	Pyinma	*Lagerstroemia speciosa*	1,887	7,297
414	Shaw	*Sterculia spp.*	1,280	4,853
443	Taukkyan	*Terminalia tomentosa*	30,328	114,958
424	Taung-thayet	*Swintonia floribunda*	1,993	7,553
257	Taw-thayet	*Mangifera caloneura*	3,603	13,656
166	Thabye	*Eugenia spp.*	7,827	29,668
339	Thadi	*Protium serrata*	6,993	27,038
417	Thande	*Stereospermum personatum*	1,227	4,650
175	Thapan	*Ficus glomerata*	1,860	7,049
434	Thitsein	*Terminalia belerica*	6,937	26,294
195	Yemane	*Gmelina arborea*	2,386	8,794
118	Yindaik	*Dalbergia cultrata*	1,795	6,615
98	Yinma	*Chukrasia tabularis*	1,701	6,269
30	Yon	*Anogeissus acuminata*	5,734	21,736
235	Zaungbale	*Lagerstroemia villosa*	1,552	5,883

* Girth limit for AAC is 6 feet in girth or 58 cm in diameter at breast height.

Appendix 13.

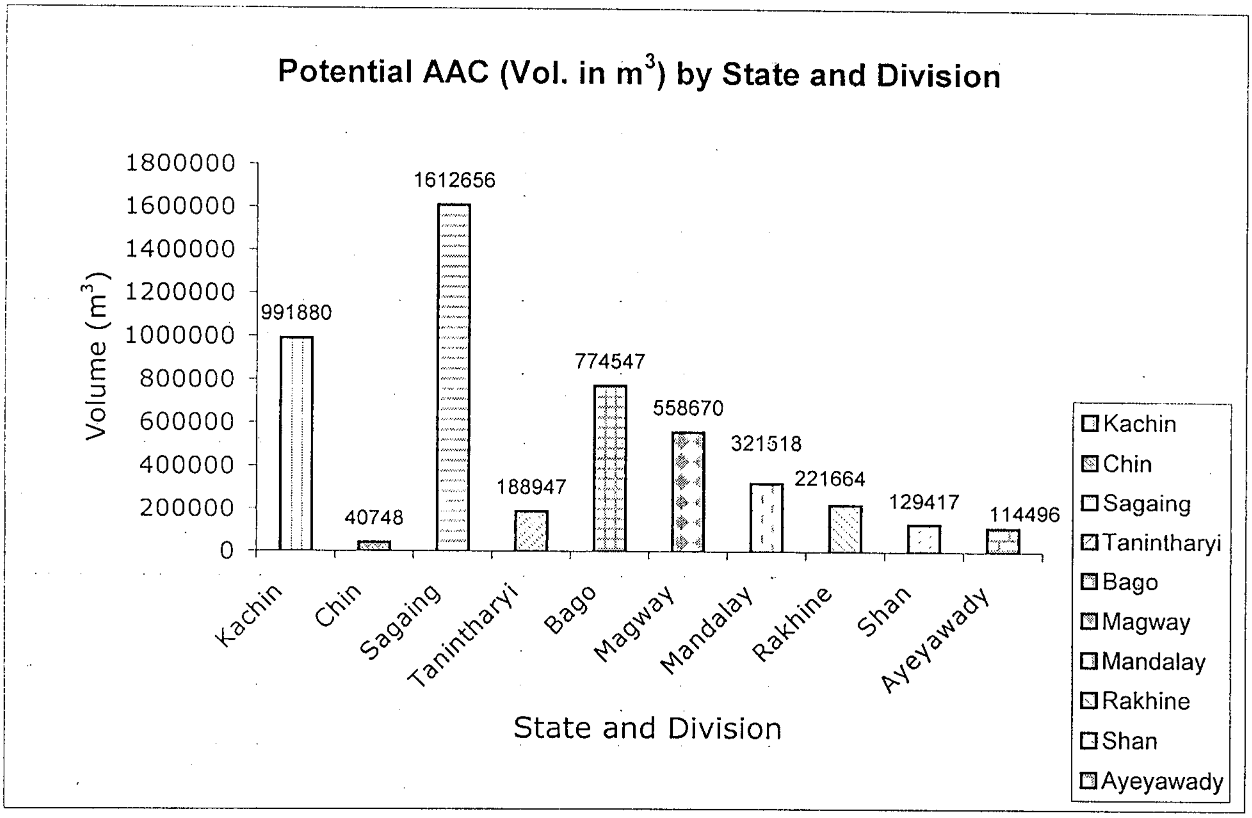
Potential LUS in Ayeyawady Division				
Spp. Code	Myanmar Name	Botanical Name	*AAC (No. of Tree)	Volume (m^3)
(1)	(2)	(3)	(4)	(5)
215	Myaukchaw	*Homalium tomentosum*	605	2,292
148	Myauk-ngo	*Duabanga grandiflora*	470	1,782
236	Nabe	*Lanea grandis*	451	1,711
424	Taung-thayet	*Swintonia floribunda*	12,891	48,864
166	Thabye	*Eugenia spp.*	625	2,368
282	Thit-pagan	*Millettia brandisiana*	478	1,812

* Girth limit for AAC is 6 feet in girth or 58 cm in diameter at breast height.

Appendix 16.

POTENTIAL PRODUCTION OF LUS BY STATE AND DIVISION

State/Division	Vol. (m^3)/ha.	H.S.W.C. (ha.)	Annual Coupe(ha)	AAC in Vol. (m^3)
Kachin	18.12	1641845	54728	991880
Chin	2.91	419668	13989	40748
Sagaing	10.03	4824362	160812	1612656
Tanintharyi	4.84	1171590	39053	188947
Bago	10.70	2170781	72359	774547
Magway	11.11	1508296	50277	558607
Mandalay	7.09	1361392	45380	321518
Rakhine	6.60	1006879	33563	221664
Shan	5.58	695669	23189	129417
Ayeyawady	7.95	432213	14407	114496
				4954480



Most abundant Lesser Used Species by State/Division

Sr. No.	State/Division	Most abundant LUS Species		
		1st most abundant species	2nd most abundant species	3rd most abundant species
1	Kachin State	Baing (Tetrameles nudiflora)	Yemane (Gmelina arborea)	Yinma (Chukrasia tabularis)
2	Chin State	Taukkyan (Terminalia tomentosa)	Letpan (Salmalia malabarica)	Taung-thayet (Swintonia floribunda)
3	Sagaing Division	Taukkyan (Terminalia tomentosa)	Gyo (Schleichera oleosa)	Thabye (Eugenia spp.)
4	Tanintharyi Division	Thabye (Eugenia spp.)	-	-
5	Bago Division	Didu (Salmalia insignis)	Taukkyan (Terminalia tomentosa)	Chinyok (Garuga pinnata)
6	Magway Division	Taukkyan (Terminalia tomentosa)	Didu (Salmalia insignis)	Yon (Anogeissus acuminata)
7	Mandalay Division	Didu (Salmalia insignis)	Taukkyan (Terminalia tomentosa)	Gyo (Schleichera oleosa)
8	Rakhine State	Taung-thayet (Swintonia floribunda)	Thabye (Eugenia spp.)	Pyinma (Lagerstroemia speciosa)
9	Yangon Division	Pyinma (Lagerstroemia speciosa)	Thande (Stereospermum personatum)	Taung-pinnae (Artocarpus calophyla)
10	Shan State	Taukkyan (Terminalia tomentosa)	Gyo (Schleichera oleosa)	Thabye (Eugenia spp.)
11	Ayeyawady Division	Taung-thayet (Swintonia floribunda)	Thabye (Eugenia spp.)	Myaukchaw (Homalium tomentosum)

CONTENTS

ECOLOGICAL IMPLICATIONS OF INCREASED UTILIZATION OF LESSER-USED SPECIES

Professor U Chit Hlaing
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SUMMARY

Utilization of wood has relied on a few number of commercial high-valued species but the supply of these prime species are declining increasingly over time due to continuous and selective logging. Attempts have been made to promote the utilization of larger number of lesser used species (LUS). Some LUS have successfully entered into markets. Increased harvesting of larger number of LUS has implications on ecosystems of the harvested area. Possible impacts of increased LUS harvesting on biodiversity, soil and water conservation, nutrient cycling, species composition and natural regeneration , and forest-dependent people are evaluated and discussed. Myanmar also has initiated LUS promotion. Under the Myanmar Selection System, girdling of teak and selection marking of non-teak hardwoods, improvement felling and thinning are the major operations, resulting in canopy openings, and ecological reactions to these gaps are also discussed. Because teak is the most valuable timber in the world, Myanmar is internationally responsible to upkeep and conserve the genetic resources of the genus "tectona". Conservation of biological diversity and non-wood values is essential, but wood will remain as the important forest commodity, but harvesting should be carried out with minimal damage to the ecosystem and other forest benefits. Increased utilization of larger number of LUS is to be promoted within the context of sustainable forest management, and many issues including ecological implications still remain to resolve.

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Ecological Implications

of

Increased Utilization of Lesser-Used Species

(A discussion paper presented at the International Workshop on "Introduction of Myanmar's Lesser-Used Species to World Market" jointly organized by the Forest Department and ITTO Project PD 31/96 : 29-30 March 2000, Yangon, Myanmar)

by Professor U Chit Hlaing

1. Background

Global industrial roundwood production and consumption are projected to increase at an annual rate of 1.7 per cent from 1,490 million m^3 in 1996 to 1,870 million m^3 in 2010 (FAO 1999), and world demand for tropical wood over the last several decades has also grown significantly. The total annual volume of tropical timber removals increased by 73% in 1980 from 78 million m^3 in 1965 (Grainger cited by Salleh, 1997). Annual tropical wood production from producer members of International Tropical Timber Organization (ITTO) in the mid 1990s was around 172 million m^3, constituting about 11.5% of the global wood production. Statistics indicated that of the international trade worth USD 150 billion annually, only 11% was accounted for by tropical forest products (ITTO 1997). Despite these small shares in the scales of global wood production and value, supply of traditionally high-valued or wider-used tree species from the tropics has been witnessed in a declining trend.

Only a limited number of selected tropical timber species have been harvested for continuous wood production, and it is now considered as the major cause of this decline. Further, selective logging of elite species from natural tropical forests results in per hectare lower yield, i.e. 0.5-3.0 m^3 as against 4-10 m^3 from temperate forests (ITTO, 1997). Given this situation, the need for increased production of additional tropical timber species, which are in generic term accepted as lesser-used species (LUS) has become one of the reactive options and much effort has been generated. Of course, tropical forests, particularly rainforests, are characterized with a large number of plant species, of which many have utilization potential. To this end, many ITTO producer members have been engaged in promoting LUS utilization. Bolivia, Brazil, Honduras, Ghana, Malaysia, Papua New Guinea, Peru and Myanmar, etc. are among those, involved in one way or another in this area. Papua New Guinea timber species, now being exported, were all classed as LUS in the mid 1970s. A few favoured species exported by Papua New Guinea went to Australia; the rest of the trade was in logs to Japan. However, log prices were extremely low (ITTO 1995). As of 1995, ITTO had financed more than a dozen of LUS-related projects and pre-projects at a cost of over USD 5 million. However, attitudes both in the wood processing industry and by the end-users have been conservative towards the use of alternative LUS (Tolvonen, et al. 1997). Increased LUS utilization could possibly be enhanced further with the advancements in new technologies, such as composite products, non-destructive evaluation, mechanical grading system and engineered wood products. These technologies allow the use of the changing wood resource with a more diverse raw material supply, although capital investment of installing proper machineries and equipment to enable to apply the modern technologies are, in many cases, beyond the affordability of tropical timber producing countries.

Despite such efforts and technology development, challenging unc ertainties with respect to socio-economic and ecological uncertainties, facing the LUS-based industry are yet to be investigated and resolved. Generally, marketing takes place in a social context and increasing demand for social and environmental responsibility in setting new conditions for marketing (Juslin, et al. 1977). The guiding principle is that any timber species, regardless of lesser-used or wider-used, has to be produced from sustainably managed sources.

2. Balancing Development and Environmental Conservation

In managing natural production forests, promoting development without compromising ecosystem integrity has been the common goal. The International Tropical Timber Organization (ITTO) in its International Tropical Timber Agreement (ITTA), 1994 has expressed its efforts to strengthen the provisions for environmental stability and development as mutually supportive elements in sustainable forest management. ITTA, 1994 is concerned with the managing and harvesting of natural forest to achieve progress towards sustainability. The interest of the World Wide Fund (WWF) lies in conservation of species and protected areas, and in forest management. The World Conservation Union (IUCN) is seen largely concerned with environmental protection and management of natural resources including forest. Likewise, the Rio Declaration of the United Nations Conference on Environment and Development (UNCED), 1992 proclaimed 27 general principles and Principle 4 called for environmental protection as an integral part of development. The UNCED, 1992 also adopted a "non-legally binding authoritative statement of principles for a global consensus on the management, conservation and sustainable development of all types of forests" (the "Forest Principles"). Formulating and implementing criteria and indicators as effective tool at regional and national levels to measure and assess forest management performance have also been an important process since the early 1990s. Exclusively, all sets of criteria and indicators, are seen to have placed no less importance on environmental conservation and ecosystem health than on production and economic viability. Another remarkable initiative was the formulation and development of forest harvesting codes in the mid-1990s to reduce the adverse impacts of forest harvesting on the environment. In this regard, Food and Agriculture Organization (FAO) took the lead role by publishing the Model Code of Forest Harvesting in 1996. The Asia-Pacific Commission also developed the Code of Practice for Forest Harvesting in Asia-Pacific in 1997. Brazil undertook testing the applicability of the FAO Model Code in the Amazon tropical rainforests in 1997. In addition, many Asia-Pacific countries including Myanmar are now at various stages either formulating, completing or implementing their national codes of forest harvesting practices.

For utilization, forest harvesting is the foremost human intervention, that results in impacts on trees, plants, animals, micro-organisms, soil, water and other physical environment of the forest ecosystem concerned. If harvesting intensity is low and environmental guidelines are adequately followed, adverse impacts could be kept at minimum without losing ecosystem resilience, and vice versa. Moreover, practice of reduced impact logging (RIL) in forest harvesting reduces greenhouse gas emission and RIL-treated forests are said to regenerate more quickly after selective logging. With increased demand for timber due to increasing population as against the increasing scarcity of commercially important species, attempts were being made to widen the utilization of more tree species, which were lesser used in the markets. Bringing more LUS into markets will expand the resource base, make diverse raw material available to the timber industry and reduce the heightened pressure on the exploitation of traditionally selected prime species. However, it will be dependent on adequate knowledge of the ecological and socio-economic impacts of increased harvesting of LUS (Appiah, et al. 1998). Harvesting and marketing of LUS is one of the viable options to strengthen the commercialization aspect of tropical timbers and also to reinforce the stability of international trade in tropical timbers. In addition, provided that promoting commercialization of LUS is environmentally friendly, socially acceptable and economically viable, it will become a major contribution process towards achieving sustainable forest management, the ultimate goal of forestry to-day.

3. Experiences in LUS Promotion

With regards to LUS promotion, many timber producing countries have been undertaking LUS-related activities and projects, mostly with the assistance of International Tropical Timber Organization (ITTO). A From the Proceedings of International Conference on Value-added Processing and Utilization of Lesser-used Timber Species held in Kumasi, Ghana from 17-19 February 1998, it was revealed ITTO had supported six projects in African Sub-region alone were closely related to LUS promotion harvesting, processing and marketing, for a total financing of about 45 million USD. In fact, ITTO alone has sponsored over 25 LUS-related projects within the last few years. An ITTO LUS Project in Ghana which was undertaken during the mid-1990s studied the details of six LUS based on availability in the country's natural forests, and major activities were focussed on forest ecology, wood technology and forest products marketing. The project also studied another eight LUS on physical and chemical wood properties. In the late 1940s and early 1950s, African timbers now dominating European markets were lesser-used species, and so also meranti, ramin or keruing, the Southeast Asian timbers (Gordon 1995). These meranti and keruing are now treated as better-used and well commercialized timbers in the international trade. Similarly, in the mid 1970s Papua New Guinea timbers were all classed as lesser known and marketing these timbers was very difficult. But, Papua New Guinea was able to export about 2.9 million m^3 of its timbers, with significant volumes of such species as taun, callophyllum, pencil cedar, malas, erima, dillenia, mersawa and some other more frequently occuring species. Likewise, Brazil undertook a LUS promotion programme for international trade in the 1980s, and some six LUS showed significantly increasing levels of exports in the 1990s. Myanmar has also experienced the increased marketing of LUS, but on an occasional basis. Such LUS as Taukkyan, Kokko, Yon, Pyinma, etc. occasionally entered into export markets in recent years. These instances showed that LUS promotion has been taking place in varying magnitude. Given the trend of increasing demand for timber and the decline of commercial high-valued species, promotion of LUS harvesting and marketing is one of the feasible options to maintain and strengthen the tropical timber trade. An issue facing the LUS promotion is that ecological impacts as a result of harvesting of larger number of timber species for greater quantity of timber volume per unit area are to be studied, and how negative impacts, if any, are to be minimized.

4. Possible Impacts of Increased LUS Harvesting

4.1. Positive Ecological Impacts

(a) If LUS are to be harvested, less area of forests will be harvested due to increase in volume per unit area provided that the target is the same. It means less forest would be disturbed.

(b) Creaming of traditional high-valued species will be reduced and genetic diversity of these species will be less eroded, if the target is the same. Species composition of the harvested area could remain much more balanced than that of species-specific logging.

(c) Road layout and intensity are the major factors that determine the extent of damage to soil and water, and also forest cover. Because of the availability of larger quantity of timber from the same forest area, no extra road intensity will require for the same timber volume targeted.

(d) Increased quantity of timber from the same harvest area will generate more revenue and the value of forest will, therefore, increase and change for the existing forestry land use to others such as agriculture, will unlikely occur.

4.2. Adverse Ecological Impacts

While more understanding on the ecological effects of LUS harvesting is needed, many issues are challenging the LUS promotion.

(a) Surface soil would be more disturbed and higher degree of soil compaction will take place if larger volume of timber permit area is extracted using conventional ground logging practices. If it is the case, increased surface runoff and therefore increased sediment transport will eventually occur. Because land management and water management are the indivisible two and tightly coupled together, disruption of hydrological regime will impose problems on land management as well. Once soil erosion has started to take place, sediment movement and transport into watercourses, leading to water pollution will continue to occur for several years more even through logging is completed within one year.

(b) It is more likely that the residual stand and natural regeneration are subject to increased damage during harvesting operation, and therefore check the growth, damage to advanced regeneration and seedlings, and lead to decreased production of quality seeds.

(c) Harvesting of timber, if economically more viable, may lead to an increase in the harvest area. As the selection system, a common practice in natural production forests of the tropics, allows the loggers to cream the forest by taking healthy, marketable and elite stems, the remaining forest will have a large number of less quality trees, adversely affecting the overall health condition of the forest ecosystem.

(d) Harvesting of increasing number of trees will create gaps, which may be more favourable for the regeneration of light-demanding species rather than shade-bearer species. However, ecological temperament of tree species, presence or absence of mother tree, seed-dispersal means of the tree species, site and landscape characteristics and degree of disturbance will interactively determine the way natural regeneration process has to take place. Depending on these factors, species composition of the remaining forest may or may not change.

(e) Increased harvesting of larger number of species due to wider utilization LUS may lead to loss of intra-specific variation and genetic diversity within individual species. The variety of species, ecosystems and habitats influence the productivity and services provided by the ecosystems, and thus the ecosystem's functions are subjected to changes when intervention takes place. It should always bear in mind that biodiversity conservation is the key to maintain the earth's life support system provided by nature and the dynamic equilibrium between the living resources and the physical environment. However, changes in biodiversity caused by harvesting of larger number of tree species has not been well investigated.

(f) Plants and soils constitute a self-reinforcing system through bio-regulation of soils by plants, retaining nutrient cycle and supporting microbial activities. In other words, energy flow from plants maintains soil ecosystem, which feeds back to promote plant growth. Harvesting of increasing number of trees may, therefore, impose threats to the disruption of such a self-reinforcing system. (Perry and Michael 1997).

(g) When a canopy gap is created due to logging, seedlings of both shade-tolerant and light-demanding species have a chance of growing up. New gaps also provide opportunity for the colonization of pioneer species, which will much depend on various factors, such as modes of seed dispersal, presence of seed trees, species biology, climatic conditions, management objective, configuration of the harvested area, etc. In either single-species selection or species-group selection logging, retention of quality seed trees with vigorous growth and straight-bole form is therefore strongly commended.

(h) Theoretically, any tree can provide wood, food, shelter, aesthetic value and other intangible services. From the point of non-wood forest products (NWFPs) and services, removal of a tree from a habit will certainly reduce such benefits. Many tree species have the potential for herbal medicine. In many instances, NWFPs such as fruits, nuts, leaves, etc. of a LUS are more valuable than timber. Harvesting of increasing number of tree species will therefore adversely affect the well-beings of the forest-dependant people. As noted by Rietbergen and Duncan 1995, procedures for the full valuation of important LUS need to be established as some LUS might be worth more standing in the forest than as timber on the market.

(i) While forest ecosystems are highly important in the development of climate change mitigation strategies, conventional tropical logging practices release much greenhouse gases(GHGs) through the rapid decay of trees, other vegetation and soils damaged or disturbed during logging operations. According to some studies, conventional logging in the tropics can damage up to 70% of the residual trees in harvest areas. However, reduced-impact logging (RIL) can maintain long-term viability of forest resources, biodiversity values, reduce fire risks, and protect topsoils (FAO, 1998). In this connection ITTO published Libreville Action Plan 1998 to 2001 to promote guidelines on RIL to facilitate the attainment of sustainable forest management (SFM) in tropical production forests. RIL includes actions in the course of log extraction from planning through road construction, logging to silvicultural treatment after logging.

Because RIL would reduce damage to residual trees, encourage quick regeneration after logging, minimize disturbance to soil which is the major reservoir of carbon and nitrogen in terrestrial ecosystem, RIL is accepted as a useful GHGs offset option (Ministry of Forestry and Estate Crops, Indonesia 1999).

5. Harvesting of Forest Resources in Myanmar

5.1. Resource Base

Some 1,347 species of big trees, 741 species of small trees, 1696 species of shrubs, 96 species of bamboo, 36 species of rattan and 841 species of orchids were recorded in Myanmar. Six forest types which are namely sub-alpine and temperate forest, deciduous dipterocarp forest, mixed deciduous forest, tropical evergreen forest and tidal/swamp forest form as major forest ecosystems.

5.2 Forest Policy, Legislation and Institutional Framework

Myanmar forest policy was formulated anew in 1995, taking account the UNCED forest principles and agreements, and other international sustainable forestry concepts. Policy objectives are, among others, to promote efficient harvesting and sustainable utilization of all forms of forest produce, and to encourage the use of under-utilized species. The old Forest Act, 1902 was replaced by the new Forest Law, 1992 encompassing forest protection, conservation, reforestation, production and people participation and private sector involvement in forestry to ensure the implementation of forestry programmes for realization policy commitments. Protection of Wildlife and Wild Plants and Conservation of Natural Areas Law was also newly enacted in 1994, replacing the old Burma Wildlife Protection Act, 1936. Protected areas system (PAS) was introduced in the new law of 1994, integrating the international and country-specific requirements in biodiversity conservation. In 1995, Community Forestry Instructions were issued by the Forest Department to promote local people's participation and decentralization in managing forests. To further improve harvesting practices for sustainable production of forest products, and for upkeep of environmental stability and ecosystem integrity, National Code of Forest Harvesting Practices in Myanmar was also formulated to be implemented together with other existing rules, procedures and instructions in harvesting timber and other products from forests. While Forest Department (FD) is for conservation and management of forests, Myanma Timber Enterprise (MTE) is for harvesting, processing and marketing of forest products and both are instituted under of the Ministry of Forestry.

5.3. Forest Management with respect to Timber Harvesting

Myanmar selection system (MSS) regulates forest harvesting by fixing annual allowable cut (AAC) for each species. Silvicultural treatments including improvement felling, timber cutting and thinning activities for improving forest health and production. AACs for teak and non-teak hardwoods are 409,060 m^3 (226,953 H. tons) and 3,236,071 m^3 (1,795,424 H. tons) of prescribed sizes respectively. The average annual harvests of teak and other hardwoods by MTE in the 1990s were about 220,000 H. tons and 700,000 H. tons respectively. To this end, non-teak hardwoods, constituting a major portion of LUS could still be harvested much more (Myint Than, 1999).

5.4. Timber Species with Potential for Commercial Harvesting

Some 700 species are noted to reach exploitable size. FD has identified 458 non-teak timber species and these species are categorized into 6 groups depending on their commercial importance. The remaining 142 (i.e. 700 minus 458) are very few in number by species-wise for any scale of harvest. To provide an overall picture, the classification of 458 species in 6 groups is given in Table 1 and categorization whether commonly used or lesser used is made. Of 458, only 41 species (i.e. about 11%) are found to be commonly used.

Table 1. Categorization of 458 Species with Potential for Commercial Harvesting as of NFI Identification

Group	No. of Species	Commonly-Used (No.)	Lesser-Used (No.)
I	6	6	-
II	24	9	15
III	26	9	17
IV	16	6	10
V	10	2	8
VI	376	9	367
Total	458	41	417

Source: Myint Than, 1999.

From Table 1, number of species from Group I to Group V are 82, of which 32 are noted as wider- or commonly-used and the rest 50 as lesser-used. The grouping of these 82 non-teak hardwoods with potential of commercial value are given in Appendix 1.

Calculated AACs in voulme of these 32 species based on their composition per cent and extracted volumes in 1993-94 and 1994-95 (Myint Than, 1999) and AACs of 19 tree species, identified by the ITTO Project PD 31/96 as LUS (Myint Swe, et. al. 2000) are for comparative study, shown in Table 2. Some LUS are found entering the markets although occasionally.

Table 2. Species composition in per cent and extrapolated volume for 32 species of Group I to V on 1.3 million tons AAC of non-teak hardwoods and calculated AACs for 19 species identified as LUS by the ITTO Project PD 31/96

Species by Group (32 tree species)	Species Composition and Volume based on 1.3 mill. tons of AAC		Calculated AAC (tons) based on inventory	Actual Timber Volume extracted by MTE	
	Species Composition (%)	Extrapolated Volume Available		1993 - 94 (tons)	1994 - 95 (tons)
Group I					
Pyinkado	17.00	221,000		86,551	96,232
Padauk	1.24	16,120		7,196	3,406
Thingan	0.32	4,160		2,488	3,663
Thitya	1.41	18,330		4,771	4,140
Ingyin	2.24	29,120		9,671	11,310
Tamalan	0.31	4,030		483	873
Group II					
In	4.47	58,110		47,212	52,234
Kanyin	13.39	174,070		145,816	150,025
Binga	0.45	5,850	37,872	-	-
Hnaw	0.71	9,230	103,260	2,649	1,733
Sagawa	0.15	1,950		-	1,128
Thinwin	0.86	11,180		285	727
Yamane	0.58	7,540	117,124	547	746
Yindaik	0.33	4,290	29,653	277	-
Yinma	0.19	2,470	79,676	-	-
Group III					
Thinkadu	0.36	4,680	8,979	7,348	12,701
Kanyaung	0.51	6,630		889	1,211
Taw thayet	1.07	13,910	84,632	-	4,430
Taung thayet	3.13	40,690	217,721	18,447	16,255
Htauk Kyant	3.97	51,610	598,181	16,906	12,999
Pyinma	0.88	11,440	141,172	2,214	-
Panga	0.41	5,330	62,557	1,215	1,151
Yone	1.32	17,160	135,764	4,515	3,061
Thapye	2.21	28,730		1,975	2,353

Group IV					
Didu	3.55	46,150	177,349	7,827	9,053
Nabe	1.14	14,820	158,102	1,936	3,090
Baing	1.00	13,000	235,848	-	1,101
Myaukngo	1.43	18,590	93,138	-	1,154
Letpan	0.86	11,180	123,532	-	-
Kokehe	0.61	7,930	-	726	620
Group V					
Leza	0.69	8,970	53,883	-	1,295
Myaukchaw	0.56	7,280	59,857	-	-

Source: Myint Than, 1999 and Myint Swe, et. al. 2000

6. Canopy Opening and Mixed Deciduous Forest Ecosystem

6.1. Harvesting of Teak by Girdling under MSS

Teak is the most valuable species in export market, and its composition is 10% on the average and may go up to 20%. Teak being a light-demanding species, its advanced regeneration, if any, can shoot up once the big dominating teak is girdled and removed. However advanced regeneration of teak under the conopy teak is extremely rare. One major reason is that the topsoil underneath big teak trees is frequently too much eroded to facilitate teak germination and regeneration. However, existing shade-tolerant seedlings and some hardy bush and climbers could be present under big teak trees. Therefore, when a big and economically matured teak is girdled and removed, advanced growth of shade-tolerant species may have the greater advantage of newly created canopy gaps. It means that girdling and removal of a teak tree likely favour the establishment of shade-tolerant advanced seedlings, because of the low germinating capacity of the hard coated teak seeds. Species composition of the forest stand may, therefore, be altered. As a consequence, non-teak hardwood species may take larger percentage of the species composition of the forest from which teak is harvested. That is the reason why the Girdling Rules prescribe to retain teak seed trees during girdling operation and this prescription must be followed if teak-bearing forest ecosystem is to be maintained. However, many of the left teak trees, which are under the prescribed girth limit or size, are physiologically matured and can produce good seeds. Colonization of pioneer species in the new gaps created by teak tree removal needs to be thoroughly studied; it will very much depend on the biology and silvicultured characteristics of tree species, presence of seed trees, topography, site factors, size of the opening etc.

6.2. Harvesting of Non-teak Hardwoods under MSS

In Myanmar, the "Selection Felling Marking or S.F. Marking" is carried out when non-teak hardwoods of prescribed girth limit and above are selected and marked for harvesting. The canopy opening as a result of the removal of non-teak species will also encourage the establishment of advanced regeneration, which may be teak or non-teak seedlings, saplings and poles. Under a non-teak tree, there is a greater chance of having teak advanced growth although some other factors may influence its existence. New regeneration of teak and other hardwood species can occur in such gaps.

6.3. Improvement Felling

Improvement felling (IF) is usually done in conjunction with girdling operation, with the object of improving the establishment and growth of existing commercially important species, especially teak. Felled trees are usually left behind and no commercial extraction is done. Some felled trees, eg. ficus species are the source of food and nesting place for many birds. New gaps created by IF may encourage the regeneration of light-demanding species. Felled trees, lying on the slope may act as barrier to check surface runoff and sediment movement, and thus control soil erosion. They can also stop the movement of teak seeds carried down along the slope by rainwater or surface runoff, and may thus encourage germination. However, IF may cause damage to soil surface, natural regeneration and near-by saplings and poles. It may induce tree species regeneration because the canopy opening is not too large to allow the invasion of weeds and grasses. The major differences between IF and LUS harvesting for commercial purposes are:

- IF aims at the betterment of existing more valuable species, and almost all felled trees are LUS, and are left behind in the forest. LUS harvesting concentrates on the utilization and marketing of felled trees.
- Canopy opening in IF tends to be small while LUS harvesting, particularly species group harvesting can create larger gaps, inviting the invasion of weeds and grasses.
- When felled trees under IF decay, it can improve soil structure and the function of soil micro-organisms. In LUS harvesting, felled trees are extracted, leading to much more soil disturbance.

6.4. Thinning in Natural Congested Stands

Thinning in natural congested teak stands of mixed deciduous forests is another silvicultural treatment to provide the left teak trees with wider crown space and soil nutrients for further growth. Non-teak species of lower canopy layers are retained for the sake of species diversity and for soil erosion control and soil improvement. For natural congested stands of <u>Pyinkado</u> or other commercially important species, thinning is also done in similar context. Therefore, the purpose of canopy opening in thinning is essentially to make improvement of the existing valuable species for better growth by retaining non-teak tree species of lower-storied layers. Thinning does not intend to change the existing species composition.

6.5. Genetic Conservation with respect to Girdling

Each species has its own measure of variability, contained in its gene pool. The variability is perpetuated through genetic recombination in each generation. Such variability and diversity enables species and communities both to flourish in existing conditions in a variety of forms and to adapt to changes in the environment. Genetic conservation does not depend on the preservation of particular individuals or communities but rather on the continued existence of their genes. Gene conservation, therefore, does not preclude harvesting provided that the gene pools are reproduced with similar composition in succeeding generations for continued evolution is maintained. (Institute of Foresters of Australia 1979). Genetic conservation of Myanmar native species such as teak, Pyinkado, Padauk, Tamalan, etc. should be made to ensure the availability of genetic resources in perpetuity. Because of the worldwide importance of the genus "tectona", Myanmar has a very special and an international responsibility for the conservation of the genetic resource of this genus. The growing stock and natural regeneration of teak and other valuable commercial species in Myanmar's forests are fast declining (Keh, Kyaw 1995). Selection girdling and illicit cutting of teak has led to the gradual drain of teak trees, which are capable of producing quality seeds for future generations (Tun 1995). The selection system harvest elite teak trees of exploitable girth limit and up. Retaining seed trees as stipulated in the Girdling Rules needs to be strictly followed. Increased harvesting of larger numbers of LUS will reduce pressure on the harvesting of teak and it may encourage the genetic variability and diversity of the genus "tectona". Harvesting of larger number of LUS may also maintain the species composition of the mixed deciduous forest ecosystem in the succeeding generations with a better gene pool of teak. It may also provide opportunities for continued genetic recombination in the continuing evolution, if timber volume extracted is fixed.

7. Discussion on Possible Ecological Implications

7.1. Genetic Variability and Diversity

Implication

Selection logging system will increase the creaming effect because larger number of elite species are removed. In addition, changing technologies in wood-based industry, allow smaller-sized trees of wider species range to enter markets and the forest will be left behind with much more smaller-sized trees. Harvesting of increasing number of LUS will adversely affect genetic diversity, and this effect will worsen if smaller trees are accepted by the markets.

Discussion

If it is accepted that wood is an important commodity, then wood harvesting is an important component in forestry which should be implemented with minimum threats to the integrity of the entire ecosystem. Managing a land exclusively for nature conservation can impose excessive demands on other lands. While it is acknowledged, without reservation, that conservation of part of the indigenous forest is essential to retain certain non-wood values, multi-resource character of forest needs to be enhanced. Excerpts from ITTO Guidelines on the Conservation of Biological Diversity in Tropical Production Forests is given in Appendix 2, as reference.

Adoption of longer felling cycles, retention of adequate number of seed trees of selectively-logged LUS, avoidance of creating large canopy gaps and prescription of not only economically-mature but also biologicaly-matured girth limits for logging are the essential measures to maintain the integrity of the entire ecosystem. However, Myanmar has to shoulder the most responsible for the conservation of genetic resources of the genus "Tectona" and every possible effects to the genetic variability of teak should therefore be taken into account and mitigated. However, biodiversity conservation measures should not be developed in isolation, but with due consideration and priority to the role of forestry sector's contribution to the economy.

7.2. Soil and Water Conservation

Impacts

Increased LUS harvesting has a high potential for increased soil structure damage, compaction of surface soil and increased surface runoff. The harvested site may therefore become a source of land and water pollution. Sediment discharge once initiated because of logging activities will continue to take place for many years more. Impact of felled trees on the ground, skidding of logs to landing sites, construction of skid trails and timing of skidding are considered as major causes.

Discussion

Many timber producing countries have developed National Codes of Forest Harvesting Practices in addition to departmental instructions, logging rules and operational harvesting procedures. Forest harvesting could become an effective management tool to improve the growth rate and productivity of the forest stands if these guidelines and instructions are adequately implemented. However, following the guidelines are, of course, costly.

In Myanmar, elephant logging has been the routine extraction practice. MTE employs about 4,500 to 5,000 elephants for log skidding. The use of elephants in timber harvesting does not need to construct skid tracks and therefore reduce road density and soil disturbance. Animal logging reduce soil compaction, road density, noise nuisance, stand damage and environmental pollution if compared with the effects associated with the use of tractors and other machineries. It seems recommendable that animal skidding, full valuation of forest resources, rigid implementation of the National Code of Forest Harvesting Practices and effective post-harvest silvicultural treatments including enrichment planting as appropriate are the essential measures to mitigate the adverse impacts that are likely to be imposed by increased harvesting of LUS. Nevertheless, it is recommended that any timber either better-used or lesser-used should come from sustainably managed sources as mandated by ITTO's Year 2000 Objective.

7.3. Nutrient Cycling

Implication

Tropical forest soils are easily destabilized when they are disturbed. Removal of vegetative cover accelerates soil erosion process, reduce biomass inputs and leaching of soil minerals, and nutrient cycling system is therefore disrupted. Rainforest soils will particularly be affected when forest cover is removed. In a strict sense, fallen trees and its biomass when decayed are the major inputs to activate soil fugal and microorganisms and to recharge the soil nutrient status.

Discussion

Too large openings or gaps should not be created by increased LUS harvesting. Too large gaps may encourage the colonization of weeds and grasses. The size of the gaps should be optimal for natural regeneration of tree species, and ecological temperament of tree species and the presence or absence of seed trees are the interactively determinant factors and should further be studied for better understanding of the ecosystem processes. The fact is that quick regeneration of plant species will bring back the soil nutrients, and return of tree cover is much better.

7.4. Species Composition and Natural Regeneration

Implication

It is uncertain whether increased harvesting of larger number of LUS will or will not induce changes in species composition of the present and next generations. For Myanmar's mixed deciduous forests in which composition of teak is much higher than other individuals, opening up the canopy by removing non-teak trees is considered to encourage the establishment of teak advanced regeneration. Because of warmer condition in the openings, germination of teak seeds would also be encouraged. In moist and humid forest conditions, teak seed germination may be more pronounced if fire hazards are not severe enough. Recruitment of new seedlings and establishment for other non-teak species will depend on ecological, climatic condition and site factors. However, species diversity is generally enhanced by disturbances that occur at intermediate levels of frequency and intensity, those that do not exceed the capacity of the system to recover fully between disturbances. It is true that forest ecosystems developed after harvesting are unlikely the same state as existed prior to disturbance.

Discussion

Increased LUS utilization may generally favour wind-pollinated and/or wind-dispersed species, many of which are higher price utility timbers and disfavour heavy shade-tolerant hardwoods (Rietbergen and Duncan 1995). In this connection, modes of seed dispersal of harvested LUS are also to be investigated further. Presence of advanced regeneration, its establishment and elimination of logging damage to the existing advanced regeneration are among the important measures to encourage the return of the vegetative cover.

Understanding the LUS biological characteristics and ecosystem functions as a whole process will enhance the effectiveness of post-harvest silvicultural treatments. Individual species cannot be treated in isolation, rather ecosystem approach must be adopted.

7.5. Local Communities and Indigenous People

Impacts

Forest and trees are the source of food, shelter, herbal medicine, recreation, generating aesthetic values and seasonal extra income for forest-dependent people, both local and indigenous. Removal of trees from an ecosystem will invariably affect the daily life, culture and behaviour of these people. Increased LUS harvesting will provide the local people with a network of extraction roads, better transport and increased communication with outsiders and outside population centers. It means localization, if not regionalization may take place in many aspects of this particular human ecosystem which is once isolated, remote and difficult to access.

Discussion

In some cases, a standing tree species can be more valuable than its wood or timber, particularly when its wood utilization value is not very uncertain. Usefulness or utility of tree species therefore needs to be carefully analyzed. Localization effect on indigenous native people could be immense if harvesting planning and design do not adequately take into account these effects, which can bring both advantages and disadvantages for the sustainable development of this forest society. These social issues should be integrated into forest harvesting and management schemes, as a major component in SFM. It is also important to maintain and enhance the traditional forest-related knowledge of the indigenous people, who themselves are an integral part of the ecosystem, and have been harmonizing with natural processes.

7.6. Carbon Absorption and Carbon Release

Impacts

The rate of carbon absorption by trees is a function of growth rates, age, species, site, annual precipitation, etc. When trees become matured and growth rates are reduced, the net carbon absorption is also reduced. In theory, mature forests reach a stage of equilibrium with respect to carbon absorption (Ciesla 1995). Increased removal of mature trees in LUS harvesting will adversely affect as follow:

- reduce carbon dioxide storage capacity;
- disturb the natural cycling of GHGs of the soil;
- increase the fire risk and logging residues will, therefore, release carbon faster when they are burnt; and
- reduce carbon absorption rate when increased harvesting damages the residual trees and advanced natural regeneration.

Discussion

If harvesting techniques are not environmentally friendly, fire risk will increase and damage to the environment will be greater, and increased logging waste mass also occur. All these factors will reduce carbon absorption and storage capacity of forests and make quick release of carbon from biomass and the forest soils. The storage of carbon by forests is temporary in nature. It is important that removal of trees needs to be adequately compensated with increased growth rate of the residual forest and healthy regeneration. Code of Practices for Forest Harvesting and other environmental guidelines need to be followed to reduce the emission of GHGs. Country-specific RIL techniques should be developed and applied to reduce damage to the left trees and the forest soils, to encourage natural regeneration after logging so as to lessen the immediate release of carbon dioxide and methane from the burning of wood, decay of biomass and soil carbon. According to Pinard, 1994 as quoted by Willian, 1995, while residual forest can store up to 185 tC/ha by applying RIL, residual forest after conventional logging can store only about 120 tC/ha.

8. Conclusion

Form the ecological stand point, increased LUS harvesting seems to have more demerits than merits. However, efforts are made to promote the utilization of LUS with emphasis minimizing adverse impacts. Myanmar and many other timber producing countries have already been engaged in the LUS promotion. Although there still remain uncertainties and constraints in LUS promotion, implementation of national forest policies, forest laws and rules, code of forest harvesting practices and other guidelines on the one hand and multi-sectoral partnenship at all levels on the other, need to be further strengthened. Social issues of forest-dependent people must be adequately integrated in attempts to promote LUS utilization. Understanding of the ecological processes and silviculture of individual species needs to be enhanced through research studies and information exchange.

Importance of non-wood benefits has an important effect on timber-producing role of the forests. But how far this effect will be allowed to go, and how much this effect will be allowed to undermine the very real benefits wood provides still need to be resolved. If they go too far, it will be unfortunate. Likewise, options related to biodiversity conservation should not be developed in isolation, rather they should be developed with respect to the forestry sector's contribution to the economic development. Whilst genetic resources and non-wood values are, without any reservation, to be conserved, genetic conservation depend very much on the continued existence of particular species or communities. Therefore genetic conservation does not preclude harvesting as long as gene pools are reproduced with similar composition in succeeding generations and opportunity for continued evolution is maintained. In general, many LUS find their way to markets although many issues still remain to resolve. Research is much needed to find more qualified LUS for increased timber supply. For example, a case in point is *Hopea minutiflora* which is indigenous only in Myanmar, indicating the fact that LUS promotion is still in need of further exploration on a wider range of species.

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ABBREVIATIONS

AAC	Annual Allowable Cut
FAO	Food and Agriculture Organization
FD	Forest Department
GHGs	Greenhouse Gases
IF	Improvement Felling
IUCN	World Conservation Union
ITTA	International Tropical Timber Agreement
ITTO	International Tropical Timber Organization
LUS	Lesser-Used Species
MSS	Myanmar Selection System
MTE	Myanma Timber Enterprise
NWFPs	Non-Wood Forest Products
PAS	Protected Areas System
RIL	Reduced-Impact Logging
SF	Selection Felling
SFM	Sustainable Forest Management
UNCED	United Nations Conference on Environment and Development
WWF	World Wildlife Fund

Appendix 1

Non-teak Hardwoods with Potential for Commercialization

Group I

	MYANMAR NAME	BOTANIAL NAME
1.	Pyinkado	*Xylia dolabriformis*
2.	Padauk	*Pterocarpus macrocarpus*
3.	Thingan(Thingan-net)	*Hopea odorata*
4.	Thitya	*Shorea oblongifolia*
5.	Ingyin	*Pentacme siamensis*
6.	Tamalan	*Dalbergia oliveri*

Group II

	MYANMAR NAME	BOTANIAL NAME
1.	Anan	*Fagraea fragrans*
2.	Binga	*Mytragyna rotundifolia*
3.	Hmanthin	*Cinnamomum iners*
4.	Hnaw	*Adina cordifolia*
5.	In	*Dipterocarpus tuberculatus*
6.	Kanyin	*Dipterocarpus spp.*
7.	Karawe	*Cinnamomum inunctum*
8.	Kashit (Thitka)	*Pentace burmanica*
9.	Kokko	*Albizzia lebbek*
10.	Kyana	*Xylocarpus molluccensis*
11.	Magyipway	*Diospyros pendula*
12.	Pinle-kanazo (Kanazo)	*Heritiera fomes*
13.	Sagawa (Saga	*Michelia champaca*
14.	Sit	*Albizzia procera*
15.	Taung-tama	*Cedrela serrata*
16.	Thadi	*Protium serratum*
17.	Thinwin	*Mellettia pendula*
18.	Thitkado	*Cedrela toona*
19.	Thitkhaya	*Diospyros oblonga*
20.	Thitmagyi	*Albizzia odoratissima*
21.	Thitsho	*Pentace griffithii*
22.	Thitsi	*Melanorrhoeausitata*
23.	Tinyu	*Pinus spp.*
24.	Yemane	*Gmelina arborea*
25.	Yindaik	*Dalbergia cultrata*
26.	Yinma	*Chukrasia tabularis*

Group III

	MYANMAR NAME	BOTANIAL NAME
1.	Aukchinsa-ni	*Amoora wallichii*
2.	Gangaw	*Mesua ferrea*
3.	Kanyaung	*Shorea thorelii*
4.	kaunghmu	*Anisoptera scaphula*
5.	Kyilan	*Shorea assamica*
6.	Maniawga	*Carallia brachiata*
7.	Nyan	*Quercus serrata*
8.	Panga	*Terminalia chebula*
9.	Peinne-bo	*Palaquium polyanthum*
10.	Pyinma	*Lagerstroemia speciosa*
11.	Sandawa	*Cordia fragrantissima*
12.	Talainggaung	*Madhuca longifolia varlatifolia*
13.	Taukkyan	*Terminalia tomentosa*
14.	Taung-peinne	*Artocarpus chaplasha*
15.	Taung-thayet	*Swintonia floribunda*
16.	Taw-thayet	*Mangifera caloneura*
17.	Thabye	*Eugenia spp.*
18.	Tharapi	*Calophyllum kunstleri*
19.	Thingadu	*Parashorea stellata*
20.	Thitcha	*Quercus spp.*
21.	Thit-e	*Castaneopsis spp*
22.	Yingat	*Gardenia coronaria*
23.	Yon	*Anogeissus acuminata*

Group IV

	MYANMAR NAME	BOTANIAL NAME
1.	Baing	*Tetrameles nudiflora*
2.	Chinyok	*Garuga pinnata*
3.	Didu	*Salmalia insignis*
4.	Gwe	*Spondias pinnata*
5.	Kokhe	*Salmalia anceps*
6.	Letkok	*Sterculia foetida*
7.	Letpan	*Salamalia malabarica*
8.	Linlun	*Sapium baccatum*
9.	Ma-u-lettan-she	*Anthocephalus cadamba*
10.	Myaukngo	*Duabanga grandiflora*
11.	Nabe	*Lannea coromandelica*
12.	Odein	*Ailanthus triphysa*
13.	Sawbya	*Pterocymbium tinctorium*
14.	Setkadon	*Trewia nudiflora*
15.	Thitto	*Sandoricum koetjape*
16.	Wetshaw	*Erythropsis colorata*
17.	Other Softwoods	-

Group V

MYANMAR NAME		BOTANIAL NAME
1.	Kuthan	*Hymenodictyon excelsum*
2.	Kyun-bo	*Premna pyramidata*
3.	Lamu	*Sonneratia caseolaris*
4.	Leza	*lagerstroemia tomentosa*
5.	Myaukchaw	*Homalium tomentosum*
6.	Myauklok	*Artocarpus lakoocha*
7.	Ondon	*Litsaea glutinosa*
8.	Pyaukseik	*Hploptelea intergrifolia*
9.	Tayaw	*Grewia tiliaefolia*
10.	Thitpyu	*Wendlandia glabrata*
11.	Other Hardwoods	-

Excerpt form ITTO Guidelines on Biological Diversity

The Guidelines discuss, in an introductory section, the key issues in the conservation of biodiversity in Production Forests. They explain the nature of biodiversity, the benefits it offers and the threats to it. They emphasise the key role of Totally Protected Conservation Areas (TPA), and the complementary value of sustainably managed production forests. Finally they discuss the part that biodiversity plays in the functioning of production forests.

The Guidelines themselves are divided into Principles and Recommended Actions: in policy and legislation; in promoting the role of sustainably managed production forests in conserving biodiversity at the landscape level. There are also sections on implementation and research. The most important section for management in the field is that dealing with the conservation of biodiversity at the management unit level in production forests. This part of the text is reproduced below.

Considerations for the Conservation of Biodiversity at the Management Unit Level in Production Forests

With careful land use planning that gives particular attention to the complementary location of all retained forest areas, production forests can potentially play a key role in the conservation biological diversity at all levels. However, whether or not this potential is realised in practice will depend in very large part on how particular production forests are managed at the operational level. The following principles and recommendations for operational management will help to maximise the contribution of production forest to the conservation of biodiversity.

5.1 Planning

5.1.1 Choice of silvicultural concept

Principle 7

Silvicultural systems that aim to change species composition or selectively remove certain structural or floristic components of the forest can have a negative effect on biodiversity conservation. Forest areas of recognised importance for biodiversity conservation should be the subject of special action as recommended below.

Recommended Action 8

Particular care should be taken in applying silvicultural treatments to ensure that adequate populations of species which are important in food chains or in providing ecological functions (keystone species) are retained.
In the case of plantations, the use of indigenous species should be encouraged.

Recommended Action 9

Trees with hollows, standing dead trees (snags) and decomposing fallen trees all have ecological importance for a range of species and not all should be removed from the forest in any silvicultural treatment to improve timber yields.

Recommended Action 10

The use of pesticides and other chemicals should be kept to a minimum in any silvicultural treatment, and the manufacturers instructions for the use of each product should be strictly observed.

5.1.2 Yield Regulation, Annual Allowable Cut and Rotation Time

Principle 8

The presence of some larger and older trees in the forest, and longer intervals between the disturbances caused by harvesting operations, generally favour biodiversity conservation.

Recommended Action 11

In forest areas of recognised importance for biodiversity conservation incorporate consideration of the effects of rotation length, felling cycles, girth limits and size of the annual area cut over in deciding the allocation of the AAC.

Principle 9

In general a mosaic of old-growth forests in close proximately to logged forests will help to maintain biodiversity.

Recommended Action 12

When determining yield allocations and rotation lengths for particular management units, plan logging operations so that a mosaic of recently logged and old growth forests are maintained over time.

5.1.3 Management Inventory and Mapping

Principle 10

A system of small (approximately 100 ha) undisturbed forest reserves within the management area can have profound positive effects on biodiversity conservation that are disproportionate to their (small) size. A system of such reserves, carefully distributed throughout the management area, can act as temporary refuges for fauna moving away from the active logging areas and also as sources for rapid recolonisation.

Recommended Action 13

Within each major management area, a system of small virgin reserves should be designated on the management plan mad maps. The boundaries of these reserves should be marked in the field where feasible.

Principle 11

Not all areas of a production forest will have equal importance for biodiversity conservation. Sites of particular importance for biodiversity conservation (key areas) will include;

- areas adjacent to TPA reserves;
- areas with populations of rare or endangered species or with high concentrations of endemic species, or with exceptional species richness;
- areas with unusual land forms, geology or other physical features not adequately represented in TPAs;
- rivers, streams and wetland ares;
- areas with forest types not represented in TPAs;
- areas that contain biological diversity of social or cultural value, or of medicinal, agricultural or other economic value; and
- areas that contain habits frequented by migrating species.

Recommended Action 14

Management inventories should aim to locate key areas within all production forest units that are known to have higher biodiversity values as outlined in Principle 12.

Recommended Action 15

Working plans should prescribe appropriate management measures in accordance with the specific biodiversity value of these key areas. Buffer strips of on intervention should be established along streams and around lakes and wetland areas.

5.2 Extraction

Principle 12

Biodiversity conservation is strongly affected by degrees of canopy disruption, extent of damage of the standing vegetation and severity of erosion.

Recommended Action 16

Reduce individual gap size as far as possible unless specifically requred for the regeneration of key species[1]. Avoid creating very large gaps that equate to areas of local clearfelling.

Recommended Action 17

Minimise machinery and felling damage to the residual stand, undergrowth and soil.

Technical Session 2

CONTENTS

STRUCTURAL UTILISATION OF TIMBER, INCLUDING REFERENCE TO LESSER USED SPECIES

by

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1. INTRODUCTION

This paper is intended to provide an overview of the current international trends on the structural utilisation of timber, together with an indication of some matters related to the utilisation of lesser known species.

During the past 20 years, there has been a quantum leap in the technology of timber engineering, particularly with respect to understanding the characteristics of timber structures. This has been primarily due to the increased interest of academics in the topic of timber construction; however, some of it has also been due to architects concerned with designing prestige structures, while some is also undoubtedly due to the favourable costs incurred by using timber for certain classes of residential and commercial construction.

There is now an immense quantity of literature on timber construction, but much of it is difficult to access. However, an effective global overview of progress can be found in the papers presented at the following international conferences:

- **1984** Pacific Timber Engineering Conference, Auckland, New Zealand, May. *Chairman:* J. Little;

- **1988** International Conference on Timber Engineering, Seattle, USA, September. *Chairman:* R.Y. Itani;

- **1989** Pacific Timber Engineering Conference, Auckland, New Zealand, August. *Chairman:* G.B. Walford;

- **1990** International Timber Engineering Conference, Tokyo, Japan, October. *Chairman:* Hideo Sugiyama;

- **1991** International Timber Engineering Conference, London, UK, September. *Chairman:* C.J. Gill;

- **1994** Pacific Timber Engineering Conference, Gold Coast, Australia, July. *Chairman:* R.H. Leicester;

- **1996** International Wood Engineering Conference, New Orleans, USA, October. .*Chairman* V.K.A. Gopu;

- **1998** World Conference on Timber Engineering, Lausanne, Switzerland, August. *Chairman:* J. Natterer;

- **1999** Pacific Timber Engineering Conference, Rotorua, New Zealand, March. *Chairman:* G.B. Walford.

Another good source of information are the proceedings of the meetings of CIB–W18 (International Council for building Research Studies and Documentation, Working Commission W18–Timber Structures). These Meetings are held annually; the 30th Meeting was held in Vancouver in 1997; the proceedings of these meetings contain about 450 papers, mostly on research in structural mechanics. Most of the information in these proceedings relate to softwoods used in temperate climates. Some information on engineering with hardwoods in tropical climates is given in the CIB–W18B Conference held in Malaysia in 1992 (Malek *et al.* 1992).

Good overviews of specific topics are to be found in a set of UNIDO lectures prepared by CSIRO, Australia (UNIDO, 1985a), a set of timber engineering lectures prepared by an European group (Blass *et al.* 1995) and a useful guide to practical information prepared by NAFI, the National Association of Forest Industries, Australia (NAFI 1989). International trends are best followed by reading digests such as World Wood Review (e.g. Widman 1997), Timber and Wood Products International and overview papers (e.g. Murray 1991).

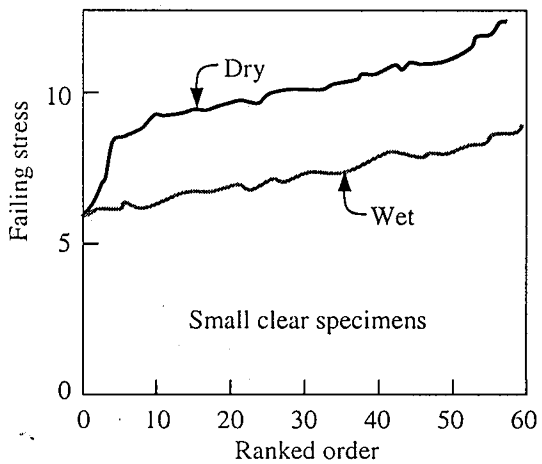
The following text contains a brief overview of the various significant developments that have occurred during the past two decades. First matters related to the grading and classification of timber for structural purposes are discussed. Then general topics related to the use of structural timber are given. The references cited have been chosen solely as examples, and are intended to be neither comprehensive nor the best ones available. Most of the references cited herein relate to Australian Standards, because of the author's familiarity with those Standards. However, extensive sources of similar information are to be found within the North American ASTM standard and European CEN standards.

2. CHARACTERISTICS OF STRUCTURAL SIZE TIMBER

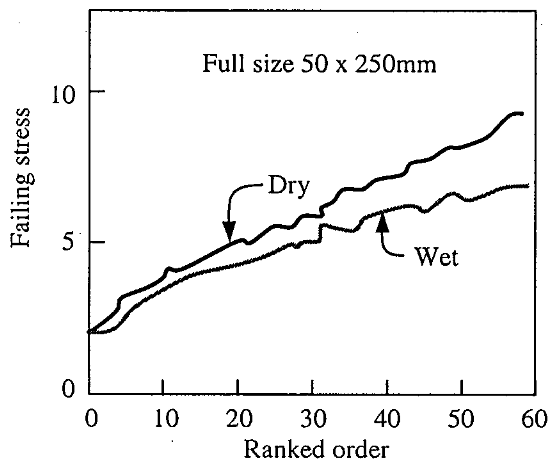
Prior to 1970, the characteristics of timber were assessed on the basis of the characteristics of small clear pieces of wood. However, following the extraordinary pioneering work by Madsen (Madsen 1992), it was realised that this could be quite misleading. This is because the strength of structural size timber is heavily influenced by the presence of natural features such as knots, pith etc.

Two examples to illustrate the difference between the behaviour of small clears and structural size timbers are shown in Figures 1 and 2. In Figure 1 it is seen that seasoning the timber improves the strength of small clear wood specimens and also the average strength of structural size timber. However, at the 5-percentile level, the characteristic value used for design purposes, the seasoning has no effect on structural size timber. A similar effect is noted in the measured load duration effects shown in Figure 2. The Australian Standard for evaluating the properties of full size structural timber is AS/NZ 4063 (Standards Australia 1992).

The lesson to be learned is that there are times when it can be quite misleading to assume that the characteristics of structural size lumber are the same as those of clear wood.



(a) Clear wood



(b) Structural timber

Figure 1. Effect of moisture on the bending strength of timber (after Madsen 1972).

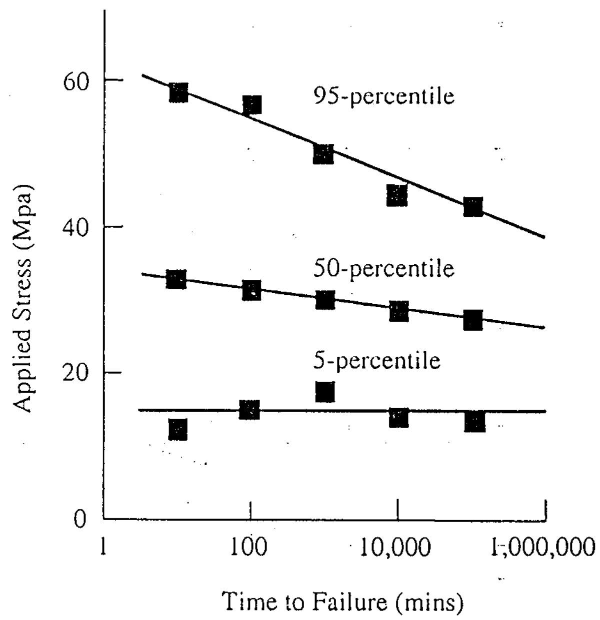


Figure 2. Effect of load duration on strength of dry timber (after Madsen 1971).

3. ASSESSMENT OF THE STRUCTURAL PROPERTIES OF STRUCTURALLY GRADED TIMBER

Once timber has been sorted into structural grades, the structural properties of each grade are evaluated by "in-grade testing". The term in-grade testing refers to the evaluation of the design properties of stress-graded timber by testing structural size timber.

Prior to 1970, most assessments of the structural properties of timber were based on the measurement of the properties of small clear pieces of wood. For example even today within Australia, timber species may be assigned to 'strength groups' on the basis of testing small clear pieces of wood according to the Australian Standard AS: 2878 (Standards Australia 1986b). These tests refer to either testing small pieces in bending, or even just by measuring air-dry density. Once this has been done, the structural lumber can then be graded in terms of visual defects according to AS: 2082 (Standards Australia 1979) for Hardwoods or AS: 2858 Standards Australia 1986a) for softwoods and placed into one of the 10 Australian structural grades. An example of a typical classification procedure for this purpose is given in Table 1.

Table 1. Relationship between structural group and stress grade for hardwoods as given in AS: 2082 (Standards Australia 1979)

Strength group	Stress grade for design properties			
	Visual grade No. 1	Visual grade No. 2	Visual grade No. 3	Visual grade No. 4
S1	F27	F22	F17	F14
S2	F22	F17	F14	F11
S3	F17	F14	F11	F 8
S4	F14	F11	F 8	F 7
S5	F11	F 8	F 7	F 5
4S6	F 8	F 7	F 5	F 4

However as noted earlier, Madsen (Madsen, 1992) has shown that the use of clear wood properties can be quite misleading. As an additional example it should be noted that while the strength of the clear wood of Douglas fir is superior to that of a spruce-pine-fir mix, the reverse is true for the structural size timber. As a result, in North America, Europe and Australia, the measurement of structural properties is today undertaken by testing full size structural timber for all commercially important species.

In-grade testing is applied to a particular size and grade of structural timber. The procedure that is used to grade the timber is irrelevant. In Australia, the in-grade test procedures used are given in the standard AS/NZS 4063: Timber–Stress-graded–In-grade Strength and Stiffness Evaluation (Standards Australia 1997).

As an example, the test configuration specified in AS/NZ 4063 for evaluating the bending strength and modulus of elasticity is shown in Figure 3. In addition to the test configuration, the Standard specifies the method to be used for selecting the test specimen, i.e. as would occur in-service without any specific bias. The Standard specifies that the sample shall comprise at least 30 test specimens; in practice samples of 100–200 specimens are not unusual.

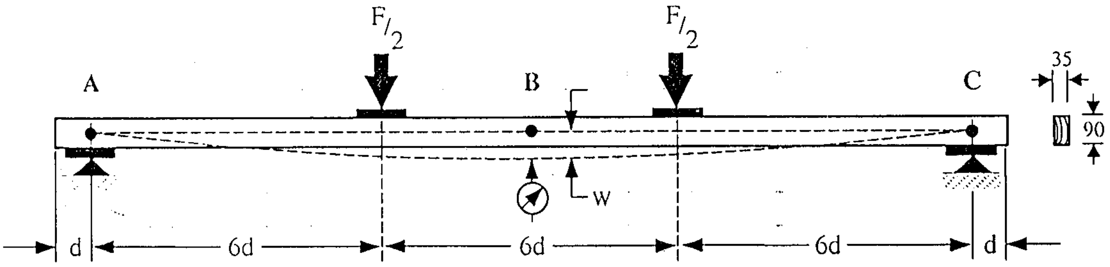


Figure 3. Configuration specified in AS/NZS 4063 for the measurement of bending strength and modulus of elasticity.

From the test data the characteristic bending strength R_k and characteristic modulus of elasticity E_k are given by

$$R_k = R_{0.05} \quad (1a)$$

$$E_k = E_{mean} \quad (1b)$$

where $R_{0.05}$ and E_{mean} denote 5-percentile and mean values respectively. These definitions of characteristic values are typical of those used in Limit States Design Codes. Methods for converting these characteristic values to basic working stresses are given in AS/NZ 4063. There are also procedures for converting these characteristic values to values for use with modern Limit States Design Codes.

The standards also contain test procedures for evaluating tension strengths, compression strengths and shear strengths.

An important feature of in-grade testing standards is that they contain a penalty factor to account for the fact that if only small sample sizes are used, then there are uncertainties in the estimate of the characteristic values. Thus if a sample of Size N is tested, then equation 1(a) is replaced by

$$R_k = R_{0.05,data} \, [1 - 2.7 \, V_{data}/\sqrt{N}] \quad (2)$$

where $R_{0.05,data}$ and V_{data} refer to the 5-percentile and coefficient of variation of the test data of bending strength.

Table 2 shows a comparison between the use of small clears and structural size specimens for the evaluation of the properties of structural timber. The data for the structural size evaluation refers to an evaluation for a full range of sizes, grades and structural properties; typically 5,000–10,000 test specimens are required for this purpose. It is apparent that the small clears approach, while less accurate, is considerably cheaper than structural size testing. Hence the small clears approach probably represents the best option in the utilisation of multiple species hardwood forests, when a penalty of 30% loss in strength can often be absorbed easily without affecting their end use.

Probably the most cost-effective procedure would be to use in-grade testing to evaluate the most important properties, such as bending strength and modulus of elasticity, and then to use these values to estimate all other properties (such as tension strength) from previously observed relationships. This is the approach followed in the European CEN standard.

Table 2. Comparison of two methods for evaluating the design properties of structural timber

Evaluation method	Cost for evaluating one species	Laboratory time	Typical error in 5-percentile strength estimate
structural size timber	$1000 000	1 year	±5%
small clears	$ 1000	1 week	±30%

4. STRUCTURAL GRADING

4.1 Basic Concepts

The basic concepts associated with structural grading or "stress-grading" as it is commonly known are shown schematically in Figure 4. An input resource is sorted by some procedure into an output comprising several grades of timber (usually including a reject grade).

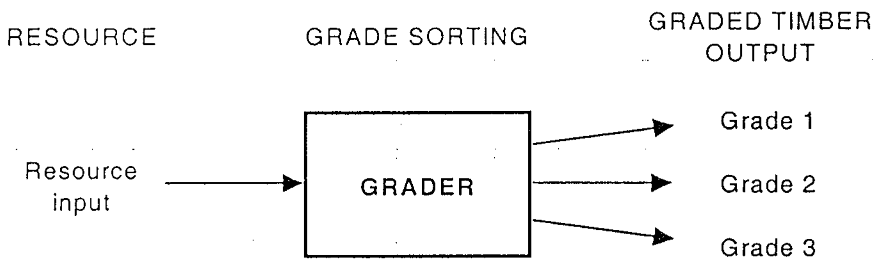


Figure 4. The basic elements of stress-grading.

The effect of grade sorting on the structural properties is illustrated in Figure 5. Essentially a stress grade of material is obtained by selecting all timber between two limits of the grading parameter, the coefficient of variation of the stress-graded material V_g is related to the coefficient of variation of the input resource V_{ir} by

$$V_g = V_{ir}\sqrt{1-r} \qquad (3)$$

where 'r' denotes the correlation coefficient between the measured and predicted values of the structural parameters. It is seen than an increase in the prediction correlation coefficient 'r' leads to a reduction in the coefficient of variation of the properties of the graded timber.

Figure 6 illustrates the influence of the coefficient of variation of stress-graded material on the efficiency of utilisation, i.e. the ratios of characteristic 5-percentile value to the mean value $R_{0.05}/R_{mean}$. An increase in the correlation coefficient 'r' leads to a decrease in coefficient of variation V_g and an increase in the efficiency of utilisation.

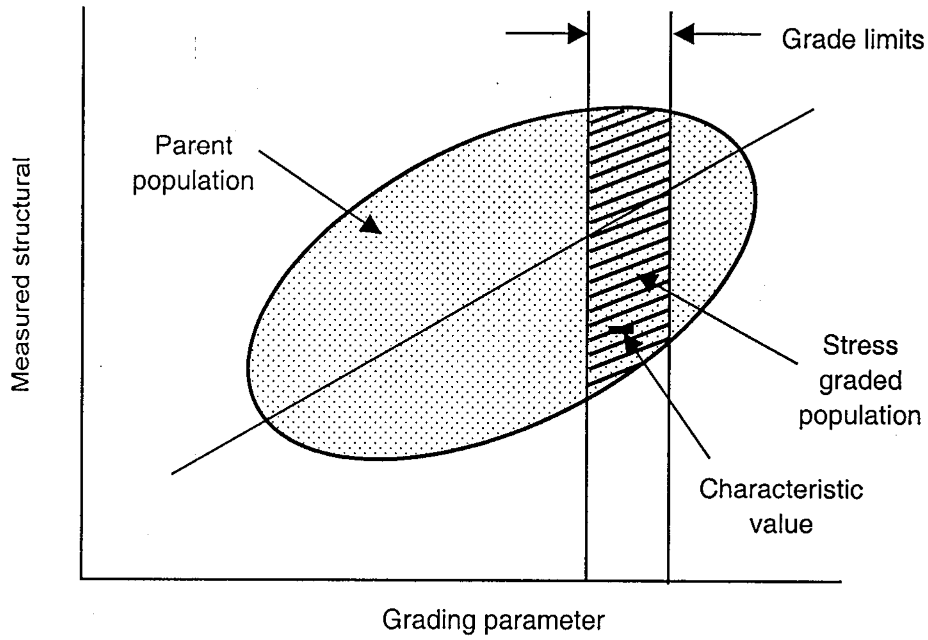


Figure 5. The concept of grade sorting.

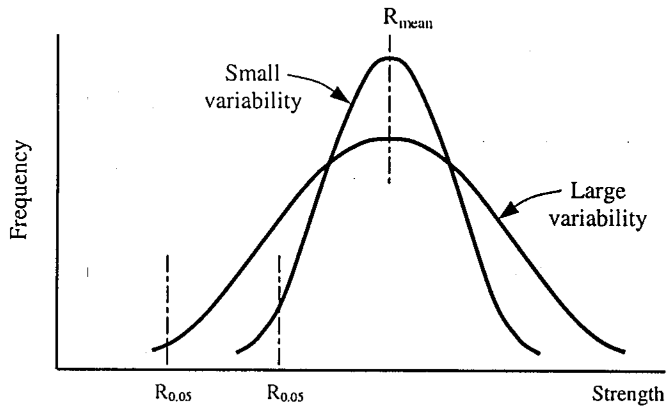


Figure 6. The effect of variability on the characteristic value $R_{0.05}$.

4.2 Visual Grading

Visual grading is based on limiting the size of natural features such as knot size, slope of grain etc. Examples are the Australian Standard AS 2082: Visually Stress-graded Hardwood for Structural Purposes (Standards Association of Australia, 1979) and AS 2858: Timber–Softwood–Visually Stress-graded for Structural Purposes (Standards Association of Australia 1986a).

It should be noted that the output of visual grading can be quite sensitive to changes in the input resource. In addition, the concept of initial evaluation based on in-grade testing procedures is often omitted. If reliance is placed solely on testing small clear pieces of wood, then estimates of the characteristic strength R_k for structural size timber will frequently be up to 30% too high or 30% too low relative to the true value. A difficult feature of visual grading is the size effect. This size effect refers to the fact that when defects of the same relative size are permitted within two sizes of timber of the same grade, then often the larger size will have the smaller strength, i.e. a smaller ultimate stress at failure. This size effect is considered to be so important that it has been standardised within an ASTM Standard D 1990–91: Establishing Allowable Properties for Visually-Graded Dimension Lumber from In-Grade Tests of Full Size Specimens (ASTM, 1991).

For the case of the bending strength of beams, the ratio of strength values σ due to the size effect is given by

$$\left(\frac{\sigma_2}{\sigma_1}\right) = \left(\frac{d_1}{d_2}\right)^{0.29} \left(\frac{\ell_1}{\ell_2}\right)^{0.14} \tag{4}$$

where the subscripts 1 and 2 refer to sizes No. 1 and No. 2 respectively, d is the beam depth and ℓ is the beam span.

In the above it is assumed that a larger beam has a lower strength. However, in some studies in Australia the reverse has been found to be true. For example, for Hoop Pine visually graded to Structural Grade No. 4 according to AS 2858, the 5-percentile bending strength was found to be 18.5 MPa and 20.1 MPa for 140 x 35 mm and 240 x 45 mm respectively. A probable reason for this is that larger, more mature logs were used for cutting the larger sizes.

A recent innovation in the Australian scene is that with the introduction of in-grade testing to monitor characteristic values, it has now become worthwhile to develop special grading procedures for each particular structural material. These grading procedures are usually much simpler and more effective than those given in conventional visual grading standards such as AS 2082 and AS 2858. Some discussion on this topic has been given by Madsen (Madsen 1992).

4.3 Machine Grading

Currently within Australia most structural hardwoods are visually graded. However, about 90% of structural softwood timber is mechanically stress-graded. This has occurred largely for reasons related to production efficiency. Some idea of the production benefits to be gained by using machine stress-graders can be obtained from the fact that current machines operate with speeds of 100–700 metres per minute. However there are so many other potential benefits related to machine grading that this is likely to be universally the preferred grading method in the forseeable future.

One of the most obvious benefits of machine grading is the potential for increased efficiency due to the application of electronic scanning technology. The more information obtained from a scanning operation, the more improved will be the strength predictions; increase in the correlation coefficient then leads to reduced variability according to Equation (3) and improved efficiency. Electronic technology now being employed on a limited trial basis include microwave scanners (Leicester and Seath, 1996), x-ray scanners (Rouger *et al.* 1994), sonic wave technology (Sato *et al.* 1994, Arima *et al.* 1990, Ross *et al.* 1996) and video imaging, Figure 7.

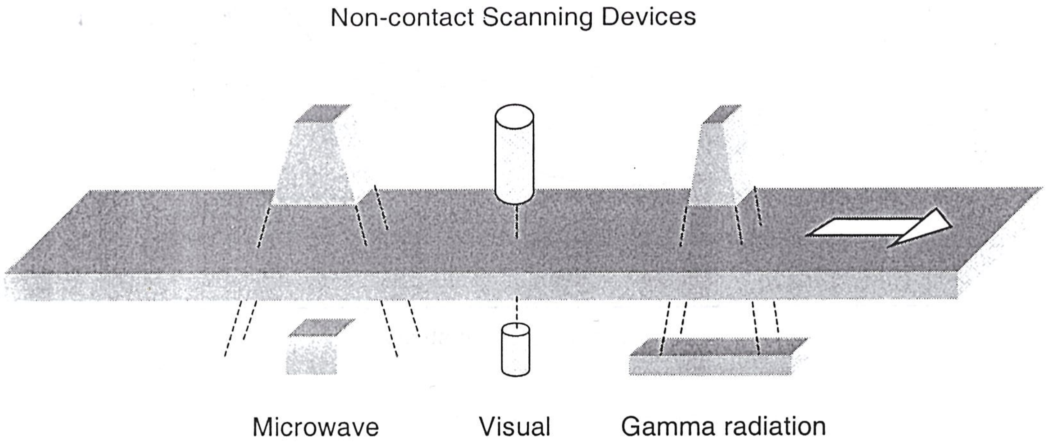
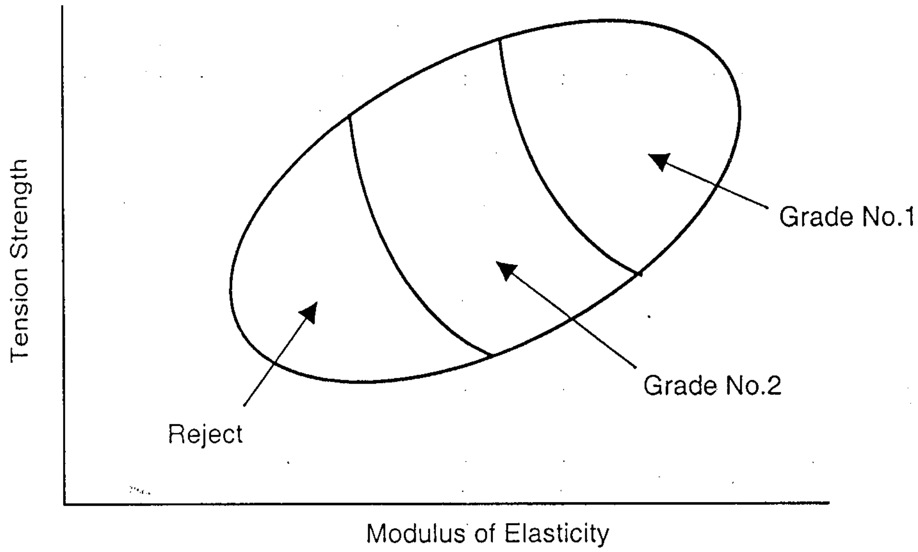


Figure 7. Examples of non-contact scanning devices.

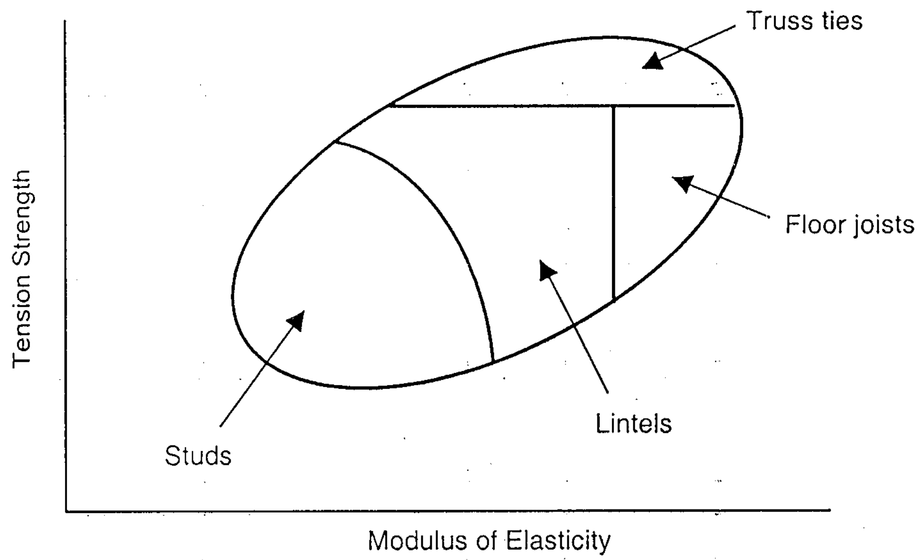
A second benefit from machine grading is that because multiple parameters are used, each structural property can be independently assessed. This then leads to the potential for grading for end-use, as illustrated in Figure 8, and accordingly a better optimisation of resource.

Finally, mention should be made of the fact that machine grading coupled with scanning provides the potential for quality control at high operational speeds. For example, the use of computers to obtain ensemble averages of graded timber forms a powerful diagnostic tool to assess the stability of a grading operation (Leicester and Seath, 1996). These methods are currently used by Pine Australia during mechanical stress-grading operations.

Incidentally, it should be noted that machine grading, unlike visual grading, is easily manipulated to produce grades of any specified characteristic strength or stiffness values. In particular, the size effect for visual grades such as that given in Equation (4), may be built into the system, or may be removed altogether; thus the choice of stress-grade properties can be chosen to suit resource and market conditions.



(a) Conventional stress-grading



(b) Grading for end-use

Figure 8. Schematic illustration of the effects of conventional and end-use grading.

4.4 Quality Control of Structural Timber

Apart from efficiency, a second important aspect of stress-grading is control of the quality of the stress-graded material. To do this effectively it requires monitoring of the input resource, the sorting operation and the output resource.

The input resource is related to log species, source and silvicultural practices. Monitoring of the sorting operation depends on the method of sorting. Monitoring of the output is described in AS/NZS 4490: Timber–Stress-graded–Procedures for Monitoring Structural Properties (Standards Australia, 1997). This Standard specifies in-grade testing procedures for the initial evaluation, daily monitoring and the annual monitoring purposes. For daily monitoring, a conventional CUSUM procedure is suggested (Leicester 1994).

The difficulty

The fundamental difficulty in quality control of structural timber is that structural quality is related to the 5-percentile strength, a property that is difficult to measure accurately with small sample sizes when these properties have large variability. Except in in-grade evaluations, where the producer incurs a penalty for limited sample sizes according to equation (2), the general approach has been to use acceptance criteria such that the producer incurs no penalty if his product has the target characteristic values. The result is that the consumer then incurs a risk of accepting under strength material. The risk to the consumer has been studied via Monte Carlo simulation and the results have been reported in an earlier paper (Leicester 1994). The following gives examples of these findings. They have been used to initiate changes in Australian Standards.

Daily checks

Daily CUSUM checks are often used as output controls of stress graded timber. It has been found that for a daily sample of $N = 5$ and $V_R = 0.45$, and a sudden drop of 20% in the characteristic 5-percentile strength, it will be about 3 months before the CUSUM system triggers a production halt. This is obviously unsatisfactory to the customer.

Periodic checks

Periodic checks specified in the Australian Standard AS/NZS 4490 (Standards Australia 1997) are typically made on samples of about $N = 100$, with a repeat in the case of non-compliance. It has been found that the risk to the consumer is that there is a 10 percent chance that the material will have a characteristic strength that is 20% below the target value.

Batch checks

If the 5-percentile value of a batch with $N = 30$ is used as the basis for an acceptance criterion, with a repeat test permitted if failure to comply occurs, then with the compliance target set to satisfy the producer, the consumer incurs a 10% chance that the parent population will have a characteristic strength that is 50% below the specified value.

5. UTILISATION OF LESSER USED SPECIES

5.1 The Problem

The difficulties in utilising LUS (lesser used species) timber are due to the fact that there are many species, that there are difficulties in species identification, and that there is too small a volume of accessible timber if only a few species are utilised. The extent of the difficulties associated with the occurrence of multiple species is indicated by the fact that there are some 4000 useable species in Indonesia, 2500 species in Malaysia, 4000 species in the Philippines and 2500 in the forests of South America (Tesoro, 1986; Arbàiza, 1986). In the mixed species rainforests, almost any species used will qualify as a LUS.

In the following, some options for utilising LUS will be considered.

5.2 Option 1. Favoured Species

One option that is highly favoured by architects and engineers who are practising in relative isolation is to use only a limited set of favoured species. By placing such a limitation, it is not too difficult to acquire reliable information on the important properties of the timber such as for example, those related to structural, durability and supply aspects. Once the supply of these few species has been exhausted, then another set of species can be chosen.

5.3 Option 2. Grouping Plus Visual Grading

Probably the most common strategy to cope with multiple species is to group them according to small clear wood properties and then to stress-grade them by visual methods. This concept is illustrated schematically in Figures 9 and 10. Within Australia, the grouping is done according to AS 2878: Timber–Classifications into Strength Groups (Standards Association of Australia, 1986b) and the stress grading is undertaken in accordance with AS 2082 and AS 2558. This procedure has been applied to 600 Australian species.

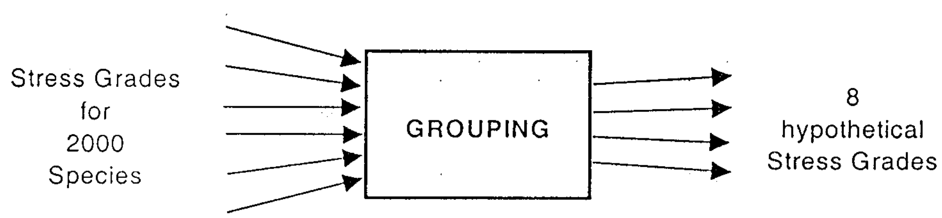


Figure 9. Concept of strength grouping.

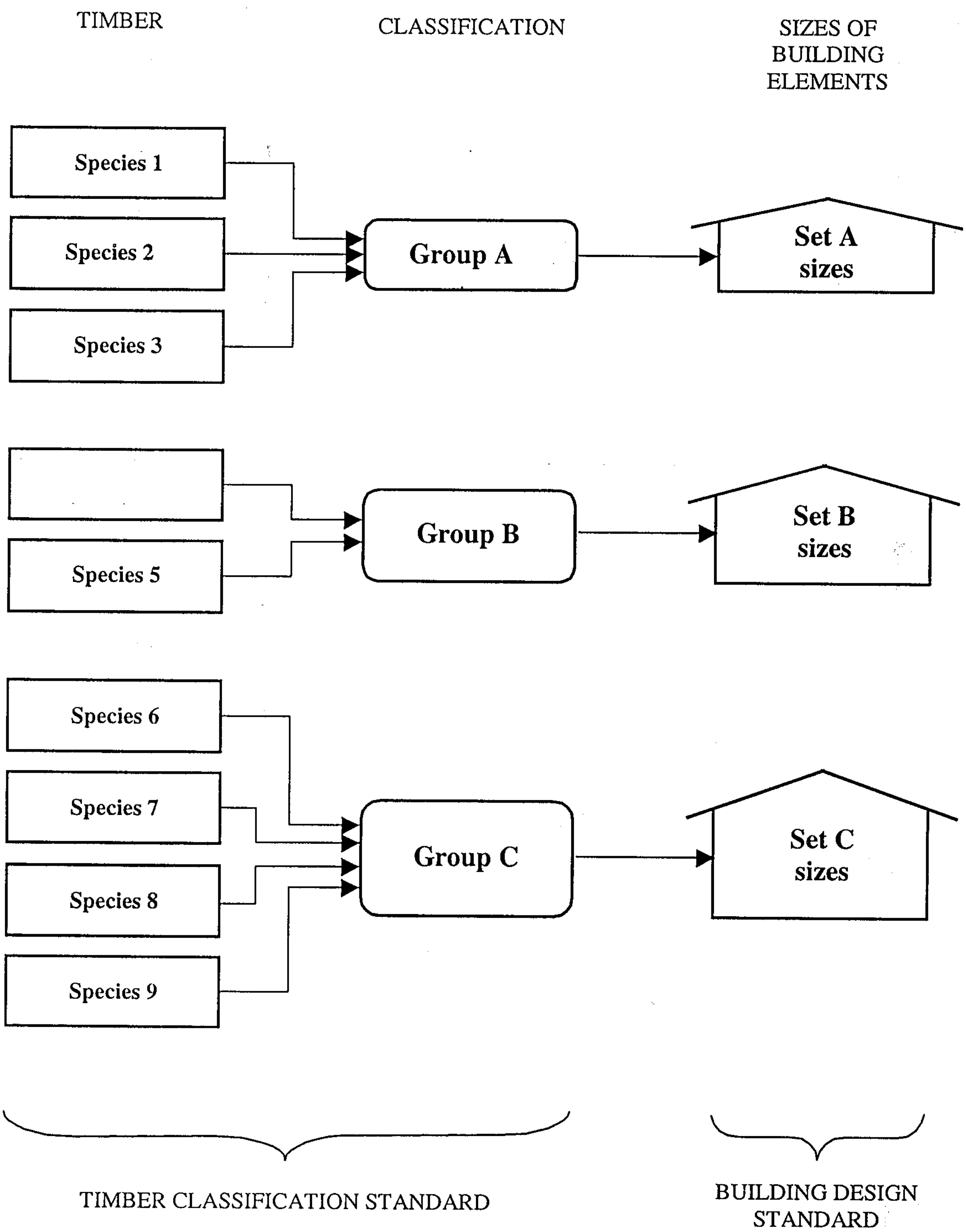


Figure 10. Application of strength grouping.

The Australian strength grouping procedure has also been applied to 700 species of African timbers (Bolza and Keating, 1972), 500 species of South East Asian Timbers (Keating and Bolza, 1982) and 200 species of South American timbers (Berni *e al.*, 1979).

The other similar classification groups include those for species from Africa (Campbell and Malde 1970, Comben 1971, Okigbo 1966, Ward 1974), Malaysia (Burgess 1956, Engku Abdul Rahman bin Chik 1972), Singapore (Singapore Timber Standardisation Committee 1966), Philippines (Espiloy 1978), Indonesia (Suparman Karasudirdga *et al.* 1978, Iding Kartasujana and Abdurahim Marawijaya n.d.), Laos (Timber Research and Development Association 1976), Papua New Guinea (PNG Department of Forests 1972, Eddowes 1977, Bolza *et al.* 1975), Fiji (Anon 1968, 1970), Solomon Islands (Forestry Division 1976, 1979).

A general discussion on this type of strength grouping has been given in a previous paper (Leicester and Keating, 1982 and by Pearson 1965).

5.4 Option 3. Machine Grading

Machine grading methods are not as sensitive to changes in the input resource as are visual grading methods and hence machine grading is an ideal method for stress-grading mixtures of unidentified species. Recommendations for application of this procedure have been made in a study on Malaysian timbers (Collins and Amin 1990). An example of the evaluation data is shown in Figure 11.

The efficiency of the method can be improved by presorting according to species type (e.g. eucalypts) or according to wood type (e.g. mature or juvenile trees).

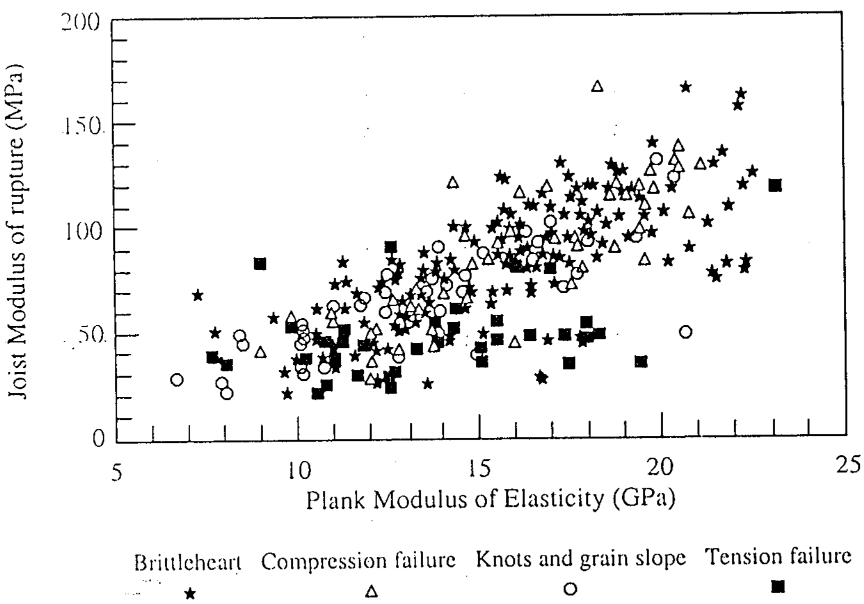


Figure 11. Relationship between stiffness and bending strength for Malaysian Mixed Hardwoods (after Collins and Amin 1990).

5.5 Option 4. Proof Grading

An interesting method of coping with multiple species is to use the technique of proof grading that was developed in Australia (Leicester 1984c). An Australian Standard based on this technique has been published – AS 3519: Timber–Machine Proof Grading (Standards Australia 1993).

Essentially the method comprises two steps. The first is to presort the timber into a grade by any method desired. Next the timber is passed through a proof testing machine that continuously stresses the timber in bending as it passes through. If the timber is below grade, the machine will break it and so it will be rejected.

The most obvious advantage of this procedure is that it does not require species identification, often an impossible operation under mill conditions. In addition it does not require highly skilled grading personnel; if a mistake is made, the machine will break the timber and reject it.

A fairly simple machine, the Hilleng Proof Grader, was manufactured in Australia for this purpose. It has been applied in about 20 small mills. Although the proof grading procedure is quite simple, the research and analysis related to this procedure has been quite sophisticated (Leicester 1984a). The proof loads used and the acceptance criteria take into account factors such as length of timber that is graded, the span of the proof testing machine, the type of passes used and the damage that occurs during proof testing.

At one particular mill the log intake comprised 150 species of rainforest timbers and it was noted that on several occasions the graders made errors in species identification; these errors were noted only because the machine failed the timbers during proof testing. Without the benefit of the machine, major errors would have occurred during a conventional visual grading operation.

6. UTILISATION OF AUSTRALIAN HARDWOODS

Because of a ban on the logging of rainforest species, almost all the hardwoods utilised in Australia are indigenous eucalyptus timber. They cover a wide range of strengths and relative to the softwood species they are generally stronger. However, on the negative side they are heavier, more difficult to saw due to growth stresses, difficult to season and to glue, difficult to nail (if seasoned), tend to split easily and tend to warp and twist during drying. Yet despite these disadvantages, until recently eucalyptus timber, including unseasoned timber accounted for half the structural timber used in Australia.

Some of the methods used to overcome these difficulties have included edge sawing to mitigate the effects of growth stresses, the use of glued wrapping during seasoning to reduce drying stresses, increased edge distances for connectors to reduce splitting and special fixing techniques for attaching wall sheeting to unseasoned timber to reduce the effects of twisting during drying. . End and edge distances for nailing are usually assessed by direct trial. However, for other types of connectors, appropriate recommendations are given in AS 1720.1, which contains a method for assessing the tendency to split.

Usually the clear wood of eucalyptus is very straight grained and so this wood is culled to be sold as timber for making furniture timber. Large size beams are formed by end or edge joining 5–6 m lengths with metal connectors. Recent studies of plantation grown eucalypts indicate that their structural quality is inferior to that of forest grown eucalypts; in addition the latter appear to be more susceptible to decay.

7. STRUCTURAL MECHANICS

7.1 General

During the past few decades there have been some very sophisticated developments in timber engineering technology. These indicate a trend for the use of timber as a sophisticated structural material, in many ways comparable to the use of steel. Accordingly it is implied that for the structural design engineer, the structural properties of the stress-graded timber are equally reliable as those of steel. To illustrate the degree of sophistication involved, the following is a discussion of some of the current concepts used in timber engineering.

7.2 Fracture Mechanics

If linear elasticity is used to analyse structural elements containing sharp notches or manufactured cracks (such as the butt joints in glulam) such as for the examples shown in Figure 12, it will be found that the predicted stress at the notch root or crack tip is infinity. Hence, fracture initiation at a notch root is related to a *stress intensity factor* rather than stress. Methods for computing the stress intensity factor for practical cases have been described previously (Leicester 1974, Leicester and Walsh 1982, Walsh 1974).

For the case of a butt joint, Figure 12(b), the nominal stress at failure σ_{ult} is related to the critical stress intensity factor k_{1c} by

$$\sigma_{ult} = \frac{k_{1c}}{\sqrt{2\pi a}} \qquad (5)$$

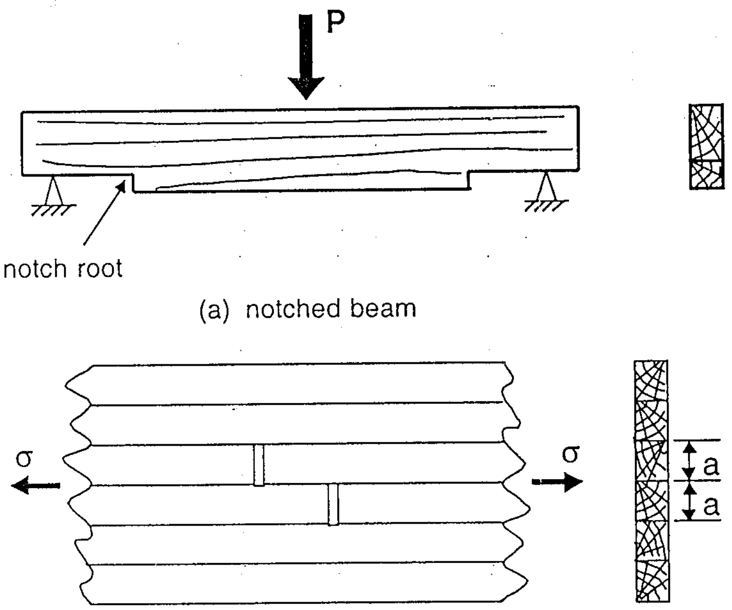
where 'a' denotes the lamination thickness and hence also the crack length. The factor k_{1c} depends on the species of timber.

7.3 Buckling of Slender Members

Timber structures are often fabricated with members that are sufficiently slender that they have the potential to fail through a buckling mode. The mathematics of failure through a buckling mode can be extremely complex, and the successful design against such a failure mode is dependent to a large extent on developing simple design procedures for coping with this mode. In AS 1720.1, the Australian Timber Engineering Design Code (Standards Australia 1997), the nominal failure stress of a slender member, denoted by σ_{ult}, is given by

$$\sigma_{ult} = k_{12}\,\sigma_{stable} \qquad (6)$$

where σ_{stable} is the ultimate strength if the member were stable and k_{12} is a stability factor. In AS 1720.1, k_{12} is specified as a simple function of member geometry and material properties. This format has been used to introduce many complex failure modes such as those related to beams, plywood webs and spaced columns (Leicester 1972, Leicester and Pham 1984).



(a) notched beam

(b) butt joints in glulam

Figure 12. Examples of stress singularities.

7.4 Load Duration Effect

If a structural element is loaded continuously to a high stress level, its long term strength will be considerably reduced relative to its short term strength. Many theories have been proposed to explain the load duration effect (e.g. Foschi and Barrett 1982, Madsen 1992, Lu and Leicester 1994) and the results have been incorporated into design codes such as AS 1720.1.

7.5 Mechano Sorptive Effects

Probably one of the most amazing characteristics of timber is its deformation response when subjected to moisture cycling while stressed (Leicester 1971a, Toratti 1992). This is illustrated in Figure 13. The mathematics of this are usually expressed by use of a mechano-sorptive element combined with the usual springs and dashpots. An example of this is given in Figure 14. The deformation of a mechano-sorptive element, denoted by ε_{ms}, is related to the applied stress σ and moisture change Δ_m by

$$\varepsilon_{ms} = A\,\sigma\,\Delta_m \tag{7}$$

where A is a constant that depends on the moisture content.

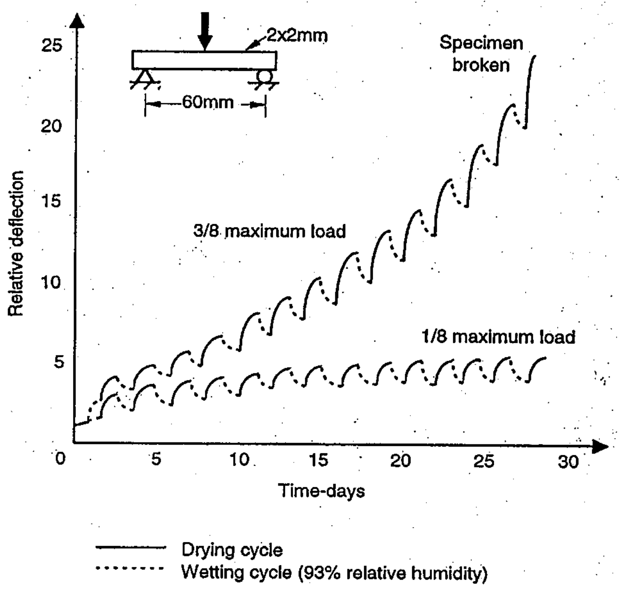


Figure 13. Load carrying wooden beam subjected to moisture cycling (After Hearmon and Paton 1984).

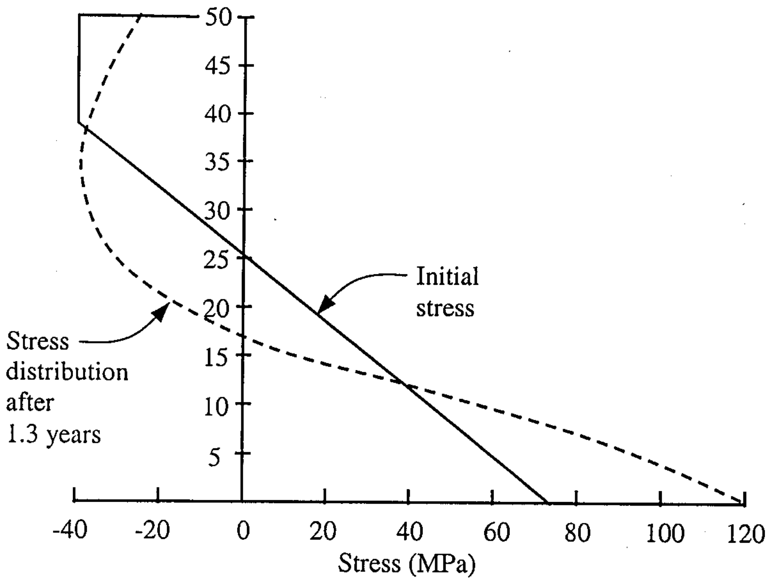


Figure 14. Typical schematic model for the mechano-sorptive deformation of a wood element.

An obvious application of mechano-sorptive concepts is in the prediction of building deformation under long duration loads. A less obvious but equally interesting application is to use the theory to assess the redistribution of stress with time, Figure 15. This can lead to a reduction with time of the predicted load carrying capacity of a structural element such as that shown in Figures 16 and 17.

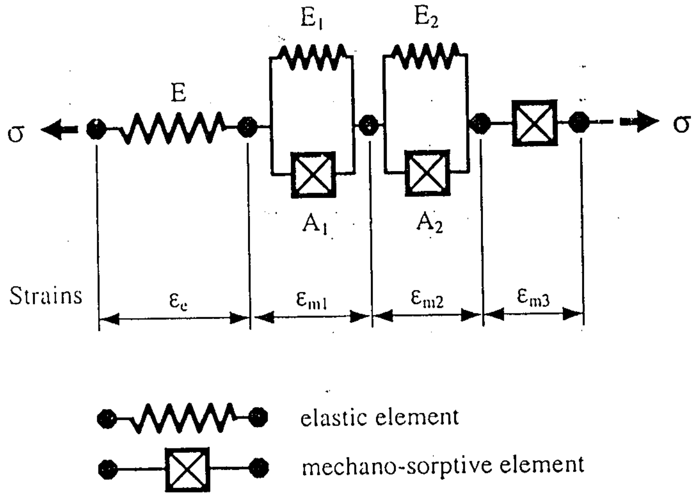


Figure 15. Computed stress redistribution of a beam due to mechano-sorptive effects (after Lu and Leicester 1994).

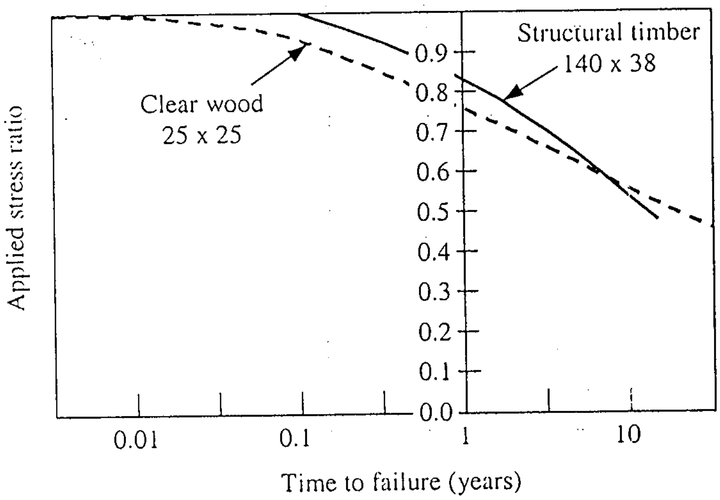


Figure 16. Theoretical prediction of time to failure due to mechano-sorptive effects (after Lu and Leicester 1994).

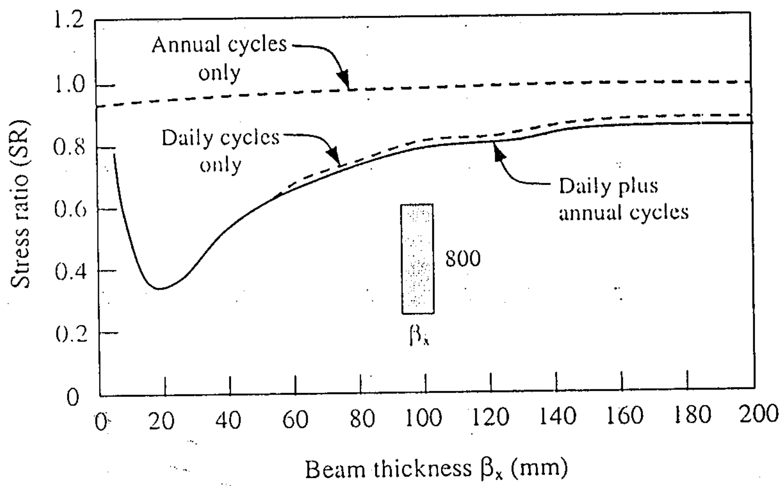


Figure 17. Theoretical prediction of stress ratio to cause failure in 20 years due to mechano sorptive effects (after Lu and Leicester 1994).

7.6 Combined Effects

When some of the above effects are combined, some quite complex phenomena can occur. For example, consider a column under long duration load (Leicester 1971b, 1972). The buckling effects are increased by mechano-sorptive effects, and failure stress is reduced by the load duration effects. These matters have been considered in deriving the design rules for AS 1720.1.

Another interesting example is the influence of mechano-sorptive effects to create internal stresses that can have a dramatic effect on the fracture strength of timber, particularly at the roots of notches. Interesting examples of this effect were given at a 1996 COST 508 Wood Mechanics Conference in Stuttgart (Jensen and Hoffmeyer 1996, Ranta-Maunus 1996).

7.7 Glulam

Because of their large size and expense, the strength of glulam is usually assessed by theory rather than by direct testing. The best procedure available at the moment is based on Norwegian research (Falk *et al.* 1992). The results are stated in the following form for the bending strength of glulam beams, denoted by σ_{glulam},

$$\sigma_{glulam} = k_{lam1}\, \sigma_{FJ} \tag{8a}$$

$$\sigma_{glulam} = k_{lam2}\, \sigma_{stock} \tag{8b}$$

where σ_{FJ} and σ_{stock} denote the tension strength of the finger joints and the stock material of the laminates respectively, and k_{lam1} and k_{lam2} are laminating factors, typically in the range 1.3–1.5.

7.8 Metal Connectors

Dowel connectors

The yield loads of dowelled joints systems, such as for example, nailed and bolted joints, are very well predicted by a yield theory, often referred to as the European yield theory (Larsen 1994, Aune and Patton-Mallory 1986). By assuming that the steel dowel has a plastic moment capacity M, and the wood has a plastic yield bearing strength q per unit length of dowel, the yield load capacity of a joint system can be computed. A simple example of this is illustrated in Figure 18.

This yield theory is elegant and simple to apply: it is used in EC5: Design of Timber Structures Part 1-1 (Eurocode 5 1993). Some caution should be exercised in applying the yield theory because it covers only one mode of failure; for example, it does not take into consideration the potential for a failure through splitting.

Nail plate connectors

Another elegant theory for joints is one that has been developed for joints fabricated with nailed plate connections (Källsner and Kangas 1991, UEAtc 1979). This theory takes into account the fact that these joints have many potential modes of failure: as a result, the strengths for several modes must be evaluated as input data for the design procedure, Figure 19. This theory is also used in Eurocode 5.

Special connectors

The metal connector technology today is dominated by the fact that numerous metal connectors for special purposes are invented and used commercially each year. There is no time to undertake research to develop predictive models for each of these connectors. Accordingly, nearly all of these are evaluated through load testing; standards for such load testing is now a prime focus of much activity by various standardising agencies and research groups (Foliente and Leicester 1996).

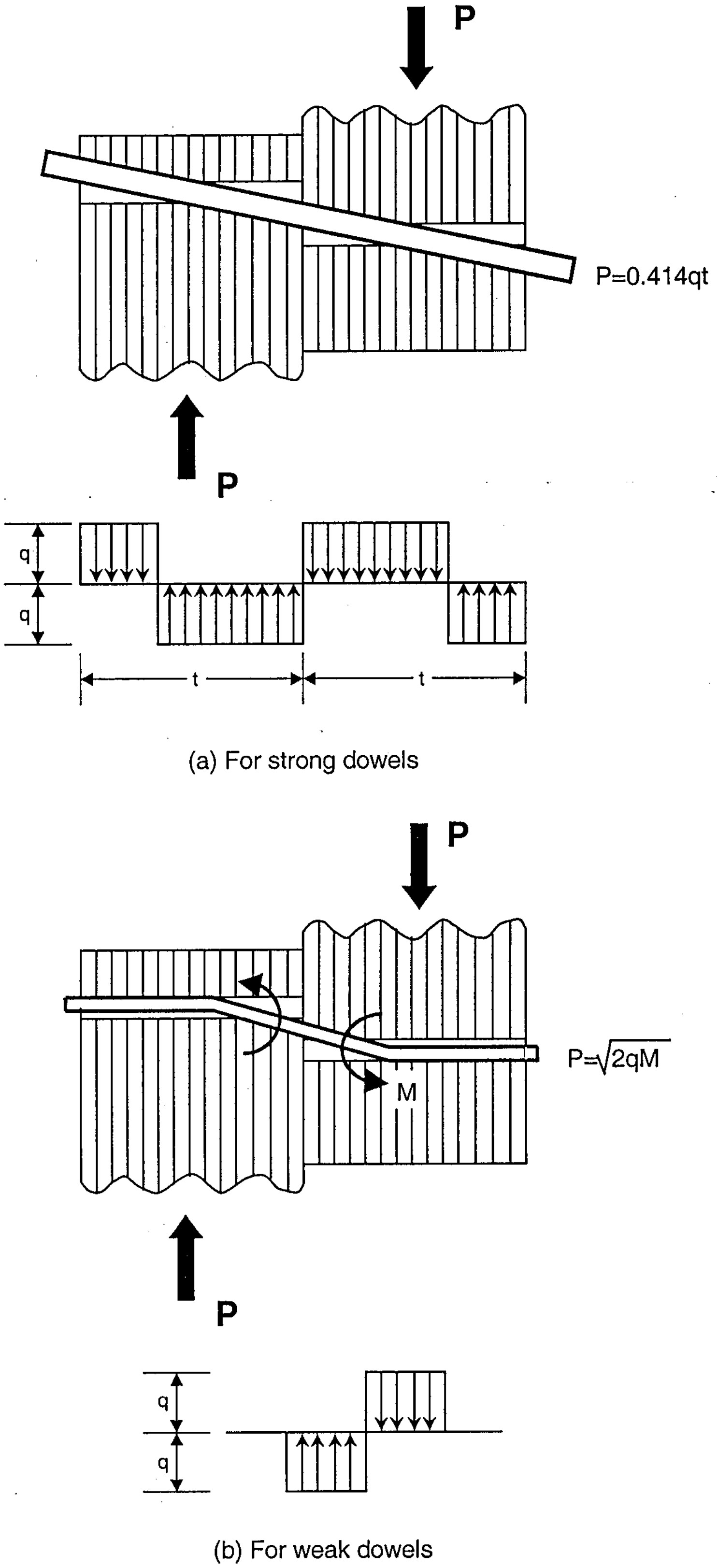
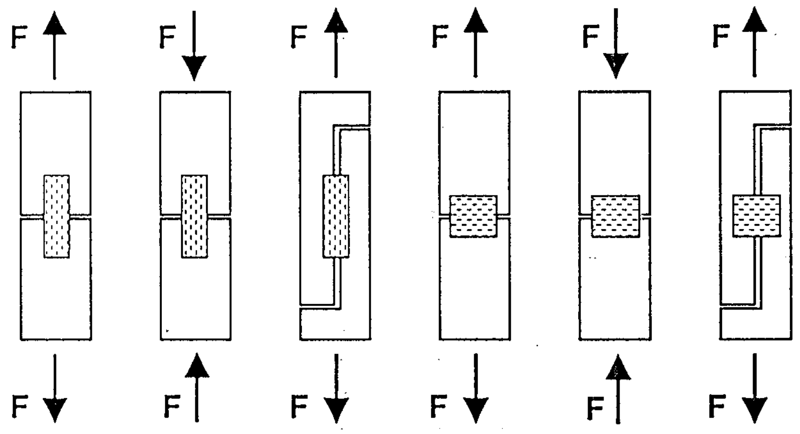
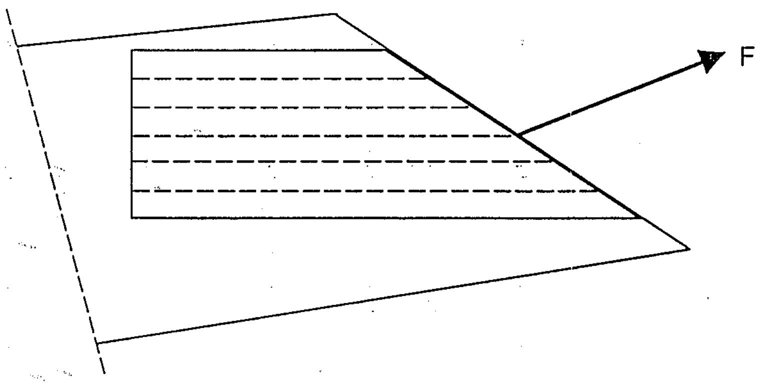


Figure 18. Examples of failure modes for dowel connectors.



(a) Load tests to obtain design properties



(b) Typical in-service load configuration

Figure 19. Load configurations for nail plates.

7.9 Glued Joints

Durability

Glue can be used to make very effective joints. Immediately after fabrication, they are usually extremely strong; however, since their strength lies in chemical bonding, there is always a question about their long term strength.

For some types of glues such as resorcinols and phenolics, it is well known that if the joint demonstrates a predominantly wood failure in a soak and chisel test, then the long term strength will be excellent. However, for some other glues such as melamine fortified urea formaldehyde, there is a debate on the long term effects when used in an environment of tropical temperatures and humidities.

An interesting development during the past decade has been to form high capacity joints for connecting large members by using epoxy to glue embedded steel rods to these members (Buchanan and Deng 1996, Madsen 1996). The indications are that by selecting the correct formulation of epoxy, the joints will also have excellent long term strength (Clorius *et al.* 1996).

Fabrication quality

Laminates for glulam structures are often formed by end-jointing short pieces of timber by glued finger joints. This fabrication is done at high speeds and even when a great deal of care is taken, it may be expected that at least 1 in 10,000 joints will be effectively a non-joint. This joint then acts as a butt joint in the glulam and according to Equation (1) reduces the tension strength of the glulam to about a quarter of its strength that it would have if there were no butt-joints present. For small structures this may not matter. However, for large structures there may be something like 10,000 finger joints within the critically stressed zones and the chances of encountering a non-joint in the critical zone is too high to ignore; if the structure is such that failure of a single member would be catastrophic, then the only solution is to ensure that all laminates are proof tested in tension prior to fabrication into glulam beams. This procedure was followed in the fabrication of glulam for the large span dome and exhibition building erected for the coming 2000 Olympic Games in Sydney, Australia.

8. STRUCTURAL RELIABILITY

8.1 In-Service Risk

The most important target in structural design is to control the risk of failure. Hence, one of the most significant advances in structural engineering has been to develop computational procedures for assessing the probability of in-service failure.

The simplest problem of this type, illustrated in Figure 20, is to consider a single element of strength 'R' and a single loading that gives rise to a load effect 'Q'. Both 'R' and Q are random variables. The probability of failure p_F is then defined by

$$p_F = \Pr\{R < Q\} \tag{8}$$

the probability that R will be less than Q, given a random choice of R and Q.

Procedures for computing p_F have been extensively researched. A basic procedure has been described in a previous paper (Leicester 1985). Quite involved problems can be solved, including problems that involve deteriorating structures, dynamic loads (such as earthquake or hurricanes) and load combinations.

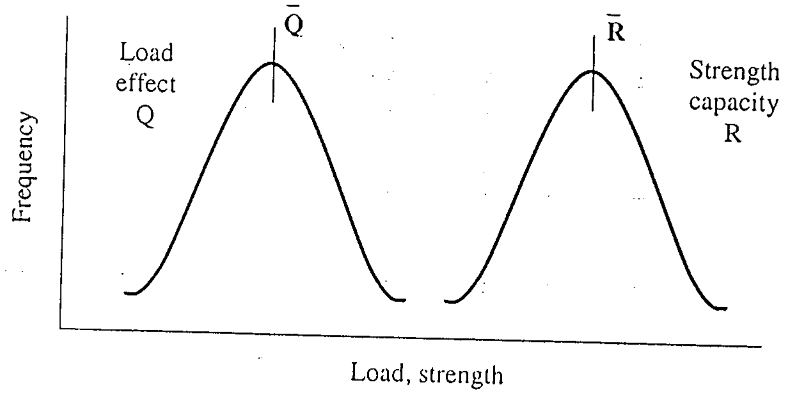


Figure 20. Representation of strength and load effect as random variables.

For legal reasons, it is often preferable to discuss a safety index rather than a risk of failure. One useful definition of the safety index β_o is

$$\beta_o = -\log_{10}(p_F) \tag{9}$$

So for example, a probability of failure $p_F = 10^{-4}$ will correspond to a safety index of $\beta = 4$. From Equation (9) it is seen that larger safety indices correspond to smaller probabilities of failure.

The selection of an appropriate risk level for design codes can be based on calibration to existing codes, or alternatively, to choosing risk levels that represent an optimised balance between the cost of structural elements and the effective cost of any failures. A procedure for optimising risk levels has been given in a previous paper (Leicester 1984c).

Extensive studies have been undertaken in USA (Ellingwood *et al.* 1980), Canada (Foschi *et al.* 1989) and Australia (Leicester *et al.* 1986) to assess the safety of existing and proposed structural design codes. An example from the Australian study is shown in Figure 21; it indicates that at the time of the study the safety implied by the proposed timber engineering design codes was less that that given by the corresponding steel, concrete and composite material codes.

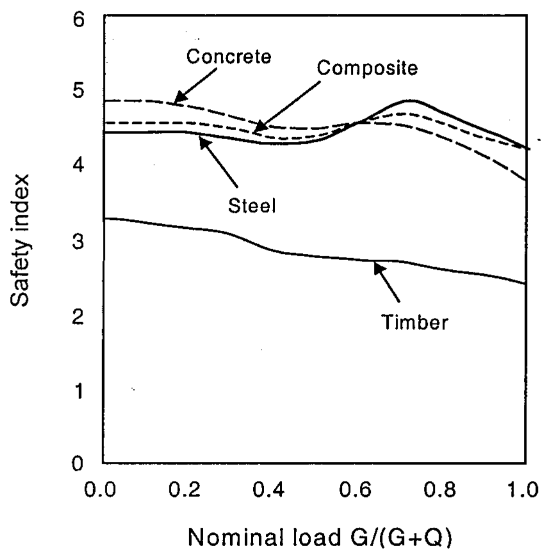


Figure 21. Comparison of safety levels for beams subjected to load effects due to dead weight G and floor live load Q (after Leicester et al. 1986).

8.2 Proof and prototype testing

Proof and prototype testing are two commonly used methods for the appraisal of product strength.

In *proof testing* every structural unit approved must first demonstrate its ability to sustain a specified proof load. In *prototype testing* a whole population of units is accepted on the basis of tests on a limited sample of units.

One of the benefits of reliability theory is that it provides a rational procedure for deriving the test loads that should be used in proof and prototype testing (Leicester 1987, 1992b) These procedures were used in the development of the Australian Timber Engineering Design Code AS 1720.1.

9. NEW TECHNOLOGIES

9.1 Materials

Probably the most exciting materials to become available to the structural engineer are Laminated Veneer Lumber, Parallam and other composite materials for replacing sawn timber. These materials can be made to have high strength, they are very reliable, of large dimension cross-section and can be made in any length.

Almost as useful are composite elements fabricated from several types of material; usually these are of light weight and may be fabricated in long lengths. Two popular examples of these are the I-beam (often fabricated with solid timber flanges and plywood webs) and the open web joist (often fabricated with solid timber flanges and light gauge steel web material). The latter is particularly favoured in domestic and light commercial construction, because the open web configuration facilitates the instalments of services.

Finally, mention must be made of the great variety of structural sheet material now being manufactured. Examples of these include Oriented Strand Board and Particle Board. They are very cost effective. However, from the engineering perspective they involve the difficulty that information on strength under long duration loads is often lacking. An interesting workshop on this topic was held in Toronto in 1993, and there were several interesting papers on this topic (e.g. Palka 1993).

9.2 Engineered Wood Products

Herein the term 'engineered wood products' will be taken to refer to both materials and building elements fabricated with wood as a dominant material. Furthermore within this overview, emphasis will be placed on aspects of structural utilisation.

There are three broad groupings of engineered wood products:

(i) *Structural elements cut from slab, board or linear forms of homogeneous material.* Examples of these would be (a) slabs of Paralam, Scrimber, glulam, laminated veneer lumber, (b) board material in the form of plywood, oriented strand board, laminated strand lumber and (c) linear material such as finger-jointed lumber.

(ii) *Structural elements cut from slab, board or linear forms of composite material.* Examples of these include (a) boards of non-uniform layup, (b) sawn hardwood end-joined by metal plate connectors and (c) I-beams fabricated from a mixture of board and slab material.

(iii) *Composite elements fabricated as complete structural elements.* Examples of these would be the Gang-nail 'Posi strut' and the MacMillan 'Trus-joist'.

Examples of these three types of engineered wood structural elements are illustrated in Figure 22.

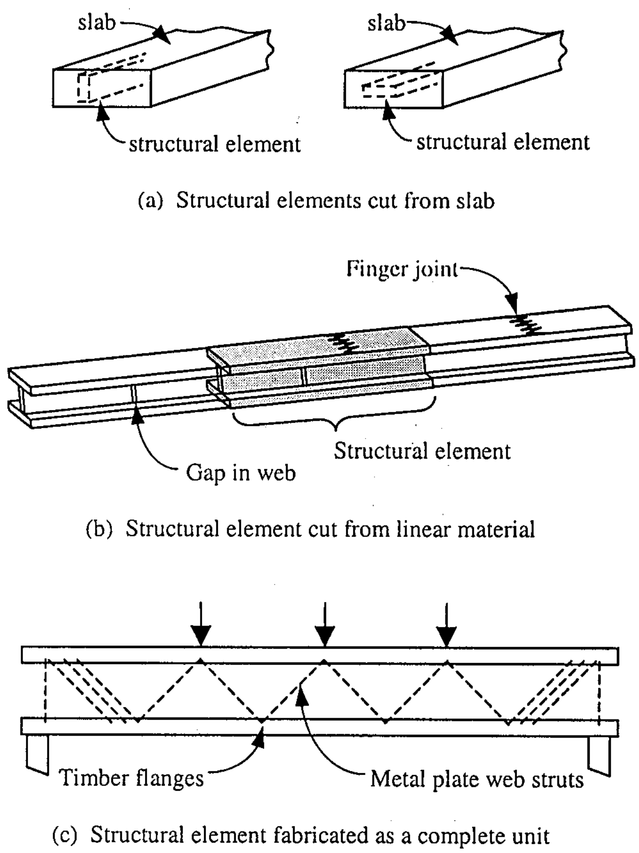


Figure 22. Examples of engineered wood structural elements.

An excellent overview of engineered wood is given in the December 1999 issue of the journal *Timber and Wood Products International.* The explosive growth of these products is indicated by the prediction that their use in the US will increase by a factor of 20 within the next 10 years. Perhaps equally important is the fact that for a given volume of timber, the value adding associated with the fabrication of engineered wood provides 2–10 times as many jobs as does the production of sawn timber.

Probably the prime driver for composite construction is that it leads to structural elements that are much lighter and of longer lengths than is possible with sawn timber. For example, I-joists up to 20m long are commercially available.

A secondary driver for the use of composite construction is the increase in utilisation efficiency. For example, to carry the same load the material used for an I-joist is much less than that of solid sawn timber because much of the material in sawn timber is under-stressed in service, Figure 23.

A less obvious source of efficiency is the potential reduction in variability in composite construction. For the case of N parallel elements, the coefficient of variation is reduced to $V/\sqrt{N}$, where V is the coefficient for a single element. Since the characteristic strength used in design is the five-percentile value, then this reduced variability leads to increased reliability as illustrated in Figure 24.

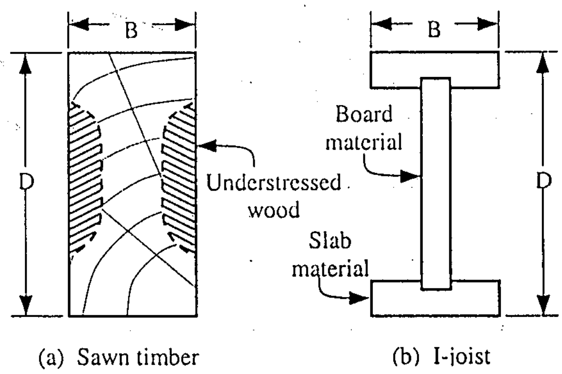


Figure 23. Comparison between rectangular sawn timber and I-beam joists.

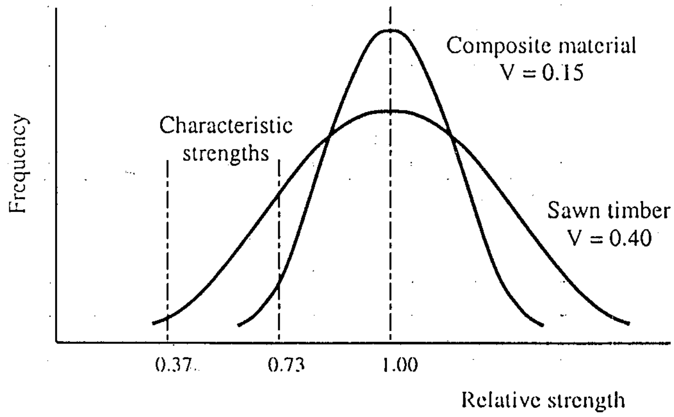


Figure 24. Illustration of the effect of variability on characteristic strength values.

Finally it should be noted that the concept of performance based standards and regulations has had a considerable impact on accelerating the introduction of new forms of composite material and composite elements. Traditional prescriptive regulations are serious barriers to change and would probably have proved a serious deterrent to the introduction of new forms of engineered wood construction.

Probably the greatest obstacle to the introduction of engineered wood construction is that the product sold, i.e. structural reliability, is not visible. The product is poorly understood by an industry that is more comfortable with a product described in terms of cubic metres rather than megapascals.

Furthermore, a large number of structural properties are required to be guaranteed. These include not only various strengths and stiffness parameters, but also the effect of long duration loads and durability effects. An example of a load duration effect is shown in Figure 25.

The effect of rare fabrication defects needs to be appreciated. An extreme example was noted in the specification for the large glulam members used for the Sydney Olympics Exhibition Hall. This glulam contained about 2,000 finger joints that would be subjected to high tension stresses in service. For satisfactory safety the fabricator would need to prove that his fabrication process was such that the chance of producing a finger joint of zero strength was far less than one in 20,000,000. The occurrence of such a joint in glulam would reduce the load capacity of an element by a factor of 5. The solution chosen was to proof test every finger joint.

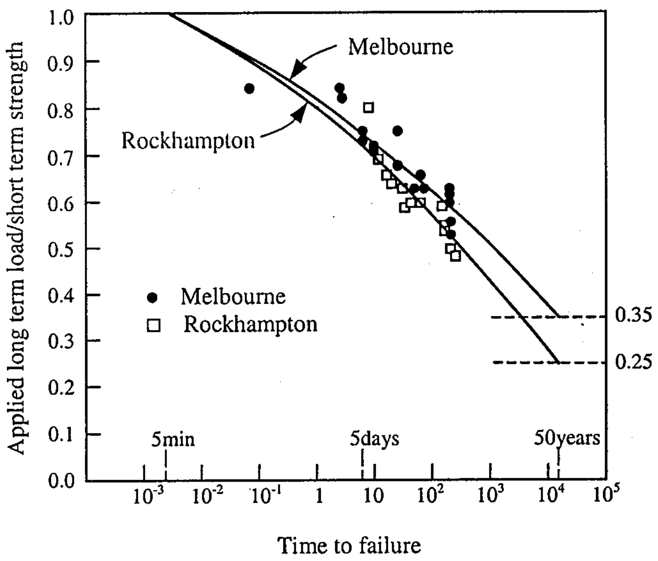
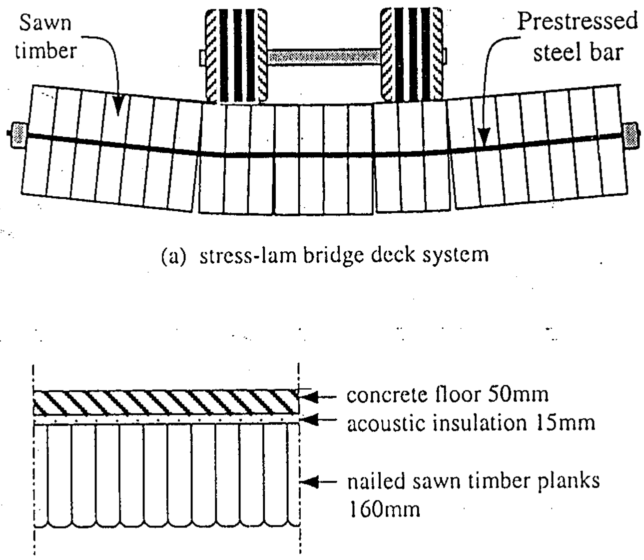


Figure 25. Relationship between load level and time to failure for Scrimber (Breitinger *et al*, 1989).

Negative concerns associated with the use of composite wood construction relate to the reliability of fabricated components and the sophisticated technology required for construction, such as the use of stability restraints and support fixings. One solution is to have specialist fabrication companies. This is especially favoured in Europe where it is not unusual to have large structures that involve complexities of shape or require extreme precision in their manufacture (Merz, 1998; Linkwitz, 1996). The second alternative is for manufacturers to sell total systems such as floor, wall and roof systems. A typical example of this would be systems sold for multi-storey residential timber frame (CSR undated).

9.3 Sawn Wood Products

To use sawn wood efficiently for major construction, it is necessary to overcome the inherent disadvantages associated with its length limitations and high variability. Two effective methods for doing this are composite constructions such as those illustrated in Figure 26. These are nail-laminated composite floor systems (Natterer, 1996) and 'stress-laminated' bridge decks (Crews, 1998).



(a) stress-lam bridge deck system

(b) nailed-lam floor system

Figure 26. Examples of laminated composite systems.

9.4 Subsystems

There is an increasing trend towards the marketing of complete subsystems that are fabricated off-site in factory environments. These include floor systems, wall systems and roof systems. The advantage to the producer is that he can optimise the use of his resource, and perhaps produce systems that offer competitive advantages from the architectural view point, for example thin floor systems. For the end user, the availability of such systems reduces design and construction time, and also reduces on-site quality control requirements.

A minor difficulty associated with the marketing of systems is that the testing regime required for a performance based assessment of such systems is often uncertain. Some attempts to develop suitable testing regimes are in progress (Foliente and Leicester 1996).

9.5 Whole Building Systems

Currently some engineer-architects, particularly in Europe, are designing whole building systems that are targeted at optimising the operation of the building from the point of view of space, thermal, acoustic and lighting requirements (Natterer 1991, Linkwitz 1996, Bruninghoff 1991). This is a difficult area to work in, but it is quite probable that in the long term, some of the concepts being developed will be systemised and so become more generally applicable.

9.6 Construction Techniques

Undoubtedly the greatest development in the construction area has been the development of hand held power tools for on-site work. This is particularly true for industrialised countries where labour costs are high. The benefits of such tools are obvious when consideration is given to the fact that joints for large portal frames may require hundreds, sometimes thousands, of nails in their fabrication (Yttrup and Evans 1996).

Hand held power tools are frequently used for driving nails, screws and staples. Some are driven by compressed air while others are totally self contained explosive-driven units. Typically nails up to 90 mm long can be driven not only into timber, but also through mild steel gusset plates up to 2.5 mm thick. The nailing rate for these operations is about one per second.

Another noticeable trend in construction practices is to develop special erection techniques for lifting large portions of the building that are fabricated on the ground. In particular, it is proving quite popular to use several cranes simultaneously to lift large sections of roof which have been prefabricated, often complete with services.

9.7 Delivery Systems

It is notable that many countries which have sophisticated technologists and even reasonable product standards do not have technical quality in their buildings. This is because an appropriate network of technology must be in place to deliver this quality. The network must involve suppliers, designers, builders and regulatory systems. All aspects must in some sense be associated with registration, appraisal and audit; there must be a paper trail of action and responsibility between all stakeholders of the building industry. Figure 27 shows an example of marking that is used on structural timber; it identifies not only the claimed structural quality of the timber, but also the source of the timber and the certification agency.

A difficult but important aspect of quality systems is the communication of information. If it is too complex for a particular technology infrastructure it will be ignored. The UNIDO Manual on house construction (UNIDO 1985b) is an interesting example of an attempt to convey quite complex concepts in a simple and user friendly manner.

9.8 Software

Developments in computer software are progressing so rapidly that it is almost impossible to envisage the future. Already sophisticated companies have software packages that enable the rapid drawing of complex building shapes, the related timber engineering design and controls for the fabrication process.

Another type of development relates to information transfer. One form is the transfer of information related to building products. Another is the exchange of information related to technology; for example a recent web site set up in Melbourne for this purpose is http://www.dbce.csiro.au/res-cap/tinder/tinder.htm (Foliente and Woodward, 1997).

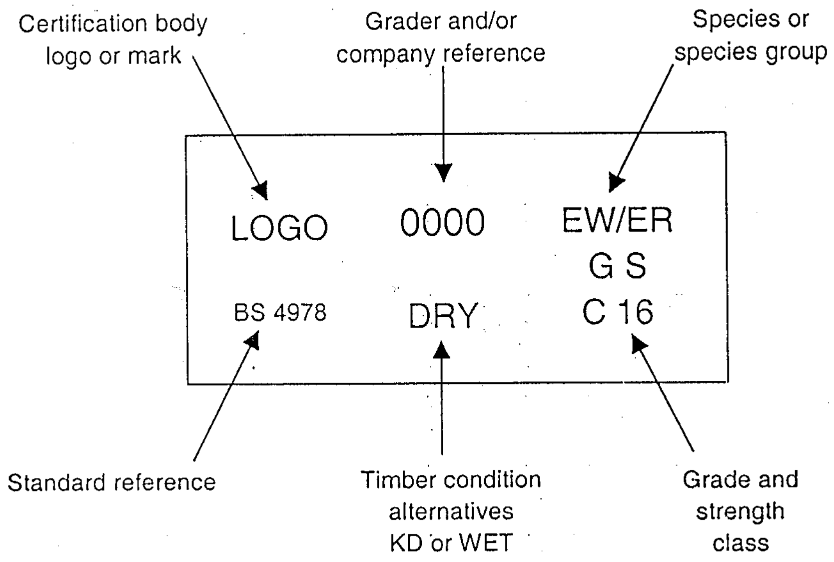


Figure 27. Example of information provided in branding structural timber.

10. PERFORMANCE BASED CODES AND STANDARDS

10.1 General Concepts

One of the most significant trends for the building industry worldwide has been the trend towards the acceptance of performance-based codes, standards and procedures (Leicester *et al.*, 1997). An example of this has been the recently published Building Code of Australia (Australian Building Codes Board 1996).

The concepts involved are illustrated by the application shown in Tables 3 and 4. The essential features of performance based codes and standards are the following;

I. There are at least two levels of specified performance, i.e. a level of product performance and a level of in-service performance.

II. Methods should be provided whereby target performances can be met either (a) by testing; (b) by computation; or (c) by deemed-to-satisfy criteria.

Table 3. Example of performance targets for use of composite I-beams

Performance control	Performance target
1. Specification of building objective	Probability of loss of life within the design life of the *building* is less than 10^{-6}
2. Design for in-service performance	For a *particular I-beam*, the probability of failure in-service (during the design life) is given by $Pr(\phi R_k < S_k) = 10^{-4}$
3. Evaluation of characteristic values – structural element – load	$R_k = R_{0.05}$ $S_k = S_{0.95}$

Notes:
ϕ = material factor
R_k = characteristic value of I-beam strength
$R_{0.05}$ = 5-percentile value of I-beam strength
S_k = characteristic value of load
$S_{0.95}$ = 95-percentile value of peak load within a design life

Table 4. Methods for achieving performance targets given in Table 3

Performance control	Method for achieving performance targets		
	Use of compliance criteria	Use of performance criteria	
		By computation	By test
1. Achieve building objectives	Specify the use of a specific set of design codes and standards	Undertake an assessment of risk to life	*Survey of existing buildings for loss of life**
2. Obtain in-service performance	Use published span tables	Design using loading codes and engineering design codes	*Survey of existing buildings for structural failures**
3. Evaluate characteristic values			
– structural element	I-beam accepted by description	Computation of strength of I-beam based on properties of components	Strength test of I-beams
– load effect	Load specified by law	*Computation of loads (e.g., for wind loads, using computational fluid dynamics)**	Load survey

* Not usual

With respect to product appraisal, testing is usually a favoured option where possible, as it provides the most certainty. There are difficulties in assessing long duration effects via testing and there are also often difficulties associated with selecting a testing configuration. However, within Australia it is now not uncommon to test subsystems such as floors, and there are even cases where testing has been applied to complete houses (Reardon 1989).

The benefits of the use of performance based criteria is that they provide a basis for developing optimised building practices. However, probably more importantly, they provide a basis for innovation (as illustrated in the following example related to design against fire), for trade and for technology transfer between countries.

10.2 Fire Safety

Since 1990 there has been an Australian Standard to compute fire resistance of structural elements. This is AS 1720.4: Timber Structures – Part 4 – Fire-Resistance of Structural Timber Members (Standards Australia 1990). The Standard is applicable to large size members, typically glulam members, that are protected by a layer of char during the fire.

The concept of unaffected timber protected by a layer of sacrificial wood is illustrated in Figure 28. The thickness of the sacrificial layer d_c (mm) is given by

$$d_c = ct + 7.5 \qquad (10)$$

where t(min) is the duration of fire and c(mm/min) is the charring rate; the charring rate is taken to be given in terms of the wood density ρ(kg/m^3) by

$$c = 0.4 + (240/\rho)^2 \qquad (11)$$

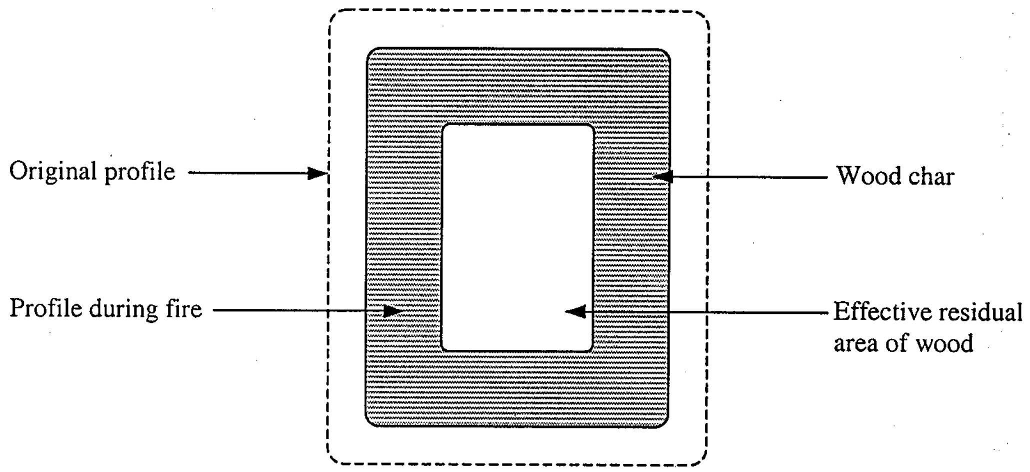


Figure 28. AS 1720.4: Concept of protection by scarificial layer of wood (AS 1720.4, Standards Australia 1990).

The residual wood is assumed to have its normal unburnt strength and the design load to be carried during a fire is assumed to be less than the lifetime peak value.

However, for fire separation walls as used in light frame multi-residential construction, it was impossible for many years to use timber because the Building Code of Australia specified that separation walls had to be built of non-combustible material. Under the evaluation procedures of the Australian Standard AS 1530.1 (Standards Association of Australia 1984) all timber, even timber impregnated with fire retardants, is deemed to be combustible.

To overcome this barrier to the use of timber, a case based on performance criteria was presented to the Australian Building Codes Board. Essentially a risk model, illustrated schematically in Figure 29, was applied to multi-storey buildings of the type illustrated in Figure 30 (Beck and Yung 1994). The building system and fire safety systems were varied from case to case.

The results of four such cases are presented in Table 5. The reference case is the reinforced concrete building without central alarm and sprinkler protection which was considered acceptable within the Building Code of Australia (Australian Building Codes Board 1996). The analysis showed that the risk to life was less in the case of a building with separation walls comprising timber frame construction with a one hour fire rating and a central fire alarm system. On the basis of this analysis, it was successfully argued that such a system should be accepted.

Table 5. Computer model predictions for building shown in Figure 31

Case No	Structural frame material	Fire resistance (min)	Central fire alarm	Sprinkler protection	Relative expected risk to life
1	concrete	90	No	No	1.00
9*	timber	20	No	No	2.27
14	timber	60	Yes	No	0.90
15	timber	60	No	Yes	0.67

*conventional light frame construction

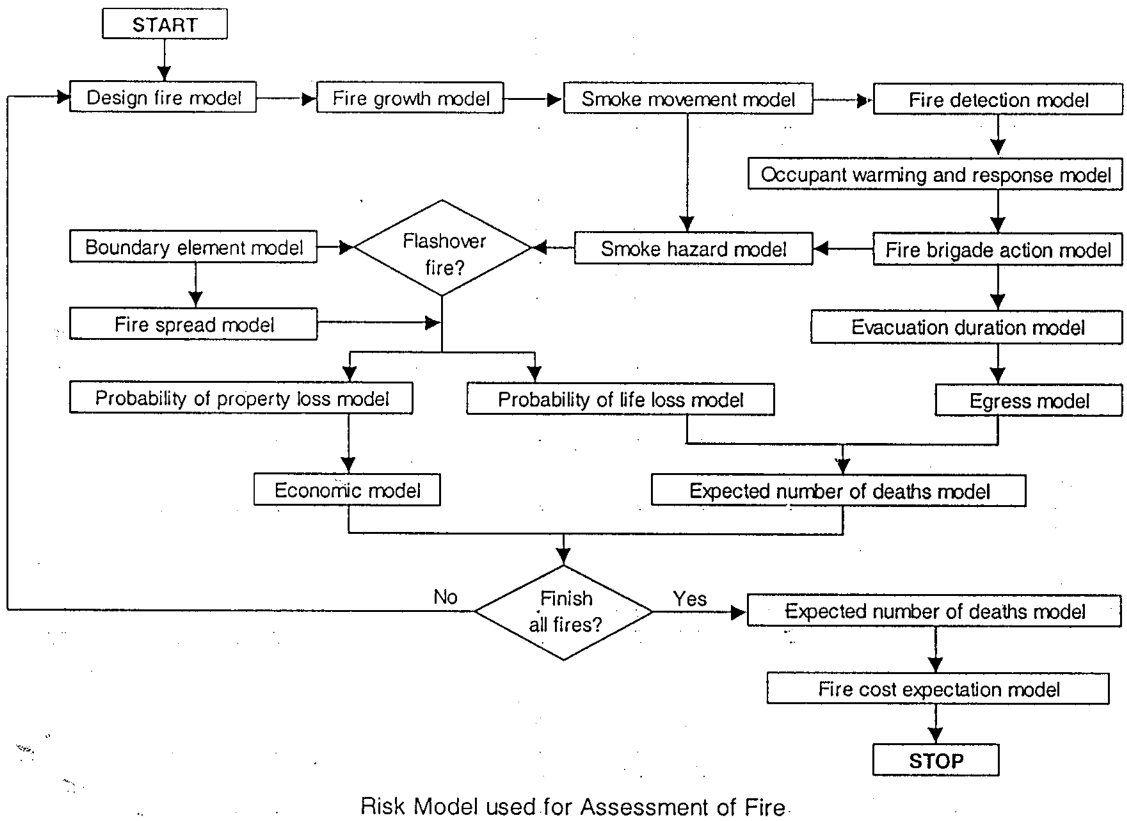


Figure 29. Risk model used for assessment of fire (After Beck and Yung 1994).

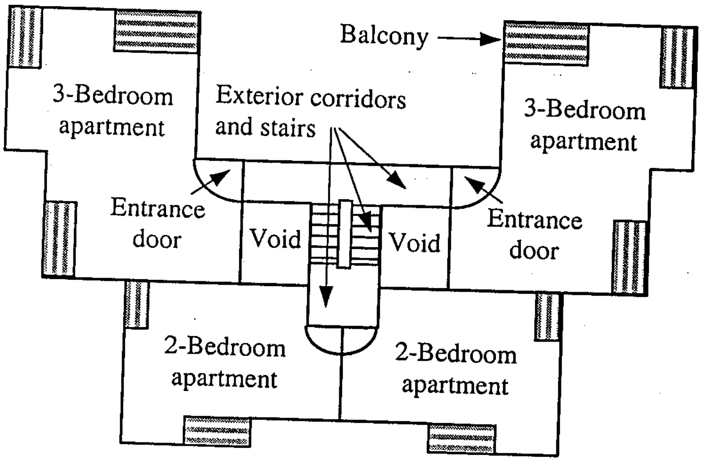


Figure 30. Plan of 3-storey apartment used for risk analysis.

In 1994, the Building Code of Australia (1994) accepted, for the first time, the use of timber framed construction for the fire separation walls between the apartments of a multistorey, multi-residential building. In Amendment 7, such a building is permitted to be up to three-storeys high and if desired also have an extra storey in the form of a masonry/concrete carpark underneath as shown in Figure 31.

A detailed exposition of Amendment 7, together with design requirements for both fire and non-fire aspects are given in the NAFI publication Multi Residential Timber Framed Construction (1995). The following are some of these design requirements.

The fire safety requirements for apartment separation boundaries are stated in fire-resistance-level units; for example, FRL $t_1/t_2/t_3$ denotes the required times t_1, t_2 and t_3 in minutes required for satisfactory structural adequacy, integrity and insulation performance respectively in a standard fire test.

SOU = Single occupancy unit.

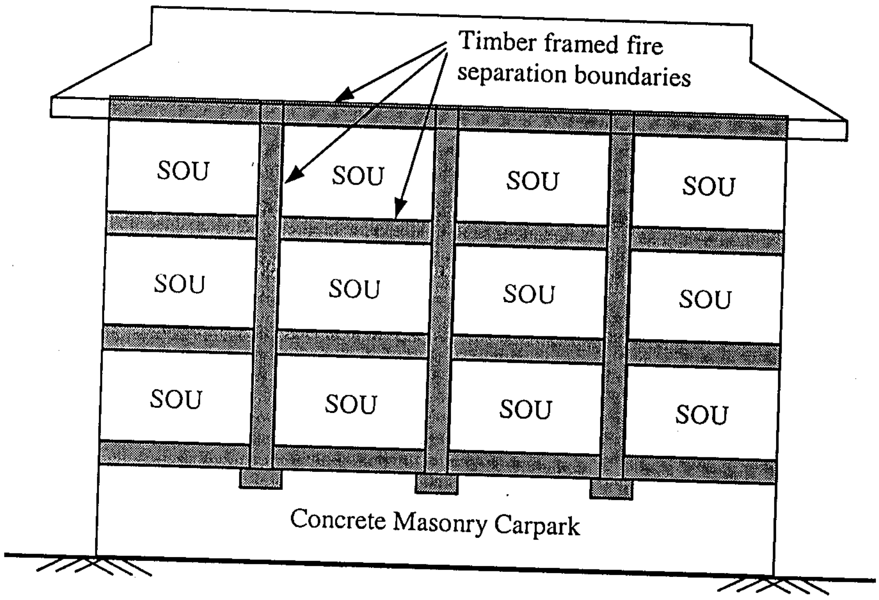


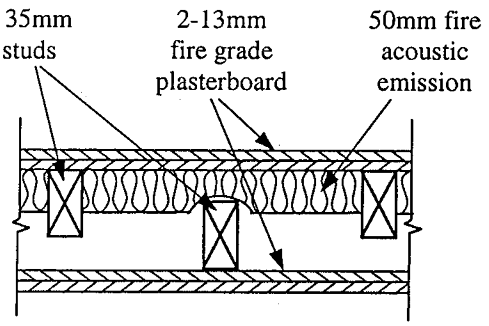
Figure 31. Example of multi-residential timber frame construction.

For common walls and fire walls the required fire resistance is FRL 90/90/90. For other walls, columns, roofs and floors, the required fire resistance depends on the number of storeys, the number of exits and on the presence or otherwise of smoke alarms and detectors.

The FRL values for various wall and floor systems are determined directly from tests according to the Standard AS 1530.4 (1990). Many examples of certified assemblies are tabulated in Part 2 of the NAFI Manual on Multi-Residential Timber Frame Construction (1995). Two examples of these are shown in Figure 32. In addition to the design of separation elements, Volume 2 of the NAFI Manual (1995) provides information on joint details, separating walls and roof spaces, doors, windows, balconies, verandahs and penetration by services. An example of a recommended joint detail is shown in Figure 33.

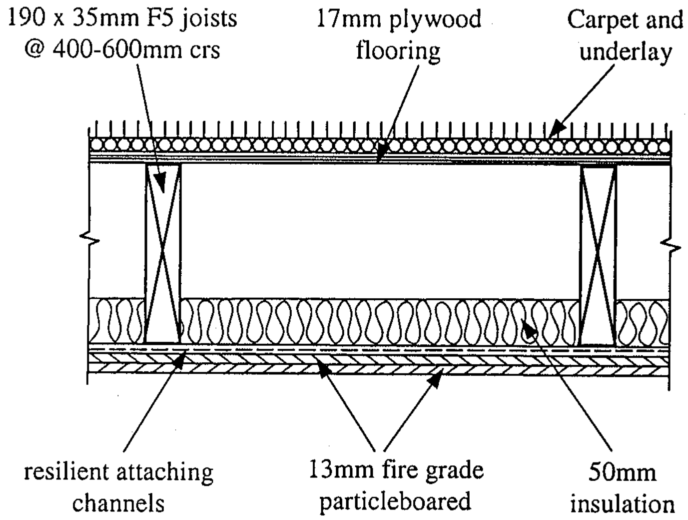
With the change of building regulations to permit the use of timber in fire-separation elements, it is now possible to construct large buildings without the interruption of bricklayers and concreters. This can now be done for buildings up to 3-storeys high in Australia and 7-storeys in England.

In a recent international Conference, Hugh Mackay gave an excellent discussion on the reasons for the growth of multi-storey timber framed construction in the UK (Mackay, 1999). Faster construction times is the primary factor. Other factors include the existence of relevant codes and standards, convenience when building within city redevelopment sites and the sustainability and environment issues associated with the use of timber.



FRL 90/90/90
STC 54
Max height 3m
Load 7.5kN/stud

(a) Staggered stud wall system



FRL 30/30/30
STC 56
11C 68
Stress 6.93MPa

(b) Floor / ceiling assembly

Figure 32. Examples of tested wall and floor systems.

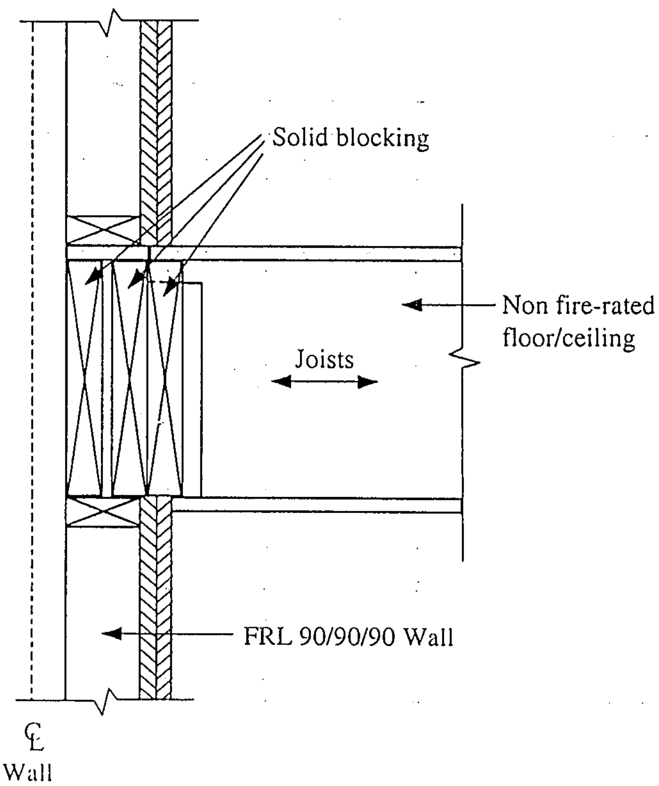


Figure 33. Example of a joint detail.

10.3 Durability

As was the case with fire, most of the existing approaches to designing for durability are limited to the use of deemed-to-satisfy solutions. An example of this is in the application of the Australian Standard AS 1604: Timber–Preservative-Treated–Sawn and Round (Standards Australia, 1993) and the use of simple classification protocols (Australian Wood Preservation Committee, 1997). These solutions are limited in application and do not provide any method for estimating the risk involved.

To remedy this situation there is a major research project within Australia to develop engineering design procedures for design against decay, termites and corrosion (Leicester, 1997). These are generic procedures which will be applicable to in-ground, exposed and protected structures. An example of the parameters considered in a prediction model of the type under study is illustrated in Figure 34. The project is expected to be to the value of US$3 million over a period of 3 years.

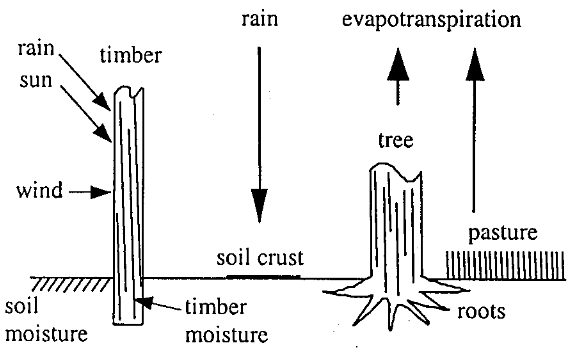


Figure 34. Illustration of parameters considered in modelling ground contact decay.

10.4 ISO Standards

The existence of ISO (International Standards Organization) Standards is potentially of considerable global benefit. They may be used for trade purposes, as model codes for countries that do not have any and as a common format for technology transfer purposes.

However, the existence and/or enforcement of ISO Standards also has the potential to create difficulties for both industrialised and emerging economies. This matter has been discussed at length in a previous paper (Leicester 1997). Tables 6 and 7 have been taken from that paper.

Currently TC 165, the ISO Technical Committee on Timber Engineering is involved in drafting standards related to stress-grading and structural evaluation of sawn timber and poles, the fabrication of finger jointed material and glulam, and the assessment of connector systems.

Table 6. Globalisation criteria for ideal ISO Codes and Standards

Codes and standards should be applicable to: • all species • all constructions • all countries – loads – climate – biological hazards – environmental hazards – existing data – existing technology – existing infrastructure – existing culture

Table 7. Some possible procedures to assist in the globalisation of international codes and standards

• use performance-based criteria • establish equivalence with national product standards • accept trade-off between efficiency and quality control • draft tiered design codes • define multiple quality levels • use grouping methods for – timber species – loads – member sizes – building elements

11. INTERNATIONAL ISSUES

11.1 Trade

The traditional barriers to the international trade in structural wood and composite products are being lowered daily through the international acceptance of performance based standards. However the large expense ($1000,000) and time (one year) required to evaluate the performance characteristics in detail of sawn timber of a single species is still an obstacle. Currently there is an urgency to develop stochastic models of timber properties to reduce the testing required (Leicester *et al*, 1996). The ideal model would be one wherein some single procedure, such as counting the average number of knots per piece of lumber, would be all the additional measurements required to translate a set of structural properties measured by one country to that as measured by another country.

A second difficulty to be overcome involves the international recognition of national assessment, auditing and certification bodies for structural quality. Within Australia, the NATA and JAS-ANZ organisations have established useful international linkages for this purpose. Thus for example, timber assessed and quality control audited within Australia by an organisation approved by JAS–ANZ would be automatically accepted in another country such as Japan or Canada.

11.2 Collaborative Research

The high cost of research and the generic nature of the information has encouraged the formation of large collaborative research networks. For example, within Europe a collaborative project on timber mechanics, titled 'COST–508', involves 77 research institutes from 17 European countries; the cost of the 5 year project has been estimated to be about US$30 m. Another large collaboration has involved Andean Pact countries in South America (Arbaiza, 1986); this project on wood technology involves 5 countries, 11 laboratories and 200 technicians.

Within the Australasian region there are standards being developed jointly between Australia and New Zealand. Also there are workshops in progress to harmonise the standards of APEC countries.

11.3 Environment

Undoubtedly one of the fastest growing areas of international interest in the timber engineering field is the interaction between building design and the environment. This may relate either to the impact on the environment by a building (e.g. Guymer and Bailey 1994) or the environmental impact due to the use of timber in building (Buchanan 1990, Bowyer 1990).

12 CONCLUSIONS

The international application of timber for structural purposes is growing increasingly sophisticated. Because of globalisation effects, any utilisation of lesser used species must take into account these trends. In particular, the structural quality of timber must be valued. This is a difficult issue with the lesser used species, both because of lack of experience with these timbers and also because of the difficulties of dealing with multiple species. Some suggestions are given within the discussions of this review paper.

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CONTENTS

RESEARCH FRAMEWORK TO INCREASE UTILIZATION OF LESSER-USED-SPECIES (LUS)

Dr. EMMANUEL D. BELLO, Philippines

ABSTRACT

The Philippines, like other tropical countries is endowed with rich forest resources, among which are some of the most valuable forests in the world. In these forests grow more than 3,000 timber species, but only a hundred or so are considered commercial and get into the international and domestic markets. With the growing world-wide demand for wood, many developing countries are disposing their premium species, which also have tremendous potential as raw materials for industrial utilization.

It is the general consensus of international experts in forestry and forest products utilization that the key to increase the utilization of the LUS is to have a sound knowledge of their location, quantities, size form and distribution, as well as of their properties and the relation of these properties to relevant specific end-use requirements. In other words, a research program geared solely towards the optimal utilization and application of as many species as possible should be carried. Such research program, however, should be carefully planned and rationalized in order to get practical results with the least possible time, effort and money. Studies for this purpose should be tailored to potential use or uses of specific species or group of species. In this regard, a four-step approach to the solution of the problem maybe considered by those concerned with forest product research.

Step 1 is to make a survey of the resource to identify those species which really qualify for commercial consideration. This survey should generate the information as to what species are adequate in size and form, and occur in sufficient quantity and concentration.

Step 2 is to choose the species for investigation those that justify economic exploitation. The decision should be based on the information gathered in Step 1.

Step 3 is to make screen tests or preliminary studies on some gross anatomical and physical features and properties to get an indication of the probable end use of a particular species.

Step 4 is to conduct a more detailed study on technological properties relevant to the indicated use, as these may weigh far more heavily than some basic and fundamental properties.

RESEARCH FRAMEWORK TO INCREASE UTILIZATION OF LESSER-USED-SPECIES (LUS)[1]

Dr. EMMANUEL D. BELLO[2], Philippines

Tropical countries like the Philippines are endowed with rich forest resources, among which are some of the most valuable tropical forests in the world. These forests yield almost unlimited benefits to the people. For example, the Philippines earned in 1997 a total of about 480 million US dollars from the exportation of wood and non-wood forest products. The government also collected more than 5.0 million dollars in terms of forestry charges. In addition to these, the 786 large manufacturing establishments of wood and wood products provided employment to 63,174 individuals (FMB, 1997). This is aside the hundreds of thousands working in small to medium sized wood shops scattered all over the country.

From a survey conducted by the Forest Research Institute (now Ecosystem Research and Development Bureau) in 1988, Rojo estimated that "taken together, the total volume of standing timbers in the productive forests (i.e both dipterocarp and pine) is 744.1 million cubic meters. Out of this total, 187.7 cubic meters which come from the unidentified "others" or 25 percent of the total volume could represent the CLAS " or LUS (Rojo, 1990). Of the more than 3,000 listed timber species in the Philippine forests, only 130 are considered commercial timber species composed of 47 dipterocarp and 83 non-dipterocarp species. The rest are sonsidered LUS (Rojo, 1990)

From the foregoing statistics, it is clear that insofar as the Philippines is concerned, our tropical hardwood species that get into the international and domestic markets represent only a very small percentage of the total number of species growing in our forests. The same or similar situation may also prevail in other tropical countries. With the growing world-wide demand for wood, many developing countries are, therefore, disposing their "premium" species to the developed countries, while ignoring or even destroying their non-commercial or lesser-used species which also have tremendous potential as raw materials for industrial utilization. This of course has the detrimental effect of imposing an excessive drain or over exploitation of the prime forest resources, while other parts of the resource, which may also have suitable specific uses, are being neglected.

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[1] *Paper presented during the International Workshop on "Introducing Myanmar Lesser-Used-Species to the World Market". Yangon, Myanmar, 29-30 March 2000.*

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Concerned with this detrimental practice in developing countries of concentrating exploitation of only a relatively limited number of tropical hardwood species, a survey of the knowledge regarding properties of secondary species of tropical woods was undertaken in 1977 under a Participating Agency Service Agreement (PASA) between the US Agency for international Development (USAID) and the US Forest Service. The survey aimed (1) "to clarify whether lack of knowledge of the potential uses of secondary woods is a significant inhibitor of secondary species utilization or whether there are other overriding factors, or whether there is a mix of factors" , (2) "to identify the necessary principles and steps to translate better knowledge of wood properties into commercial activity, both in the developed and developing world as an export", and (3) "to produce design parameters for any subsequent research activity in this area and define the potential benefits of such research" (Littlewood and Schweitzer, 1972).

In a report on his trip to the Philippines, Freas mentioned that there are several factors, which tend to inhibit a more extensive utilization of lesser-used species of timber. Among these are: (1) "the existence of an exceedingly large number of lesser-used species with different and widely varying properties and characteristics", (2) "lack of botanical information to permit their identification in the forest", (3) "lack of specific information as to their abundance and dispersion", (4) "inadequate knowledge of their location, quantities and size distribution", (5) "reluctance o the part of the industry to disrupt their procedure to accommodate species other than those few they are processing", (6) "incomplete information on the properties and technology for use of the lesser-used species". (Freas, 1973).

In order, therefore, to increase the utilization of lesser-used species, with the concomitant effect of broadening the use of the forest resource and reducing pressure on exploiting only high grade premium wood species, Freas recommended the undertaking of additional research in two broad areas. One is concerned with improvement in inventory to make a reliable compilation of these species, which occur in sufficient quantity, size and location to have potential for utilization. The other is concerned with a program of research on the technical and technological characteristics needed for the industrial utilization of these species with good potential.

It is interesting to note that the same observations and recommendations have been echoed during the International Meeting on Properties, Uses and Marketing of Tropical Timber held in Germany in 1973 (FAO, 1973) and during the International Symposium on Research and Marketing of Southeast Asian Timber Products held in the Philippines in 1974 (Anon. 1974).

It is therefore the general consensus of international experts in forestry and forest products utilization that the key to the assessment of the potential utilization of the vast number of lesser-used species is to have a sound knowledge of their properties and the relation of these properties to relevant and specific end-use requirements. In other words, a program of research geared solely towards the optimal utilization and application of as many species as possible should be carried out.

Such as a research program, however, should be carefully planned and rationalized in order to get practical results with the least possible time, effort and money. The impulse to conduct the whole spectrum of anatomical, chemical, physical and mechanical properties of each species should be suppressed. Investigations for this purpose should rather be tailored to potential use or uses of specific species or group of species. The relevant question to be asked is "what optimal use or uses can be made of this lesser-used species" rather than "what species of wood can be utilized for this or that specific purpose". In this regard, insofar as promoting fuller utilization of lesser-used species is concerned, a four-step approach to the solution of the problem maybe considered by those concerned with forestry and forest products research.

Step 1 is to make a survey and inventory of the resource to identify those species which really qualify for commercial consideration. This survey should generate the information as to what species are adequate in size and form, and occur in sufficient quantity and concentration.

Step 2 is to choose the species for investigation those that justify economic exploitation. The decision should be based on the information gathered in Step 1. It has to be emphasized at this point that the uses of tropical timber can be roughly classified into four broad categories, namely:

a) those for reconstituted wood products like paper, fiberboard, oriented strand board, or particleboard,
b) those for manufacture of solid wood products (round and sawn lumber) either for heavy and general construction like posts and piles, fences, railroad ties, trusses, girders, etc, or for utility and decorative purposes like solid parts of furniture, paneling, floorings, car-decking, cabinet work, etc.
c) those for the manufacture of veneer which could either be rotary cut cores, backs and faces, or for sliced decorative materials, and
d) those for special purposes, either in solid or glued-laminated form such as for musical instruments, picker sticks, shuttles, gumstocks, tool handles, athletic equipment, etc.

Each of these uses requires a different grade, quality, form and size, quantity, availability and concentration. For example, the raw material requirements for veneer and plywood manufacture are more exacting with regards to straightness of bole, log diameter, freedom from eccentricity and absence of knots, brash center or heart rot than those for saw logs. On the other hand, the raw material requirements for reconstituted wood products are less stringent than for sawn wood products.

Although there maybe overlaps in raw material requirements such that distinction between use categories are somewhat blurred, the resource should be geared towards the use that gives the highest percentage recovery, or maximum revenue, or both. As an illustration, logs for the manufacture of fancy veneer may also be sawn into lumber for panelling or for furniture parts but fancy veneer commands a premium price and the percentage recovery may be higher. Similarly, sawlogs could be chipped for the manufacture of fiberboard or particleboard but lumber commands higher price than woodchips.

Step 3 is to make screen tests or preliminary studies on some gross anatomical and physical features and properties to get an indication of the probable end-uses of a particular species. These screen tests should be simple and can be carried out rapidly on a random sample of only few trees, without requiring the use of sophisticate equipment or instruments.

It has been shown by Gottwald (1974) that there are close relationships between specific gross anatomical features and specific technical properties. It should then be possible to obtain important information on the probable use or uses of a particular species by means of an optical analysis of its wood structure, heartwood substances and other anatomical features. For example, extremely thick cellwalls and high cilica content, which are characteristic features of some species and not site-related biological aberrations, indicate extreme hardness and would cause rapid dulling and excessive blunting of cutting edges. Species possessing such characteristics are, therefore, not suitable for sawmilling, chipping or veneering. They could be used excellently in round form for marine pilings, and foundations for piers and bridges because of their high resistance to marine borers.

Another good example of a technologically relevant feature is the presence of filled gum or resin ducts, typical of some hardwood species. Gum exudation adversely affects the gluing process resulting in the formation of weak bonds. Since these exudations flow from gum ducts at elevated temperatures, species with these features may not be suitable for the manufacture of plywood and other glued wood products which are pressed at high temperatures.

Other examples of technological property-anatomical feature relationships given by Gottwald (1974) are between homogeneity of wood structure and abrasion resistance and the effect of presence of tyloses or other heartwood infiltration on treatability and seasoning. There are many more relationships between structural features of wood that could be easily determined by simple optical tests and sharply defined technological properties, which could be interpreted to predict logical and probable use or uses.

There are also two important properties of wood, which are easily determinable without the use of sophisticated equipment. These two properties, namely: specific gravity and shrinkage perpendicular to the grain are highly correlated with many other technical and technological properties. Specific gravity is a measure of the amount of wood substance per unit volume of wood, so that it provides certain indications on some other properties such as weight, elastic and strength properties, thermal conductivity, hardness, abrasion resistance, nail-holding capacity, etc. It is also closely related to some technological characteristics like ease or difficulty of drying, treatability with preservatives, pulp yield, and machinabiligy. A knowledge of the specific gravity of a certain species of wood could, therefore, readily allow some conclusions with regards to its possible uses. For example, high specific gravity woods would be ideal for heavy construction, industrial flooring, and railway ties, while medium specific gravity woods could be suitably used for furniture-making, parquet flooring and for veneer and plywood manufacture.

The amounts of and difference in the shrinkage that occurs in the radial and tangential directions as wood dries below the fibers saturation point are indications of its behavior during drying, its susceptibility to the occurrence of seasoning defects like checking, warping and collapse, and its stability in service. Woods with moderate or low shrinkage values are desirable in the manufacture of musical instruments, furniture, floorings, panellings, cabinets and casegoods, and other end-uses in which dimensional stability is a basic requirement. A knowledge, therefore, of specific gravity and shrinkage of a particular species could give some useful information on its possible applications.

Step 4 the last step in the proposed research scheme, is to conduct a more detailed study on technological properties relevant to the indicated end use as these may weigh far more heavily than some basic and fundamental properties. It may be more important to know that the wood could be seasoned to the required moisture content level without developing defects, is amenable to treatment with preservatives, is compatible with paints and other protective or decorative finishes, or could be machined without excessive dulling of cutting tools. (Noack and Schwab, 1974).

Investigations on technological properties should be based on the most probable uses indicated by a combination of the anatomical and physical properties resulting from an analysis of the orientation data determined in the screen tests (Step 3). They could be designed and selected to give the necessary information that have direct relevance to industrial processing for the end-use category that has come into focus.

For example, if in the basis of preliminary tests on its anatomical structure and specific gravity, a particular species appears to be suitable for veneer production, then further tests on venneer cutting, drying and gluing characteristics shall be conducted as these technological properties are of primary importance in veneer and plywood manufacture. There is no point in exhaustively studying other technological properties as chipping and pulping, spike-holding capacity, sawmilling, kiln drying, planing and others, not relevant to the predominant use intended. If the specific end-use of the plywood if outdoor purposes then studies on durability, treatability and paintability maybe of interest later, etc, become no longer necessary.

It could be mentioned at this point that even without going through "Step 4" that is conducting relevant technological studies in the laboratory. The industry itself may step in and conduct these studies in commercial processing conditions. This is possible only, however, if the industry is convinced that the species under consideration has actual economic potential for industrial utilization with regard to the probable end-use determined in Steps 3 and 4.

In conclusion, I believe that if the herein-proposed multi-step scheme of investigation on the utilization of lesser-used-species is followed, it can go a long way in promoting their commercial acceptance with the least possible expense in money, effort and time. Time maybe the most important, considering that the supply of prime tropical timber species is shrinking very rapidly.

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Technical Session 3

Contents

The Establishment of the Database of Tropical Industrial Lesser Used Wood Species

1. Introduction

The establishment of a database of tropical lesser-used wood species is carried out mostly based in previous information available in tropical wood producer and consumer countries; thus, an international and multi-institutional effort is being done.

For the development of this project, a close cooperation with the laboratory of Biomaterial Physics of Nagoya University, and additional institutions (CTFT, OFI), which should be contacted through ITTO, in order to improve the scope of the database.

We will include some additional data which could lead to a better promotion of the wood species described, especially regarding the occurrence and importance of the residual growth stresses, variation of the density along the stem, log sizes, supply possibilities and others. The information available is usually based on clear cut lumber with few references to the supply possibilities or some relevant tree features, with the additions proposed we expect to make a more realistic approach in order to improve the knowledge and use of the lesser used species. As an example we could mention the teak case, where strong residual growth stresses exist girdling has to be done two years in advance in order to prevent severe cracks after logging.

2. Institutional Frame

The main participant institution is the Nagoya University Furukawa Museum. The Furukawa Museum was established in 1982 as a result of a private and institutional joint effort. It has been in full activity since 1990 keeping wood collections and others, and publishing diverse scientific reports. The Laboratory of Biomaterial Physics (former Laboratory of Wood Physics) of Nagoya University has been involved in basic and applied research related to tropical wood species. The staff members have experience in tropical woods with several publications on Southeast Asian, African and Latin-American woods.

The Aichi Institute of Technology, Information Network Engineering Division, will assist with its staff and facilities for the development of this project.

3. Contents

The aim of the database to be provided is to present the information oriented to the final user. Data regarding the characteristics of the logs like the shape of the stem, the occurrence of growth stresses, the variation of the density along the stem and others which could be important for wood processing will be noted. An explanation of these features will also be included.

Likewise, we will include some general anatomical information in order to allow a preliminary identification of lesser-used species as well as anatomical sketches to ease the identification process. Regarding the anatomical information, the aim is to allow the user to make a general identification of a wood sample by using a magnifying glass or the naked eye. Another important feature to be covered is the market information regarding the wood species included in the database and data about main trading ports and related information. Since small volumes and small log sizes are usually found in case of lesser-used species, an effort has to be made to do a suitable assessment of potential end uses, thus grouping is needed. For this purpose, systems like a modified version of the Principal Components Analysis, developed by CTFT, or end-use requirements methods could be used.

THE ESTABLISHMENT OF THE DATABASE OF TROPICAL INDUSTRIAL LESSER USED WOOD SPECIES

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Japan

1. FOREWORD

There is an old FAO report prepared by M. Chudnoff and R.L. Youngs from the Forest Products Laboratory of the U.S. Forest Service. In their report they mentioned some of the difficulties regarding the use of tropical woods, which despite the time are still valid.

If we compare the forest resources in both temperate and tropical forests we find that they have a rich arboreal flora, but in the Temperate Zone a few species make up the bulk of the growing stock as well as the harvest. Thus high volumes of merchantable timber can be removed from comparatively small land areas. In much of the tropics, harvest has also concentrated on a few species, but with the extraction of only small volumes considered suitable for local and foreign markets. Often, 90% of the forest volume has a mix of hundreds of species that are considered non-usable. To further complicate this poor resource utilization, no silvicultural systems that are economically attractive are available to sustain supplies of most current species of choice.

On the other hand, since the beginning of this century, evaluations have been made of the physical, mechanical, chemical, and anatomical properties of thousands of timbers species by species. Most of them are tropical. Though, there appears to be a little relationship between the technical information gained and the marketability of a species or species group. Whether or not testing procedures are standardized may be irrelevant.

Another important issue is the variability of the demand. The high-demand merchantable species harvested in tropical America, West Africa, and Southeast Asia show a remarkable range of properties: From attractive figure to bland, high to low strength, highly durable to perishable, good to poor machinability, easy-to-dry to difficult-to-dry, etc. The main features common to all preferred species are large log sizes and frequent occurrence in the forest. For marketability, tree size and abundance are more critical than the technological properties of the wood.

There are some trials to overcome these difficulties in order to find suitable end-uses, like the timber grouping according to similar characteristics and the like.

Additionally, technological development that makes the raw resource more homogeneous, as pulping for example, minimizes or even erases the restrictions, once thought inescapable, of forest heterogeneity. Nevertheless, such technological developments often require large capital inputs.

2. EVALUATION OF TIMBER QUALITY

2.1 Aim of the Evaluation of the Technology Properties (10) No effect.

In case of the tropical hardwoods, the aims of the evaluation include both allotting known timbers for suitable applications and the utilization development of unknown or non-utilized timber. There are many known species that can be found in large volumes, but there is no marketability for those species that can not be obtained in the same amounts. The grouping of species can be made according to the requirements for end-use or properties and wood quality, in order to overcome the supply shortages.

There is less number of unknown and not utilized species in the Temperate Zone. However, there are high and low quality timbers within the same species and there are differences in quality between natural and planted trees. It is necessary to organize this matter.

For example, in the Japanese system the basic stress properties, based on small size samples, of red pine are larger than that of cypress or cedar. However, the quality and strength ratio of the red pine according to the results of tests on actual size samples is low because of the existence of defects. Therefore, the actual allowable stress (working stress) is as follows:

RED PINE > CYPRESS> CEDAR

It is important to feed back to forestry. For instance, planted trees, such as eucalyptus, acacia, or pine, are usually used as pulp timber, but there is a big interest to sell these species at higher prices. A close reference should be kept with breeding, tending methods, cultural operations, or the working circle in order to cope with the demand. The subjects of the material quality evaluation are:

RED PINE < CYPRESS ≤ CEDAR

- The performance (properties) of single or grouped species
- The performance within the species or group
- The performance of any species

2.2 The Method of Assessment Based on Material Quality Evaluation

The end-uses of timber can be classified into several items, such as plywood, structural elements, or furniture, and the required properties for each end-use can also be classified in such a way. According to this method, the required properties level for a determined end-use is expressed in a numerical way and the best fitted species are selected among those which satisfy the required properties.

Another important factor is the grouping of timbers. The grouping criteria should be based on color and specific gravity. Later, after comparing with known species, a suggestion on possible end-uses can be made.

In finding timber suitable for a specific end-use, several systems have been proposed, like the one by D. Noack and E. Schwab in Germany. The following table showing the necessary (++) and desired (+) property requirements was made available by them:

Range Of Application	Dimensional Stability	Strength	Normal Durability	Perme--ability	Machin--ability	Surface Finishing	Uniformity Of Growth Structure
Particle board					++	++	
Peeled veneer		+			+	++	++
Decorative veneer						++	
Solid wood		+			++	+	++
Covering interior	+				++	+	+
exterior	++		++	or ++			
Construction interior	+	++				+	+
exterior	+	++	++	or ++			
Frame work	++	+	++	or ++	+	+	+
Boat building	++	+	++				
Flooring	++	++	+				
Containers	+	++	+	or +			
Sporting goods	+	++				+	++
Harbor works		++	++	or ++			
Sleepers		++	++	or ++			
Musical instruments	+	+			+	++	++

Or another system proposed by Y. Suzuki for the Japanese market.

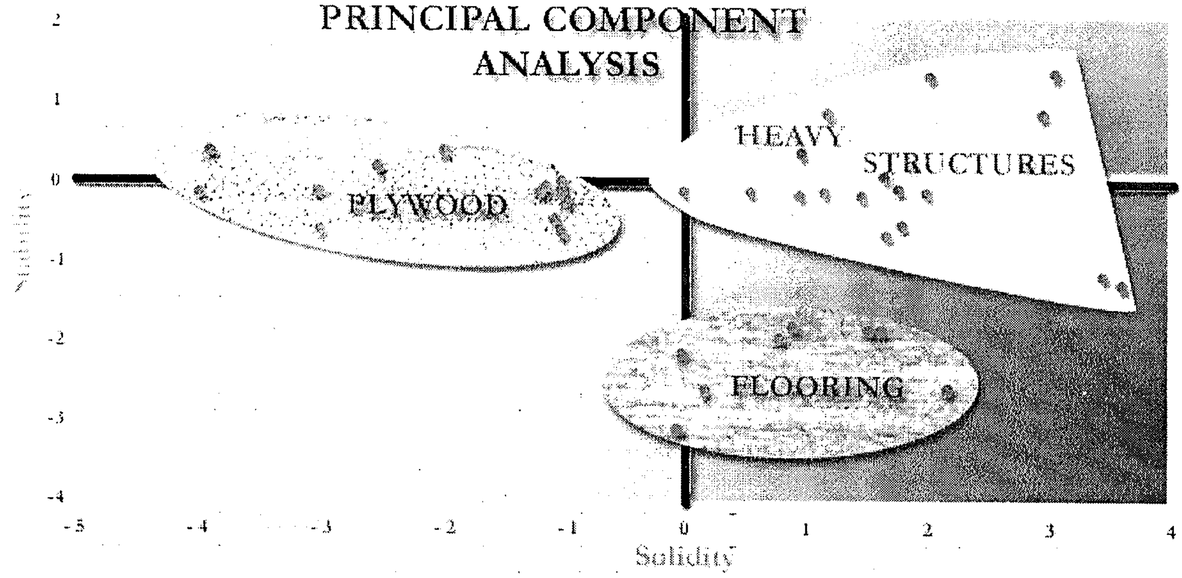
First processing	Uses code	Application range	Oven dry specific gravity	Bending strength ton/cm2	Natural durability	Appear ance	Machin ability	Stock	Example of usage	Round wood price level
Sawn wood	1	Construction exterior	>0.6	>0.8	I-II				Bridges, Crossties	III
	2	Heavy construction	>0.6	>0.8	I-II				Beams, Cross beams	III
	3	Light construction	>0.5	>0.8	I-II		O-X		Pillars, Foundations	III
	4	Construction, boards	<0.6	>0.6	I-IV				Sheathing	V
	5	Fittings	>0.4			I-II	O-X		Flooring, Steps	II-III
	6	Decks, truck bodies	>0.6	>0.8	I-II		O-X	I-II	Truck bodies, Pallets	III-IV
	7	Packing, containers	<0.7	>0.6	I-II		O-X	I-II	Containers, Packing	IV

	8	Furniture, joinery				I-II	O-X			II-III
	9	Cores	<0.5				O-X			V
Veneer	10	Plywood, construction	>0.5	>0.8	I-II		O-X	I-II	Shuttering boards	III-IV
	11	Plywood	>0.3			I-II	O-X	I-II		II-IV
	12	Veneer, cores					O-X			IV-V
	13	Decorative veneer				I	O-X		Sliced veneer	I-II

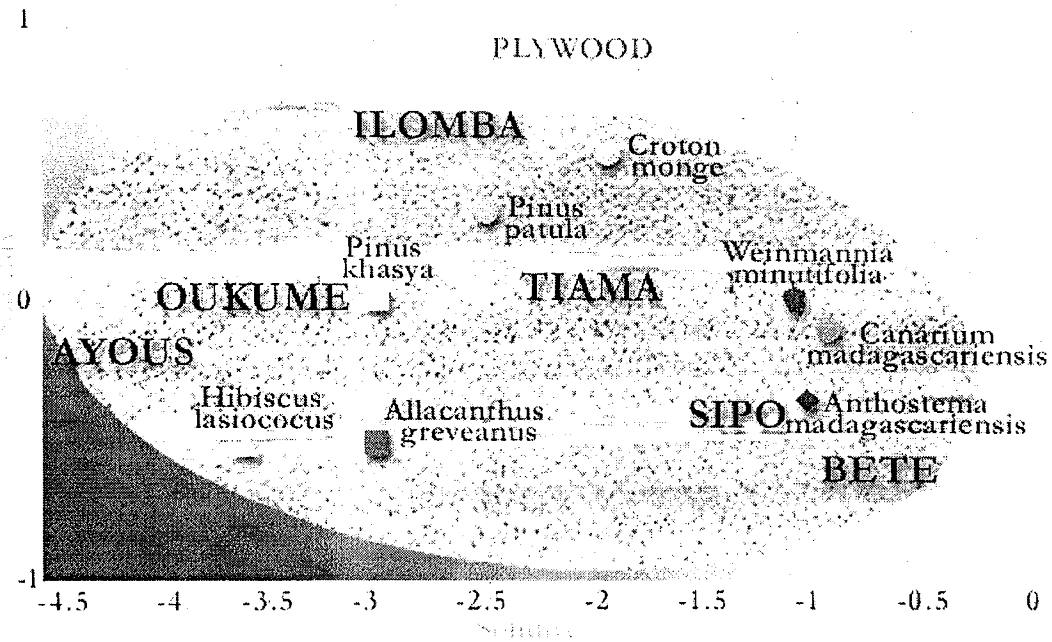
- Natural durability: I Large, V small
- Appearance: I Excellent, III Fair
- Machinability: 0 Easy, X Difficult, XX Very difficult
- Stock: I Abundant, IV Rare
- Round wood price level: I Expensive, V Low-priced

2.3 Principal Component Analysis

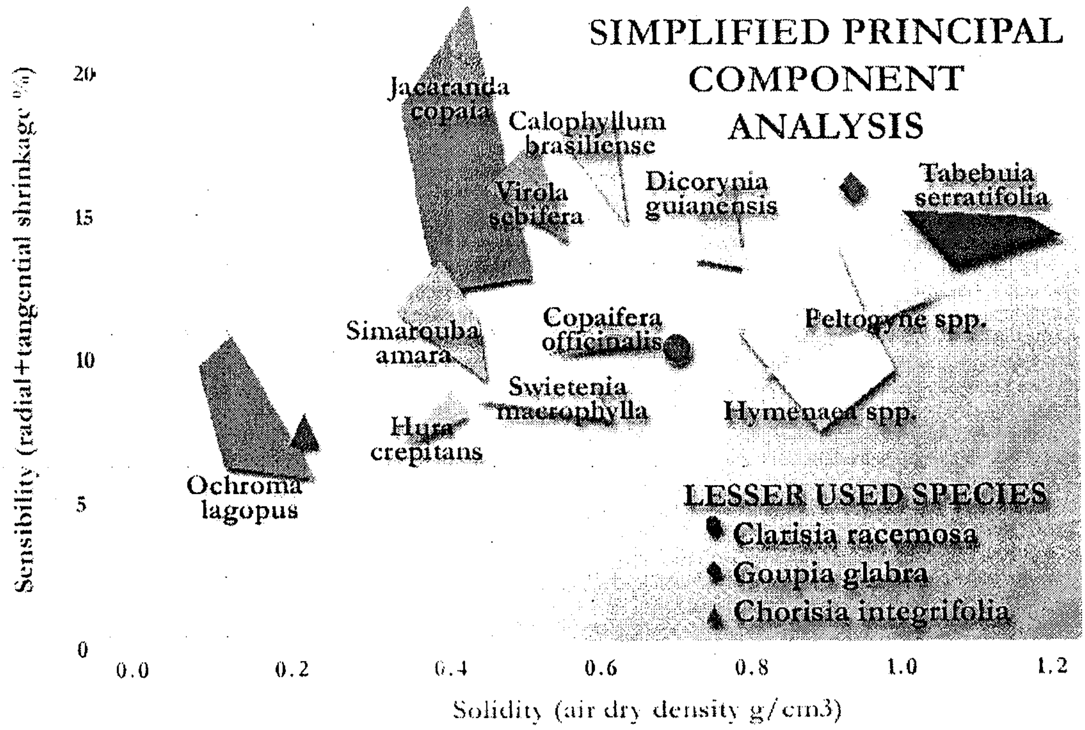
The principal component analysis, developed by P. Gueneau and F. Cailliez in France, uses several characteristics of wood to express its properties in a numerical way. The primary factor or principal component to define the technological properties of timber is the specific gravity, which has very high correlation with the strength and other properties of wood. The secondary factor is water absorption, the amount of extractives and color are considered tertiary factors. The characteristics of wood are measured and a graphic representation is possible, considering two basic axis, one for solidity and another for stability:



The case of plywood as a final use is displayed. In the following graphic some African lesser-known species are compared to commercial ones, displayed as colored dots.



An index of technological properties of wood should consider those characteristics that can be easily observed and measured. The repetition can be avoided by excluding from the results the properties with high correlation, which is the system proposed by Y. Kikata to assess the possible end-uses of lesser-used timber species:



3. LESSER USED SPECIES (LUS)

The tropical forests are characterized by their enormous diversity, with many different species per superficial unit and relatively small volumes, if compared to temperate forests. In many cases few species of the wide variety available are used for the timber market, and many of the rest can be considered as lesser-used species (LUS). Timbers considered as LUS are those that show promising market possibilities but are not used on a wide commercial level. Several factors determine this situation, among them lack of enough technical and market information. With the aim to increase the number of species used in the tropical timber market the establishment of a database of tropical lesser-used wood species was proposed. For the data to be included in this database mostly previous information available in tropical wood producer and consumer countries will be used; thus an international and multi-institutional effort will be done.

The development of the database is carried out in close cooperation with the laboratory of Biomaterial Physics of Nagoya University in Japan, the activities of the project started on May 1999.

The information to be included will lead to a better promotion of the tropical wood species and some particular characteristics will be included, like the occurrence and importance of the residual growth stresses, variation of the density along the stem, log sizes, supply possibilities and others. The technical information available up to date is usually related to technological facts, with few references to the supply possibilities or some relevant tree features. With the additions to be made, it is expected to make a more realistic approach in order to improve the knowledge and use of the lesser-used species.

3.1 Overcoming Wood defects

The shape of the standing tree and the growth stresses, are important items to express the fundamental technological properties of timber.

Additionally, it is necessary to consider other characteristics like brittle heart, mature (or juvenile) wood, heartwood, uniformity of growth structure, reaction wood or fiber length, if the species is a planted tree. These factors can be used as an index of the technological properties for the engineered wood products.

In a broad sense, the following criteria are taken into account when selecting a wood species:

- There should not be big qualitative differences between the outer part
- of the stem or mature wood, and the inner part or juvenile wood.
- Medium density species are preferred.
- The species should have an attractive color or grain.

Nevertheless, in some cases these apparent restrictions are overcome like in the case of heart rot (**mangium**), blue stain (**rubber wood**) or residual growth stresses (**eucalyptus**).

3.2 Heart rot

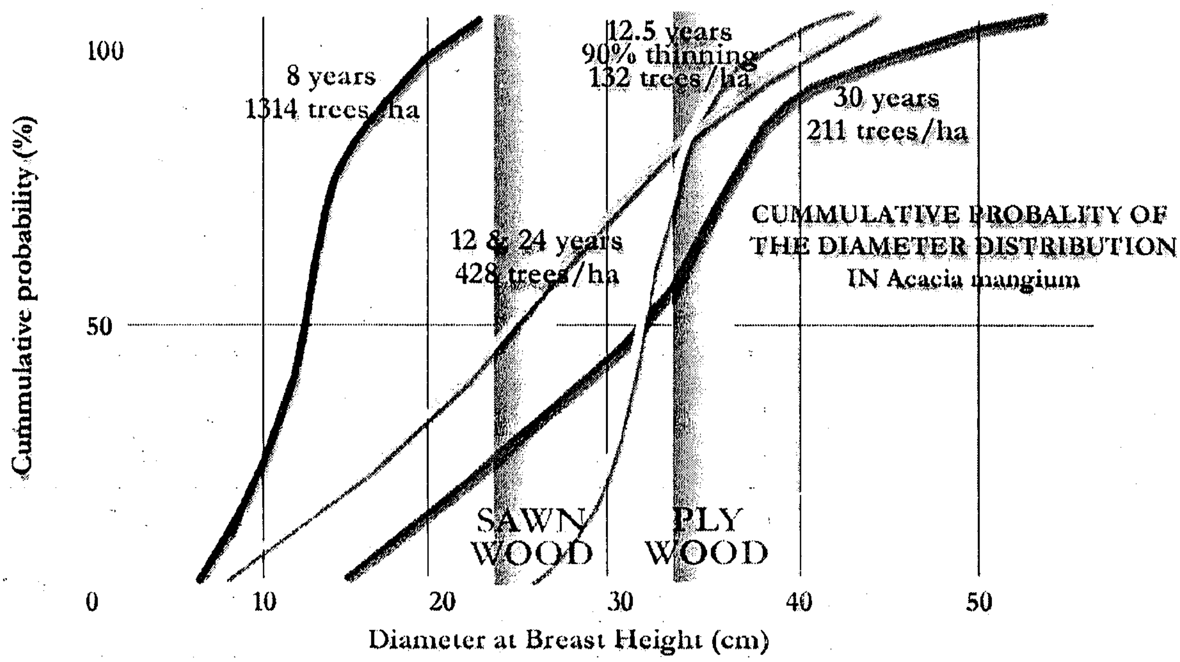
Acacia mangium was studied for several years and field experiments regarding the possible end uses and the silviculture of the species, were carried out in Indonesia and Malaysia (Sabah) in cooperation with JIFPRO. According to the results obtained in these studies it was observed that there are differences in density between the outer and the inner part of the wood stem. For this species a radial portion 5 to 7 centimeters from the pith is conformed by juvenile wood, and in some cases there is heart rot in the stem. Nevertheless, the proportion of juvenile wood was reported to be the same in 13 years old and 30 years old specimens. In Indonesia diseases and pests affected some trees, and heart rot was observed related to the soil conditions. Watery soil seemed to be the main cause for the occurrence of the defects. Heart rot was found to begin from the open wounds on the stem left after pruning. Unclean cutting and high humidity conditions seemed to trigger the infection. Delayed singling is another important factor to be taken into account.

Although heart rot was found in some trees, it can be said that the mangium plantations in Indonesia are free of serious diseases and the wood can be used without any serious restrictions.

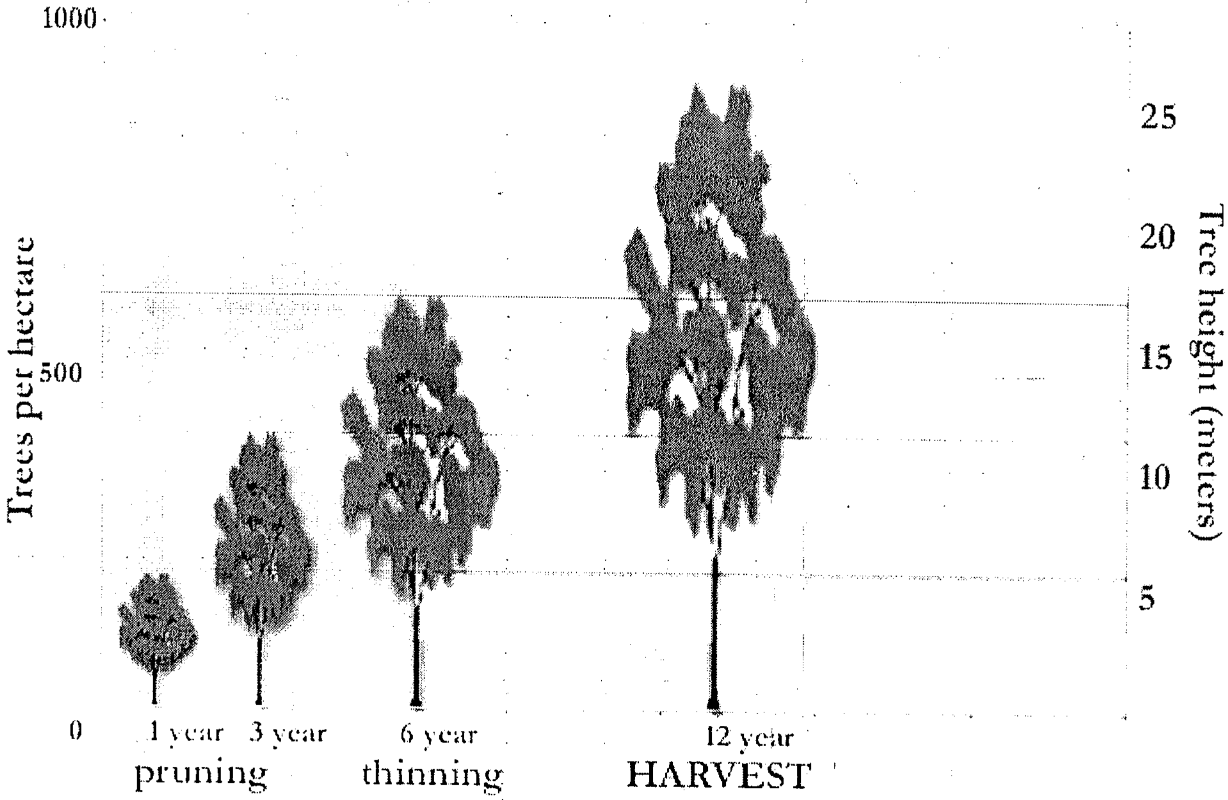
Regarding the solid wood properties, it was found that the natural durability of the timber was the same as Keruing and Kapur, commercially known species. On the other hand, despite the differences in the density distribution, the shrinkage characteristics did not differ excessively. Some slightly interlocked grain was observed, but as for the workability there were no special difficulties, *A. mangium* presents workability characteristics and nail holding similar to any other timber species of the same density. In a general sense, it was concluded that the quality of the outer part of the stem, or the mature wood, is suitable for furniture making.

In the case of plywood, it was observed that the bending strength is good but it did not show good wood failure percent after test. In the case of plywood making, more suitable adhesives should be selected. This species produces a nice surface veneer, but thicker veneer cannot be produced without applying a thermal treatment on the logs. One disadvantage observed regarding the use of *A. mangium* plywood for shuttering boards was the poor setting of cement, because of the high extractives content in the wood.

In the average, two boles up to 2 meters long can be obtained from one stem. Boles over 24 centimeters in DBH can be used for sawing, whereas boles over 34 centimeters in DBH can be used for veneering.



The diameter distribution observed displayed in the previous graphic corresponds to each silvicultural method used. Based on the outcome of the technological and silvicultural research three procedures were proposed for the management of *Acacia mangium* plantations.


1000
500
0
Trees per hectare
Tree height (meters)
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1 year
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12 year
pruning
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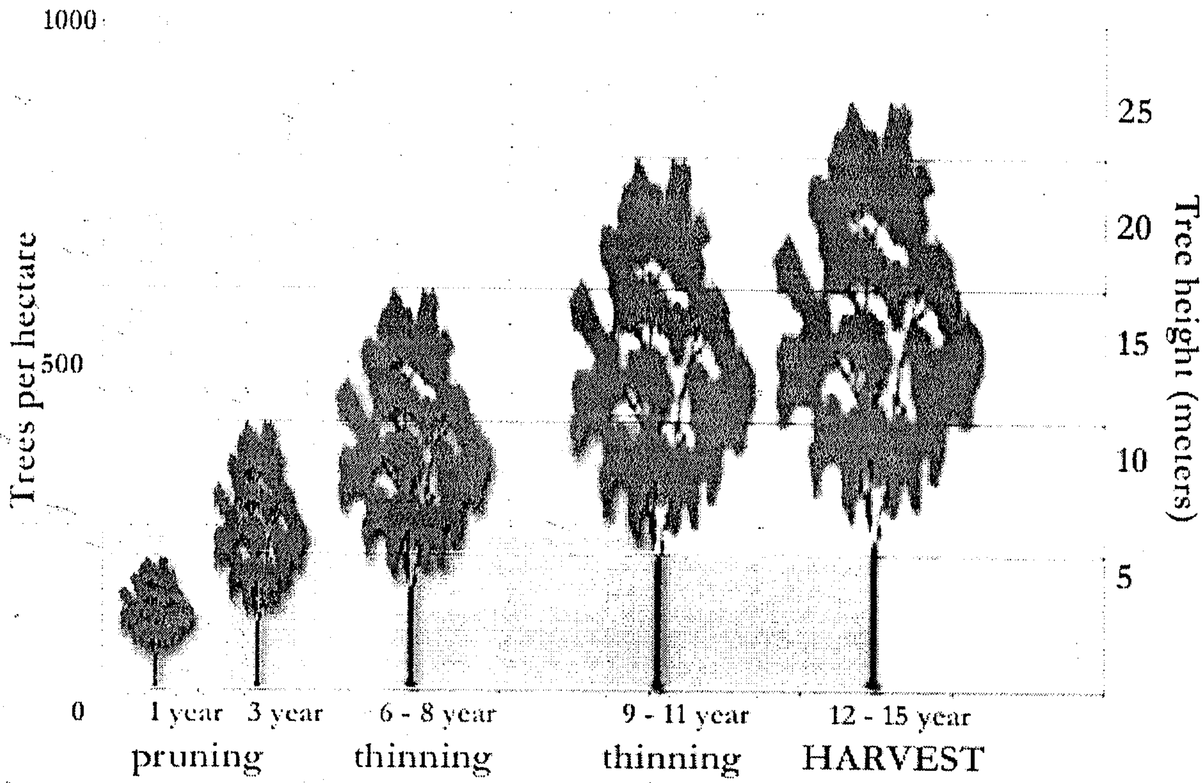
HARVEST


1000
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Trees per hectare
Tree height (meters)
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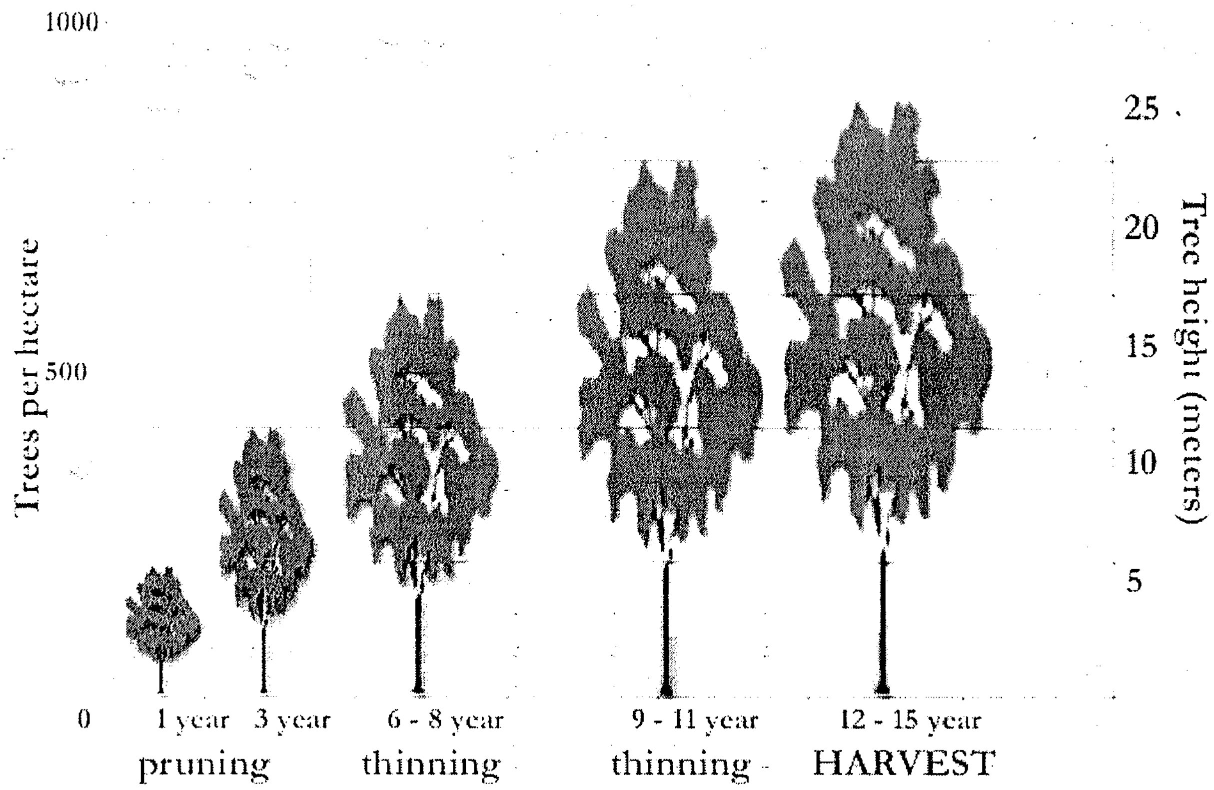
thinning
HARVEST



3.3 Blue Stain

Among the several factors that restrain the use of lesser-known species, a very important group is the one related to the appearance of the surface. The blue stain is a defect that although does not modify the strength properties of wood, definitely reduces the possible end-uses of light colored timbers since the appearance of the final product is affected, lowering its quality.

A very important example of a practical method to control the blue stain in tropical timbers at an industrial level in the case of the rubber wood (*Hevea brasiliensis*).

Originally a well-known source of natural latex, rubber wood has become since the eighties into an important raw material for the wood industry in Japan.

According to the cycle of the rubber wood plantations or due to market reasons, the trees must be replaced generating a big amount of biomass that could turn either into waste or a source of raw material.

Due to the easy attack of the blue stain, this species was not used as a source of timber, despite of having very good properties and woodworking characteristics.

Following the results of a private company research in Malaysian plantations, it was found that the blue stain in rubber wood can be avoided provided that the moisture content of wood is reduced to a level below the fiber saturation point. Thus, reducing the water content needed by the fungi to attack the timber.

In the case of rubber wood, and similarly to many light colored timbers, the incidence of the attack of blue stain fungi can be controlled according to the speed of the processing. The moisture content in wood should be reduced below the fiber saturation point as soon as possible. When not enough drying capacity is available, partial drying should be carried out until reaching safe levels and leaving the final drying for later operations. After drying is performed, the defects of wood can be removed and clear lumber is obtained by the finger joint technique. In such a way, the use of rubber wood without blue stain defects was possible.

The case of rubber wood is a typical example of a good quality raw material with some technical difficulties for processing, since its properties, workability and volumes available has turned this species into an important sustainable source of tropical timber for the international market.

3.4 Growth stresses

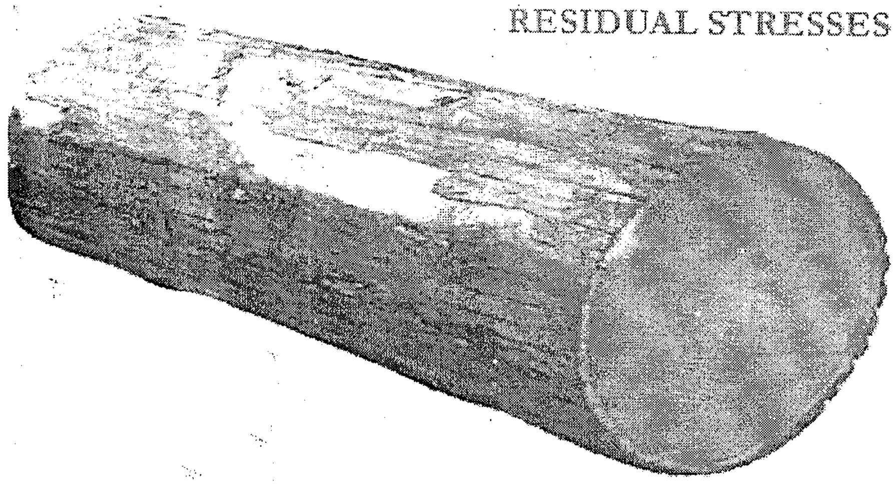
An important adaptation of the trees is the stresses in wood, which are generated and accumulated in the trunk. The residual stresses in wood are unevenly distributed and this misbalance, though important for the tree survival from a mechanical point of view, may cause further problems while processing the wood. The residual growth stresses are, to a great extent, the reason for changes in wood. They cannot be found with the same intensity in all species, but in many cases they may cause cracks, splits and wood warping.

When severe residual stresses remain, the effects are usually more obvious while sawing and drying the wood. At least partially releasing the residual stresses could reduce wood losses, while simultaneously allowing lumber to be processed with increased operation productivity, and other improvements in wood quality.

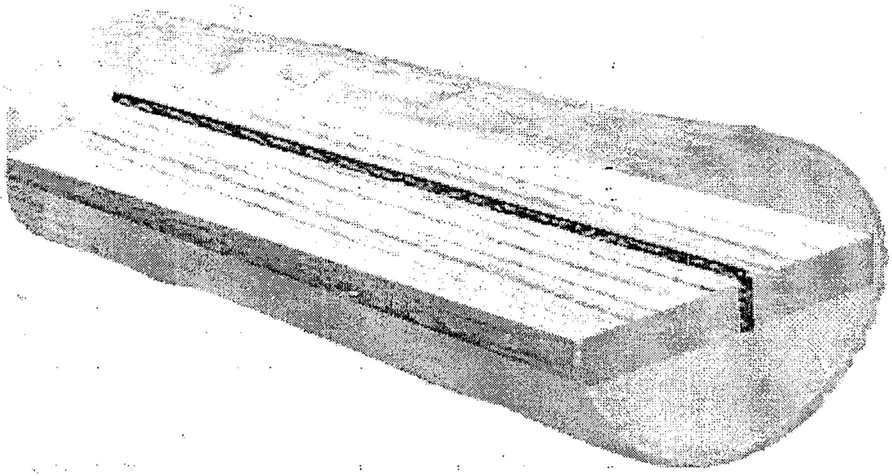
Common Name	Scientific Name	Strain (microStrains)	Young's Modulus (10^3x kg/cm^2)	Residual Stress (kgf/cm^2)
FALCATA	*Paraserianthes falcataria*	*700*	*69*	*48*
MANGIUM	*Acacia mangium*	*700*	*110*	*77*
SUNGKAI	*Peronema canescens*	*1500*	*84*	*126*
TEAK	*Tectona grandis*	*590*	*128*	*76*
EUCALYPTUS	*Eucalyptus spp.*	*764*	*84*	*64*
KEYAKI	*Zelkova serrata*	*889*	*91*	*81*
RED PINE	*Pinus densiflora*	*220*	*85*	*19*

The growing stresses can be evaluated through the released strains. The strained wood indicates that the molecules and aggregates of molecules are at abnormal distances from each other; if these molecules can slip, the stresses could be relaxed without severe modifying of the wood dimensions.

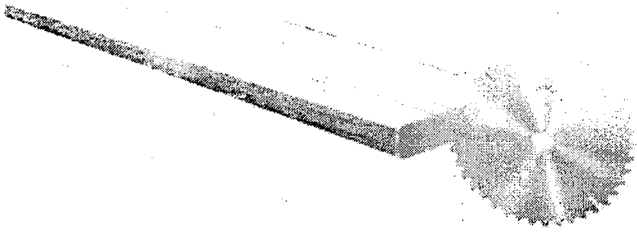
PRACTICAL EVALUATION OF RESIDUAL STRESSES IN LOGS



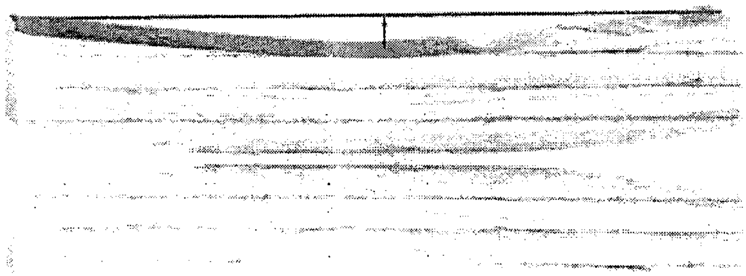
- A radial board must be cut from the log



The distribution pattern of the stresses will depend largely on the species and the growing conditions of the tree.



- The amount of stresses can be estimated from the warping ratio after sawing.

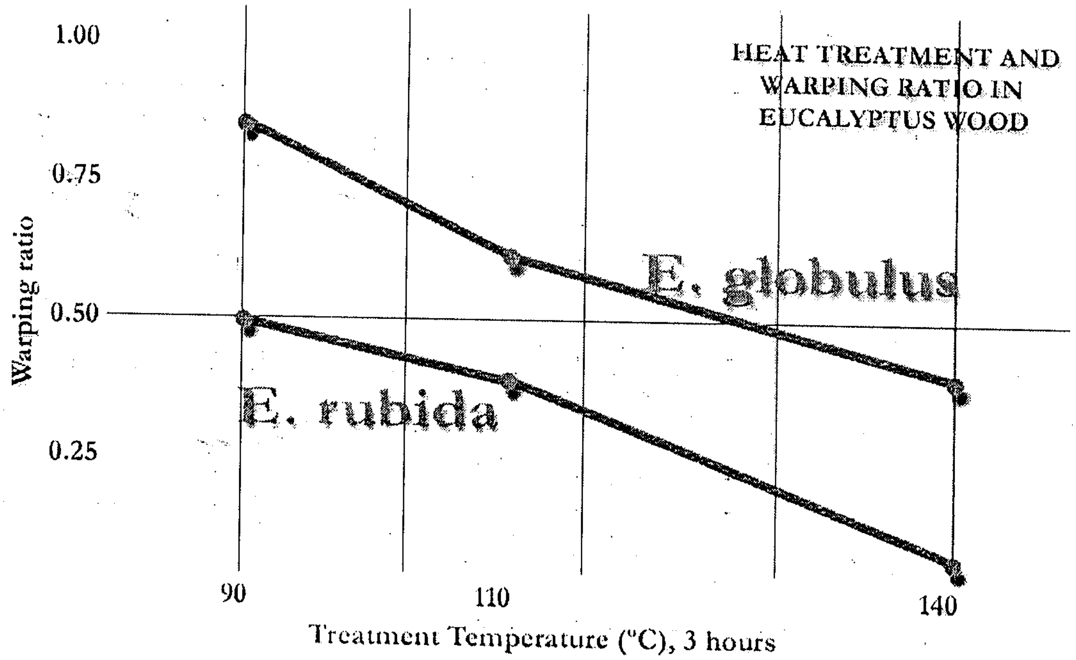


Considering the surface released strains and the elastic constants of wood, a distribution of stresses across the diameter of the log can be estimated. Under normal growing conditions compressive longitudinal growth stresses are expected close to the pith, while tensile stresses occur close to the bark due to the stress piling process in the living tree.

3.5 Relaxation of Stresses

Stresses in wood can be lessened by using different treatments, including water immersion, or by heat treatments like water boiling, smoking or steaming. As one of these measures, the thermal treatment of logs could help to prevent future economical losses while processing the wood.

The stressed wood molecules are at abnormal distances from each other, and they can slip relaxing the stresses while wood dimensions remain the same. Due to the heat treatment in logs the softening of wood occurs, and the intensity of the effect will depend on the conditions used. Under an optimal treatment, the relaxation is expected without damaging the wood quality, though in normal working conditions some adverse effects like cracks or splits may occur.

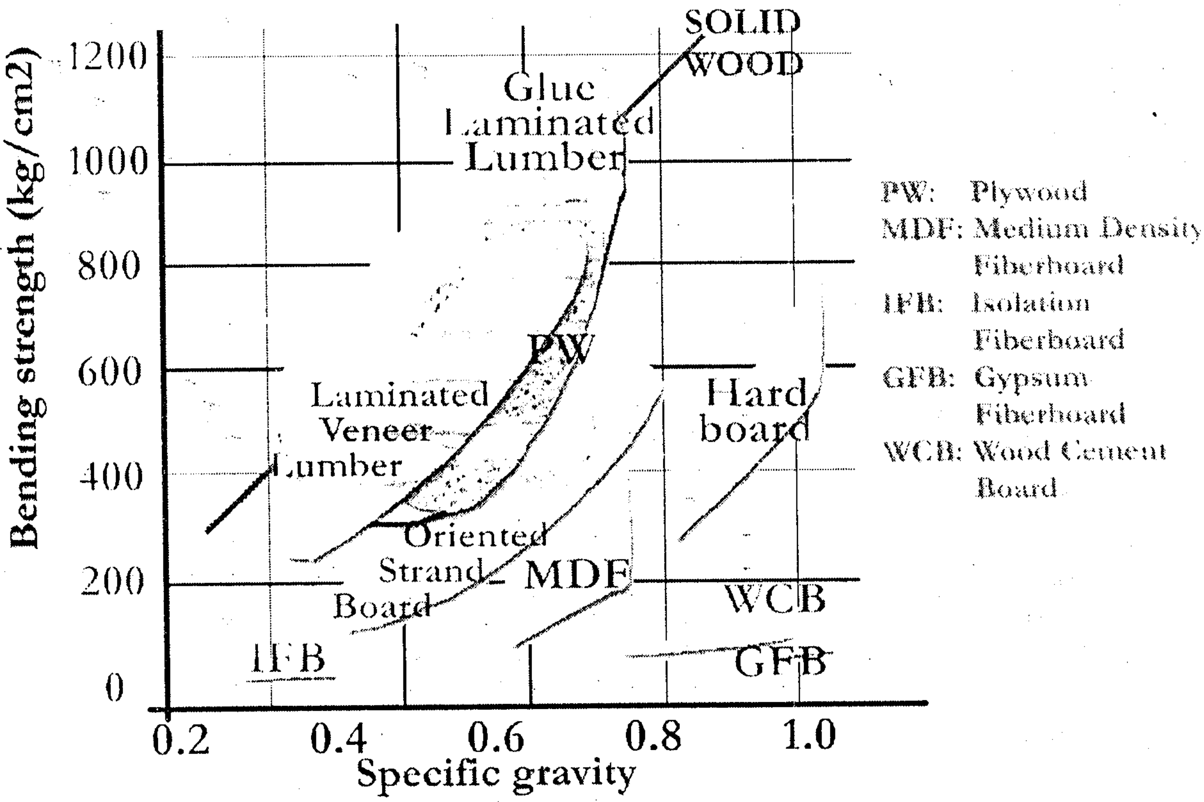


The stress-relaxed wood has no tendency to contract, expand, warp or split. Since heat invigorates molecular motion, it accelerates stress relaxation.

Another method for controlling the end splitting due to residual stresses is the circumferential kerfing method proposed by H. Kubler in Germany. In this method, a kerf around the stem is cut above and under the intended felling cut. A similar method is the girdling method widely used for standing teak trees.

4. WOOD PRODUCTS

Forests cover about 30% of the planet, and the forest products are one of the main commodities in the world trade. The main forest originated products are logs, pulpwood, chips, sawn-wood, pulp and plywood. Wood is still an extremely important source of structural material for construction and other uses. Substitutes have been looked for wood, but it has remained as one of the most important building materials due to its peculiar characteristics, especially if we consider its weight and strength, not to mention the fact that it is the only renewable source of structural construction material. In case of solid wood it is possible to assert that a specific gravity of about 0.6 covers most of the uses, thus timbers of similar density are the target for engineered wood products.



5. CONTACT INFORMATION

Project ITTO PD 58/97 Rev. 1 (I) "The Establishment of the Database of Tropical Lesser Used Wood Species".

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CONTENTS

LESSER-USED TIMBER SPECIES IN CONSTRUCTION

D L Jayanetti
TRADA Technology, UK

1. INTRODUCTION

THE SIGNIFICANCE OF LESSER-USED TIMBER SPECIES FOR CONSTRUCTION

Timber has served throughout history as an invaluable construction material but the potential for its use has never been greater. One special technical merit of timber as a material for construction is that in most developing countries there already exists some basic local infrastructure. There is already a history of pit sawing, chainsaw operators felling timber, sawmillers dealing in primary processing and joinery workshops dealing in secondary processing albeit with rudimentary equipment and techniques but nonetheless yielding valuable components for timber construction. What matters in all these is that there is a useful starting point which could be built upon. There is also some local knowledge on seasoning of timber and treatment of timber components against bio-degradation, even though one could observe gross inefficiencies in this sub-sector.

The merit of timber as a construction material from the economic or financial point of view is based on three principles. In the first place timber can be promoted as a building material if in developing countries the raw material is widely available and an entire structure could be built with minimal dependence on foreign exchange. For most developing countries any building materials technology which could be promoted with local inputs could lead to considerable savings in foreign exchange to the national economy. In the second place, there are proven small-scale and sometimes rudimentary cottage-scale technologies for timber processing. One example of this concept is with regard to roofing technology. Materials such as sawn timber can only be produced using large-scale imported technologies, whereas timber poles, preservative treated against insect and fungal attack by a boron diffusion process, can be produced locally on a small-scale.

The most important factor which predetermines timber as an environmentally friendly material is the fact that it is a renewable building material; other raw materials such as limestone, clay, sand and stone are all exhaustible and indeed there are numerous examples where large-scale cement or fired-clay bricks factories are facing closure due to depletion of proven raw material reserves.

A merit of timber construction which is probably more economic than technical is the time-scale within which a timber construction could be erected when compared with other materials such as concrete or brickwork. This whole concept fits into the potential for mass production of timber components such as bridge and roof trusses, beams and columns, door and window frames. There are examples of countries where labour is simply too costly and where labour on construction sites alone could account for half of the cost of inputs. Under these circumstances, especially where the countries fall into the category of newly industrialised countries, there should be a clear economic advantage in promotion of timber as an industrialised low cost building material.

2. LESSER-USED SPECIES

The term 'lesser-used species' is being used as well as the terms 'lesser-known species', 'commercially less accepted species' and 'secondary species'. From a marketing point of view, to call them 'secondary species' has been found inadvisable, but this is nevertheless a fair description of many of many of them which suffer from some disadvantageous technical property or are not of a sufficiently high occurrence for widespread marketing. The 'lesser-known' tag has the merit of emphasising the fact that all species need to be known both as regards occurrence and technical and decorative properties. This led to calls for more research into technical properties and to a lesser extent for greater species determination during the carrying out of inventories of growing stock. As a result research into technical properties has been going on for several years and some of these research activities were sponsored by international organisations including ITTO. It is however certain that there are many species with useful properties and significant occurrence which are likely to remain lesser used unless special marketing consideration is given to them.

For several reasons, the viability of timber in the context of construction is dependent on lesser-used timber species or plantation species rather than commercially accepted species. It is important to stress that the term lesser-used timber species does not connote inferiority; many lesser-used timber species have as yet not been characterised and may as well be comparable to the commercial species. In fact, the focus of this paper is on those lesser-used timber species which are almost indistinguishable in log size and form to the commercially known species. In many tropical countries the forests are currently being logged for only a few selected species, with many species and grades left unharvested.

If lesser-used species of timber are to be promoted for use in construction, then the secondary processing required to transform logs into structural components will all contribute to employment and skill generation. In addition to secondary processing leading to production of components for prefabricated elements, there will be need for treatment of the raw material. In this regard, the demands for local chemicals and utilisation or repair of basic machinery required for the timber industry should all influence local economic growth. Invariably, any strategic promotion of lesser-used timber species in the construction sector will promote national economic growth.

Some developing countries with relatively viable industrial bases could achieve high economic gains by promoting small-scale processing of chipboards and similar composite industrial products using lesser-used timber species as the principal raw material. Moreover, if developing countries are to slowly shift into an affordable-scale industrialisation in the construction of buildings, then the most viable starting point it seems is the use of timber in construction.

In some developing countries, lesser-used timber species could be promoted for use in construction both for the local market and for export to other developing countries where the raw material base may be inadequate. This strategy would first and foremost require a good local industrial base for secondary processing of lesser-used timber species, based on standardised products and prefabricated components. The advantage with such a strategy is that the exporting countries have the advantage of satisfying domestic needs and at the same time gaining foreign exchange earnings. The viability of this concept is based on three main issues. First of all there a few timber growing developing countries with a relatively advanced local infrastructure for small-scale industrialisation and also potential for processing of primary timber species for export. Secondly, there are some developing countries which are deficient in their resource base for supply of timber and who in the short term could be better off with imports from timber surplus developing countries. Thirdly, timber unlike materials such as concrete blocks and fired-clay bricks has a superior strength to weight ratio as well as value to weight ratio so that transport costs could be tolerable.

3. LESSER-USED TIMBER SPECIES FOR CONSTRUCTION

3.1 Reasons for lesser-used timber species not being used

To a large extent, the reasons why lesser-used timber species are not being used in construction are mainly the same reasons why timber in general is not used as a building material. In most developing countries, the available timber species, which are predominantly the commercial species, are used for roofing, door and window frames or for purely aesthetic functions such as use of plywood for wall and ceiling panelling. The choice for structures has always been a variety of industrially processed materials, notably steel and concrete. Even in circumstances where timber products are abundant on the market in the midst of scarcity or high cost of other materials, the preference has never been timber.

There are obvious social biases against the use of timber. Clients of the construction industry are yet to see timber as a durable and fire-resistant material which incidentally are the most significant factors that could influence the choice of timber. In fact it is likely that most clients of the industry do not know of any of the technical qualities of timber. However, the underlying reason is that the acclaimed qualities of timber have not been demonstrated effectively. The construction industry is easily one of the most conservative sectors and effecting change in practices or acceptability of products is usually a mammoth task; it requires efforts which transcend beyond what is currently offered in promotion of timber for construction. Unfortunately, the bias against use of timber affects the entire spectrum of the construction industry i.e. professionals, contractors, artisans, clients, policy makers and finance institutions.

The lack of regulations, codes of practice and technical manuals in support of timber construction is yet another factor hindering efforts to promote the use of lesser-used timber species in construction. Experience has proved that lack of regulatory procedures precipitates any biases against a specific building material. Worst of all this leads to low quality of products, faulty construction practices and unnecessarily high cost of the end product. Design guidelines and codes of practice, which normally could influence architects, engineers and contractors to opt for the use of timber, are non-existent. There are design manuals and codes of practice from countries in Europe and America but these are usually for coniferous timber species rather than tropical timbers and thus not relevant to the needs of most developing countries.

It is estimated that there are more than five thousand timber species in the tropical forests and the limited knowledge available suggests that fifteen hundred species are suitable for construction purposes. This can be contrasted with industrialised countries where timber has a long tradition as a construction material, yet there are only twenty coniferous timber species in use. There is very little investigational work to characterise and understand the botanical and engineering properties of lesser-used timber species. In a few countries some basic data exists but this covers only a small proportion of the total stock of species and moreover the data is not comprehensive enough to lead to any strategic planning.

The general scenario in most developing countries is whereas there are several proven research findings on production and use of local building materials, there is hardly any mechanism to translate research into viable commercial production. This phenomenon applies to an undue variety of building materials including timber, and most certainly lesser-used timber species. In timber-rich countries such as Cote D'Ivoire, Nigeria and Gabon, so much local research effort is put into forest products and in several instances very innovative findings remain stuck at the research laboratories with no opportunity of ever being implemented. This gap between research findings and actual commercial use of research results is easily one of the most important factors hindering prospects for wide adoption of lesser-used timber species in construction.

3.2 Identification of current practices of use of lesser-used timber species in construction

There are currently no significant examples of the use of lesser-used timber species as a construction material in developing countries. There are examples of use of residual timber such as the bark of trees and poles for construction of houses but these are in predominantly rural areas. The image created by use of timber in these circumstances is rather negative. There are isolated examples where lesser-used timber species have been used in construction in a modern and improved context but again these are too limited to have any meaningful impact.

The use of lesser-used timber species for construction is slowly showing potential in industrially processed timber products. The use of wood chips for composite boards in some countries dwells on timber species which are less suitable as sawn timber due mainly to their irregular form. There is potential to use chips from lesser-used timber species to manufacture wood-cement boards. In some countries where these products are on commercial scale, there is an unfavourable market trend due mainly to the unattractiveness of the finish of the boards.

3.3 The economic advantage of lesser-used timber species as a construction material

Most of the problems which currently predetermine the high cost of lesser-used timber species can actually be tackled and eliminated. Most lesser-used timber species have an inherent botanical advantage which is of economic significance - many of them have more than average density and have strength commensurate with any known commercially popular species. Several lesser-used timber species may not possess the aesthetic qualities of the primary species but nonetheless can meet the functional requirements for use in construction. Construction technology using timber in general offers particular ease of and speed of erection and moreover, requires little investment in heavy plant on site. Timber has a good strength-to-weight ratio and it is easy and quick to cut and join using basic hand tools. Erection in timber can proceed very fast and thus lead to worthwhile savings in the otherwise long gestation periods which are characteristic of fixed asset investment.

3.4 Technical merits of lesser-used timber species as a construction material

As indicated earlier, there are some timber species currently classified as lesser-used purely for the fact that they have no traditional value on either the international or local timber markets, but certainly not because of their technical inferiority. For this reason, it could be argued that the technical merits of a number of lesser-used timber species are similar to those of the commercially adopted. For the purposes of construction, the functional requirements of materials in terms of structural soundness, durability and water resistance can all be fulfilled by several lesser-used timber species. In principle the strength properties of timber correlate with the density and it is precisely in this respect that some lesser-used timber species have an advantage over the primary species.

The two areas which pose a threat to wide adoption of lesser-used timber species are with regard to:

1. fire resistance
2. durability against bio-degradation.

Fire resistance of timber members is also largely a function of density of the timber. Timbers in structural dimensions which have high densities are particularly difficult to ignite. Durability of lesser-used timber species against fungal or termite attack is also not a problem since there are established methods of preservation, ensuring longevity of timber as a structural material.

3.5 Selected small-scale technologies for treatment and preservation of lesser- used timber species

Timber preservation and treatment against bio-degradation employs a range of technologies from rudimentary through small-scale to sophisticated high-cost technologies. Of particular interest to promotion of lesser-used timber species for construction are the available rudimentary or small-scale technologies. Apart from short term treatment of logs and lumber to protect timber from stain and insect attack, there are proven methods for protection from insect attack, especially protection of timber in ground contact or exposed to the weather.

Dip diffusion treatment with borates is relatively cheap and at the same time effective as first time treatment. Dip diffusion requires little capital investment, copes with impermeable species since diffusion is through the water in the green timber, and is environmentally attractive. Drying of sawn timber is feasible in tropical climates without reliance on artificial methods. The equilibrium moisture content of timber in service in naturally ventilated buildings is in the region of 15 % but this can further be reduced to acceptable limits by simple natural processes over a longer period of time. For large volume treatment of lesser-used timber species there are small to medium-scale drying methods available, namely low-temperature kiln drying, dehumidification and solar drying. Depending on local circumstances one method may prove better than the others. However, a combination of these methods is also feasible.

3.6 Grouping

The low occurrence of a large number of species obviously suggests the possibility of grouping. This has already been done effectively in several parts of the world including the tropics for both utility and structural purposes. For structural purposes, it should be technically possible to mix species without limit from within a group. However, even in these cases it may facilitate the acceptance of grouping while still achieving considerable benefits, if mixing within a job is discouraged. Successful grouping will require careful selection of species from both the technical and commercial points of view.

Grouping of timbers was successfully documented for the prefabricated modular bridge construction programme sponsored by UNIDO and still been used in Latin America and Africa.

4. CASE STUDIES

EXAMPLES OF SUCCESSFUL CASE STUDIES IN ECONOMIC AND TECHNICAL VIABILITY OF LESSER-USED TIMBER SPECIES

4.1 Bridge building in Cameroon

The aim of this project was to develop the capability for the manufacture and erection of modular wooden bridges, capable of carrying rural feeder road traffic, using local skills and materials. The bridge consists of simple, identical prefabricated triangular wooden panels joined top and bottom to make up trusses. These trusses are in turn joined together side by side in pairs and are braced to one another to create a girder construction. The main span of 24m was constructed by a launching procedure using derricks, cables and pulleys. The timber deck is carried on top of the girders and is made using a nailed laminated timber construction, laid transversely. Longitudinal running boards direct the wheel loads of vehicles using the bridge. It has been shown that local unskilled labour can be employed in building the bridge, with a core of technicians and personnel who learn the system by being involved in each site in the country concerned. Various forms of abutments and approach spans are possible, and depending upon their design, these can also provide opportunities for local employment.

The bridge was designed for the HS 20 highway loading of the U.S. (AASHTO) design code. This is equivalent to a tractor truck with a semi-trailer of 32 tons total. Design tables are provided for spans from 9 to 27m. The tables also provide for AASHTO H 20 loading.

An important concept was the use of a local lesser-used timber, Dahoma (*Piptadeniastrum africanum*), for the majority of the structure. Dahoma is a tough, hard, heavy species, suitable for exterior work if adequately protected. The timbers for the bridge were treated with creosote using the hot and cold treatment method. A recent study by the Building Research Establishment in the UK showed Dahoma to have strength properties comparable with or slightly lower than European beech. BRE found that on drying, some material had a marked tendency to collapse and distort, and that machining properties were affected by the interlocked grain.

4.2 Rubberwood in Asia

Rubber trees have a limited productive life and are regularly replaced; Rubberwood is consequently a large and regular resource available to any country with substantial plantations. These include Indonesia, Thailand, India, Malaysia and Sri Lanka. The total area of Rubberwood plantations in Asia is estimated at around 8 million hectares. Rubberwood is not a timber plantation species and there was no reason to presume that it had potential as a commercial timber. In Malaysia and Sri Lanka especially, it was described in the past as being soft, of low quality and fit only for firewood and it was used by industries as fuel-wood and for producing charcoal. In fact it is moderately hard though not very strong with problems of low quality. Today there is strong competition between its use as commercial timber for construction applications as against its use as fuel-wood.

Rubberwood has two main problems:

1. It is perishable
2. It is prone to distortion on drying

Perishability results in staining, decay and insect attack. Distortion results in the sawn timber being generally limited to 2 metres in length with widths up 150mm. The relevance of Rubberwood to this paper is therefore not so much its use for building construction but the way in which the problems restricting its utilisation were identified and solved, and how a 'new' species can take the place of another in short supply. In Asia today, Rubberwood is used mainly for light coloured furniture, which is filling some gaps created by the reducing availability of Ramin. It has however been used for roof trusses, laminated timber, flooring, cement board and joinery, and Rubberwood has been used commercially for the manufacture of panel products, such as particleboard, blockboard and medium density fibreboard.

The perishability of Rubberwood is balanced by its permeability, which makes it very amenable to preservative treatment. As a result of much well directed research, the log and green lumber can now be protected against stain and insect attack, and the dry timber can be promoted as having the requisite durability for construction purposes. Drying problems have been traced largely to the presence of tension wood as well as to the high ratio between tangential and radial shrinkage. Currently there is a well directed research programme in Sri Lanka and India as well as Malaysia on use of Rubberwood. A notable feature of the development of Rubberwood as a very important timber species has been the insistence on good production and quality control, and the acceptance by industry of technical advice.

5. RESEARCH,COMMERCIAL APPLICATION AND PROMOTION

The extent to which the gap between research efforts and commercial application of research results poses a limitation to wide adoption of a host of local construction materials has been a matter of concern to several national governments in developing countries and the international community as large.

If efforts at bridging the gap between research and commercialisation are demonstrated, it is likely to be of high significance with regard to lesser-used timber species mainly because timber is a renewable material and there are vast resources yet to be tapped. Currently not many developing countries have embarked on those types of research innovations which for lack of proven methodologies have not had any impact on the actual needs of the construction market. However, it is likely that once a few innovations become commercially viable the scene would be set for other countries to either replicate the results directly or embark on commercially attractive research undertakings. The main constraints which widen the gap between research efforts and commercialisation of research results can be summarised as follows:

5.1 Research efforts

Unlike the industrialised countries where timber construction is widely adopted, research efforts in timber-growing developing countries often have no relationship with the actual needs of the industry. The requirements of building professionals, artisans, contractors, timber component producers and clients of construction products are often ignored in research practice. Funding is often a limitation but again experience from Europe and America and to some extent Asia suggests that once the needs of the construction industry, especially the research needs of the private sector, are catered for, there will be adequate funding to carry out the respective research. The value of research to product promotion in a developing country is amply demonstrated by the example of Rubberwood in Malaysia, which was developed from a source of fuel-wood to a competitive material for construction. Investigations into detailed properties of a variety of lesser-used timber species are lacking; grouping and nomenclature will for example be of interest to the industry and so will research on stress grading and other specifications be of commercial interest.

The extent to which efforts in research and development activity in primary timber species has helped to promote export-oriented timber species in some developing countries should serve as a clear lesson of how research remains at the foundation of any meaningful progress. Demonstration activities have also played a role in promoting primary timber species. However, the few demonstration projects on use of lesser-used timber species suffer from the general lack of thrust and a rather non-aggressive dissemination of technology.

5.2 Appropriate technologies

Although an array of small-scale technologies exists for treatment and preservation of lesser-used timber species, the same could not be said of secondary processing technology. In advanced levels of secondary processing such as for composite materials i.e. wood-chip boards and wood-cement panels, the existing machinery is almost invariably at a scale which may not be commensurate with the size and effective demand of the local market.

5.3 Standards, codes of practice, and other regulatory instruments

In countries where research and demonstration work has led to a near breakthrough in the use of lesser-used timber species, the lack of standards and codes of practice and schedules for bills of quantities specific to the lesser-used timber species could pose a severe limitation to any prospects for commercial adoption of the findings. In the first place, the reluctance of finance institutions to provide credit for potential investors in timber processing ventures and contractors alike could jeopardise any dreams of wide adoption of lesser-used timber species. In the second place and even more importantly, the competition form other materials such as concrete and steel, which are covered by ample regulatory instruments, puts lesser-used timber species in an unduly non-competitive situation. In this way, the already existing bias by both contractors and customers is aggravated.

6. PROMOTING LESSER-USED TIMBER SPECIES IN CONSTRUCTION

6.1 Timber technology culture

Most developing countries where strategies for promotion of lesser-used timber species are feasible would by definition already have an existing timber construction practice based on popular timber species. Thus there is already an existing basis for promoting the use of timber in construction. However, in most of these countries there is hardly any local timber technology culture. One of the fundamental prerequisites in ensuring a successful promotion of lesser-used timber species is to ensure that there is local acceptance of timber in general, regardless of the species. Currently, even in timber exporting developing countries, there is limited use of knowledge of timber as a material for construction..

Once the use of popularly adopted species has been widely accepted, the scene is then set for introducing lesser-used timber species. The promotional exercise should not be targeted at the consumers alone. In fact, more important than the end-user are those at the production end of the sector i.e. those engaged in primary and secondary processing. Perhaps, the most strategic component in the range of activities required for securing a local timber technology culture is the design and construction component. Ultimately, it is the carpenters, architects, foremen, structural/civil engineers, quantity surveyors and contracting personnel who would influence the wide adoption of timber in construction. In order to facilitate the intervention of skilled labour and professional work force, a deliberate effort should aim at promoting availability of structural timber components.

6.2 Technology transfer

If developing countries are to achieve any break through in promoting lesser-used timber species for construction, then the logical first step and probably the most cost effective approach should be based on a system of transferring existing proven technologies rather than initiating entirely new technologies.

In most developing countries which could be classified as timber growing or timber surplus economies, there is still a deficiency in basic know-how even on the primary timber species. Issues such as stress grading and dimensions have still not been dealt with adequately. The transfer of methodologies from industrialised countries could initially aim at ensuring rapid improvement in primary timber species technology so that once the basic infrastructure is in place the recipient countries could adapt the know-how to lesser-used timber species. In countries such as Sweden, Norway and Finland to name a few, much work has been done on timber resources assessment, nomenclature, grading rules and standardisation of dimensions which could all be of benefit to developing countries. Another area which is ripe for transfer from developed countries to developing countries is with regard to preservation of timber. Again, here the techniques or simple tools for seasoning and preservation against fungi and termites should form the basis for technology transfer.

Design and construction techniques are often ignored or understated in any programme for promotion of local building materials. In timber technology, design and construction considerations are probably even more important than timber treatment and such botanical considerations. In this respect the experiences of the industrialised countries become relevant. However, the principle of technology transfer should aim at careful adaptation rather than outright replication because of the obvious differences in the factors which predetermine design and construction details.

One area in which a few developing countries have made reasonable progress in lesser-used timber species is in primary research. Countries such as Malaysia, India, Thailand and the Philippines all have basic research centres and laboratories dealing specifically with timber and timber products. The experience acquired by the countries so far could form the basis of research know-how that could be transferred to the remaining countries, which are yet to make a start in investigations on lesser-used timber species. In Malaysia, the use of Rubberwood as a construction material has been demonstrated yet other rubber producing countries such as Liberia and Nigeria have not made such progress in this area. Another area of concern, where disparities exist between developing countries in the level of know-how and local initiative, is with regard to timber preservation technology. Advances have been made by a few developing countries is simple methods for timber preservation including developments in solar drying techniques for timber seasoning, timber impregnation technology and above all initiatives in treatment for termite protection. All these initiatives are directly applicable to lesser-used timber species and could thus form the basis for technology transfer between developing countries.

6.3 Secondary processing

One of the most viable strategies for promoting use of the timber in construction is for timber growing developing countries to embark on intensified secondary processing of lesser-used timber species. The merits of secondary processing cannot be over emphasised. The strategy fits well into the overall economies. The superiority of the building materials sector as a viable sector for industrial gains is based mainly on the multiple linkages to the national economy in both outputs and ability to stimulate a parallel growth in the input sectors. In the first place, the abundant reserves of lesser-used timber species plus the fact that timber is a renewable resource could all serve as a solid base for continuous supply of raw materials required in secondary processing plants. In the second place, the promotion of secondary processing could lead to the availability of a multitude of products which could then satisfy the rather complex market for construction. Thirdly, there are relatively simple tools and technologies available on the market for secondary processing of timber and this on its own will enhance prospects for the strategy to prove feasible to both potential producers and consumers of end product. In the final analysis an intensive use of timber in construction is only feasible if processed or prefabricated components or composites of timber are widely available on the market.

Some timber growing developing countries have come a long way in a relatively short period of time regarding timber processing. From the initial stages where focus was strictly on harvesting sawn logs for export and for sawmills, there is now a shift into secondary processing to increase added value but mainly to generate foreign exchange. A few developing countries have now moved into production of prefabricated door frames, window frames, roof trusses and panels for wall framing. There is scope for further diversification of products through secondary processing of timber, utilising lesser-used species strictly for the construction market. Fortunately most developing countries already have an established technological infrastructure for primary processing of timber and to some extent some rudiments for secondary processing which could be consolidated upon to intensify and diversify secondary processing of timber. Opportunities exist to embark on chipboards and other structural composites using chips from lesser-used timber species and cement and other additives to form a monolithic composite material.

6.4 Joint programmes: sub-regional joint demonstration projects; adaptation of internationally sponsored technology transferee.

Despite the fact that a few developing countries have made some progress in timber technology, the general picture is that of a total lack of direction and focus on the actual task of promoting lesser-used timber species for construction. One way to overcome this problem is to optimise use of the available resources by undertaking communal programmes amongst a group of developing countries.

The merits of a joint sub regional project of lesser-used timber species are several. First, the resource requirements for each timber for construction are massive compared to what is normally available from international support sources; the resources requirements will normally comprise assistance in technical expertise, supply of information and software, laboratory equipment, machinery and training of local experts. In the second place, most developing countries requiring assistance to promote lesser-used timber species for construction will tend to have identical problems such as in raw material assessment, classification, treatment, processing and design techniques so that economies will be achieved by intervening in their problems on a communal basis. Thirdly, a strategy of joint projects takes account of the contribution that the recipient countries could make to project success; the little expertise and facilities available in some of the recipient countries could all be mobilised into the project to secure some saving and ensure efficient use of all available resources.

7. SUGGESTIONS FOR ACTION

7.1 National Governments

Some of the solutions required to make lesser-used timber species affordable, technically appealing and above all available in large quantities are already unknowingly being pursued by national governments. There are on-going general policy reforms and programmes to promote wide adoption of local construction materials which if sustained would have an impact on use of lesser-used timber species. However, the peculiar requirements of lesser-used timber species would in addition to general policy reforms benefit from the following specific interventions of national governments.

7.1.1Strategic programme of assured supply base

The primary task of national governments if lesser-used timber species are to be widely adopted for construction is to embark on a strategic programme of an assured supply base. The unique advantage of timber over other materials is its renewability; if timber is treated as a depletable raw material just like limestone, clay or sand than its versatility as a potentially viable low-cost material is threatened. For this reason, governments should outline a vigorous policy of afforestation for any exploitable lesser-used timber species as a fundamental pre-requisite to any other policy interventions aimed at promoting lesser-used timber species as a construction material.

7.1.2 Promotion of standards, specifications, building regulations, codes of practice and contractual reforms.

By definition, regulatory instruments for governing the operations of the construction industry have legal implications so that it is the unique task of national governments to undertake any reforms of this nature. Like other construction materials, the strategy for promotion of standards should first and foremost aim at incorporating the use of lesser-used timber species into existing building regulations. However in order to facilitate the fast adoption of lesser-used timber species, requisite standards and specifications should be formulated and effectively disseminated. Similarly, codes of practice and simplified manuals should be prepared to guide operations in secondary processing as well as in design and construction. In this regard, governments need not search for new methodologies to achieve this target. There is sufficient experience and proven methodologies which can be directly applied or adapted. Unfortunately, lesser-used timber species are characterised by such a variety of groups with almost every group requiring specific considerations in codes of practice and specifications which would require some additional efforts.

7.1.3 Strengthening research capacity, curriculum revision and provision of specific skill requirements.

To the extent that governments are directly in charge of most institutions dealing with timber research in developing countries, it must be seen as their prime responsibility to first bring about reforms in research programming, and secondly to take positive steps towards strengthening the resource base of the institutions. Again here, governments need not devote additional resources to carry out the reform but simply reorient the approach and set-up of the research institution to link them up with the private sector producers of timber products and the construction industry. The target should be research into areas of direct benefit to specifiers, architects, engineers and contractors. Apart from general topics of investigation requiring immediate attention such as raw material assessment, identification, grouping and nomenclature there is also need for specific studies into items such as:

1. strength and durability
2. density characteristics
3. stress grading
4. low-cost techniques for seasoning and protection against bio-degradation
5. field tests for brittleness, vulnerability to splitting, grain, level of distortion
6. manufacture / construction of prototypes

If timber construction technology is to become a priority issue in national strategies, then governments must address themselves to the manpower requirements of this strategic sub-sector. The training programme should cover a vast range of skills in the timber industry; operatives for secondary processing, machine and equipment installation plus maintenance specialists, forestry management personnel, timber treatment and preservation expertise and then timber design and construction technology. In all these endeavours there must be a focus on training of skills specifically geared towards the promotion of lesser-used timber species. The training programme need not lead to setting up of entirely new institutions. One useful strategy is to strengthen existing institutions through programme reform and most of all curriculum revision. The curriculum revision should prove most useful to institutions training high-level artisans or technicians for the construction industry as well as professionals such as architects, building technologists, civil/structural engineers, quantity surveyors and mechanical engineers.

7.1.4 Effective dissemination of research and development of innovations.

The few examples of demonstration projects aimed at popularising research initiatives in the building materials sector have failed in several developing countries. However, the concept of demonstration projects is still valid and remains a vital tool for linking up research to practice. Timber construction technology would require particularly effective demonstration projects considering the unfavourable position that timber occupies relative to other building materials. Governments should take advantage of the fact that they are, in most instances, the single largest client of the building industry and use this position to demonstrate the viability of lesser-used timber species as a material for construction. Apart from the physical erection of structures, there are other modes of research dissemination which the government can manipulate to achieve the desired results. Governments can for example take full advantage of their television and radio broadcast network as well as informal systems using agricultural extension officers, health officials and teachers.

7.1.5 Fiscal policy reform and investment incentives.

There is need to review existing fiscal policies and incentive strategies not only for the timber industry but also for the entire construction materials sector. It is likely that most timber exporting developing countries would have put in place fiscal policies and related incentive strategies to boost production for export. The danger in such a strategy is that it could serve as a disincentive to investments in exploitation and processing of lesser-used timber species. If the timber industry is treated as a sub-sector of the economy with uniform tax incentives and equalisation of reductions in import levy then there is every chance that the exportable timber species would attract all the local and foreign private-sector investment. In this regard there is need for tax and similar fiscal incentives to be targeted at the promotion of lesser-used timber species, especially the secondary processing of species for construction. The incentives should cover entrepreneurs at the production end of timber as well as those investing in the use of timber components for construction. The extent to which timber is disadvantaged in relation to other competing building materials should also be reviewed so that corresponding adjustments are made on existing fiscal policies to reflect any peculiar requirements of lesser-used timber species.

The lack of standardisation of timber components for use in construction poses a problem with several negative consequences. In particular the high incidence of wastage of timber eventually makes timber seemingly costly. The lack of standardisation also leads to delays in construction time and the quality of finish. Governments bear the responsibility for promoting standardisation of measurements of timber components. Once standardisation has been accomplished for simple components, the process of industrialisation could be initiated.

There are two distinct advantages of industrialisation utilising lesser-used timber species. The first is of immediate national consequence in terms of improving delivery and stimulating national growth. The second is that governments could explore possibilities of exporting industrial components to other developing countries that may be facing a deficit in supply of lesser-used timber species. In this way timber serves a dual market and sustains the foreign exchange earning capacity of the timber industry.

7.2 International support

7.2.1 Information flow.

The rich experiences of some developed countries in the use of timber for construction plus relevant research projects undertaken by specialised international agencies could all prove useful to the needs of some developing countries who may wish to promote lesser-used timber species for construction. In this regard, the international community could support efforts of national governments through supply of relevant information to selected focal points in the recipient countries. If information flow of this nature is to be effective, the information must as much as possible be targeted to the needs of the recipient countries, implying that information must be further refined or processed before being disseminated. For example, in the area of grouping of species and similar areas, what may be required is only the methodology or concept. Similarly what may be of interest to local architects in developing countries is the design guidelines rather than detailed drawings.

7.2.2 Equipment and machinery

Perhaps the most obvious support that the international community could give to developing countries is in supply of equipment and machinery. The range of equipment and machinery required is extensive, broadly covering equipment for research laboratories, tools for treatment and preservation of lesser-used timber species, for species identification and most of all for secondary processing. It is important for donor countries or multilateral agencies taking up this challenge to aim at technologies which can be sustained by the recipient countries. This may call for some adjustments on the part of the donor countries - adaptation of existing technologies rather than outright technology replication. Donors of machinery and equipment may also explore possibilities of assisting the recipient countries in local fabrication of rather simple tools.

7.2.3 Manpower development

In the long run, developing countries will only achieve the target of adequate local capacity in the promotion of lesser-used timber species if the gaps in available manpower are dealt with in a comprehensive manner. The international community's support in this area is vital and should more importantly prove a cost-effective approach to development. Manpower development should cover both professionals and middle-level technicians and the entire range of activities required to effectively promote lesser-used timber species should be considered. The training programme to be offered should as much as possible be specific to the subject with adequate balance between classroom academic oriented courses and on-the-job practical training schemes. With regard to the latter, attachments to private sector ventures for on-the-job training have always proven beneficial to be potential entrepreneurs from recipient countries.

7.2.4 Support for co-operation between developing countries.

The responsible international agencies could initiate collaborative research and demonstration projects involving joint efforts of a few developing countries from one sub-region with logistics support from the international community. The concept of such collaborative projects has been rehearsed by agencies such as UNIDO and this should not prove too difficult to adapt to the task of promoting lesser-used timber species. The main areas of support required from the international community are for equipment and machinery and assistance in expertise. The concept entails a group of developing countries being hosted by a single collaborating country for the purpose of undertaking a project of mutual benefit to the group. After the successful demonstration stage, the international community could provide a lower margin of logistics support to replicate the initiatives to the remaining participating countries.

7.2.5 Joint research and demonstration projects.

The international community could support the efforts of national governments through bilateral programmes in research and demonstration covering a variety of aspects for promotion of lesser-used timber species. The possible areas of co-operation include raw material assessment, species identification, grouping and nomenclature, treatment and preservation techniques, field tests for classifications, secondary processing and construction techniques. Depending on the particular focus of the joint project and also depending on local infrastructure and other variables of the recipient country, the project could be hosted by the recipient country with specific components being hosted by the donor country. There could also be twinning arrangements whereby expertise from individual developing countries are attached to selected specialist companies or research institutions in the developed countries to undertake joint research programmes.

A successful outcome of a recent research project carried out by Building Research Establishment in collaboration with TRADA (both organisations in UK) is the publication of a supplement to the well known document 'Handbook of Hardwoods' which architects, engineers and the specifiers in UK always refer to. This has brought a few lesser-used species into the UK market.

The Ghana Timber Export Development Board is actively promoting their LUS species in the world market and in addition to their prototype demonstration items made of LUS, they have produced many publications and much promotional literature for the possible users of LUS.

Technical Session 4

CONTENTS

Dimensional Stability of Fifty - Four Lesser Used Timber Species of Myanmar

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SUMMARY

The properties and characteristics of timber available are very much varied but also very important. In this study, dimensional stability of fifty-four lesser-used timber species (LUS) are computed, based on the results obtained from the tests on physical properties. These tests were carried out at the Forest Research Institute (FRI), Yezin, under the title " Introducing Myanmar's Lesser Used Timber Species to the World Market " Project. Based on dimensional stability and absolute transverse dimensional changes, fifteen species which are found to be the most promising among the fifty-four LUS for manufacturing high quality wood products are selected for presentation.

Dimensional Stability of Fifty - Four Lesser Used Timber Species of Myanmar

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1. INTRODUCTION

As wood and wood based-products are recyclable, renewable, biodegradable and environmentally friendly with sustainable origin, global demand for forest products, especially tropical timbers has started to grow faster than the sustainable supply. To meet the demand, indigenous tree species producing valuable timber, except commercial timbers have now come to be of considerable potential importance for both local use and export. In view of the improved utilization of lesser-used timber species (LUS), their technological information, which remains to be developed, should be known.

In collaboration with International Tropical Timber Organization (ITTO), the Forest Department has undertaken a project on "Introducing Myanmar's Lesser-used Timber Species to the World Market" under project No.31/96 Rev.2 (M.F.I). The project was started from April, 1997 and it will be terminated at the end of March, 2000. Properties of some LUS have been investigated at the Forest Research Institute (FRI), Yezin under this project. The research on anatomical characteristics, physical properties, mechanical properties, drying behavior, durability, treatability and workability of fifty-four LUS were carried out during the project period.

As a matter of fact, one of the most important practical problems which arises during the utilization of wood is the hygroscopic shrinking and swelling of wood which occurs as a result of moisture changes. Wood responds to change in atmospheric humidity and loses bound water as the relative humidity drops, regaining bound water as the relative humidity increases. For a given relative humidity, a balance is eventually reached at which the wood is no longer gaining or losing moisture. Therefore, moisture gaining and losing in wood, below fiber saturation point is always accompanied by dimensional change. It shrinks when losing moisture from the cell walls and swells when gaining moisture in the cell walls. As such, shrinking and swelling may result in decrease or increase in dimension, losing of footage, distortion in cross section warping, surface and end checking, splitting, performance problems that detract from its usefulness. It is, therefore most important that these phenomena should be understood and carefully considered before utilization. Moreover, shrinkage of wood parts or components after their manufacture into furniture, cabinet, household utilities result in warping, splitting, cracking, failure of glue joints and diminution of the strength.

As wood is an anisotropic material in its shrinkage characteristics, it shrinks most in the direction of growth rings (tangentially), about half as much or more across the rings (radially), and only slightly along the grain (longitudinally). The combined effects of radial and tangential shrinkage can distort the shape of wood pieces because of the difference in shrinkage and curvature of growth rings.

The ratio of tangential to radial shrinkage (T/R) along with the shrinkage percent itself, constitute a means of assessing the dimensional stability of any given wood. The wood best suited for use involving critical dimensional stability is one with a low T/R ratio and with low transverse dimensional changes (Pashion & de Zeeuw,1980).

In reality, the total dimensional changes that may occur in a piece of wood, in drying from the green condition, are important considerations in finished product manufacture. The important factors, however, are the changes in dimensions that accompanied the usual fluctuation of relative humidity (RH) and temperature after wood has been placed in services. In a manufacturing plant or wood industry where products such as flooring, cabinets, or furniture are being produced, it should be routine work that stock timbers should be properly dried to an average moisture content so that the finished items will have good performance in services. As at present, manufacturers have come to realize the importance of this fact but problems still occasionally develop because of lack of knowledge in relation to the dimensional changes of wood and the relative humidity of the environment where the products are being used.

The present study is intended to investigate to select some LUS which could be best suited among the tested LUS for manufacturing high quality wood products, based on dimensional stability and absolute transverse dimensional changes.

2. MATERIALS AND METHODS

Wood samples tested in this study were collected from the Khabaung Reserved Forest and Phyukun Reserved Forest of Taungngu District, Bago Division.

Some physical properties such as, specific gravity, density, radial shrinkage, tangential shrinkage and volumetric shrinkage of each of the LUS were tested. These properties were determined using the test procedure described in ASTM designation: D 143-52 (R 1965) developed by the American Society for Testing and Materials (ASTM).

Based on the results obtained for radial shrinkage and tangential shrinkage, dimensional stability (i.e, ratio of tangential shrinkage to radial shrinkage) of each of the tested species are computed.

3. RESULTS AND DISCUSSIONS

Basic specific gravity based on green volume and oven-dry weight, air-dry density i.e, density at 12 % MC, radial shrinkage, tangential shrinkage, volumetric shrinkage together with the dimensional stability of the tested LUS are given in Table (1). Bar charts of basic specific gravity, tangential shrinkage and dimensional stability of 54 LUS are given in Fig. (1a) through Fig. (3b). These bar charts are drawn in the ascending order so as to have a clear observation. From Fig. (1a) and Fig. (1b), it can be seen that basic specific gravity ranges from 0.26 for Letpan to 0.938 for Gyo. Minimum and maximum tangential shrinkage of the tested LUS were found to be 4.3 percent and 15.3 percent respectively, for Taungpeine and Thitpayaung as shown in Fig. (2a) & (2b). Similarly, minimum and maximum dimensional stability of 54 LUS were found to be 1.47 and 3.11 respectively, for Taukkyan and Shaw as shown in Fig. (3a) & (3b).

According to past experience on the Myanmar's commercial timbers, those timbers which have dimensional stability less than or equal to 2.0 and dimensional changes i.e. radial shrinkage and tangential shrinkage less than or equal to 3.5 percent and 7.0 percent are found to be suitable for making high quality wood products.

From Fig. (2a), (2b), (3a) & (3b), it can be observed clearly that out of 54 LUS, 27 have tangential shrinkage less than or equal to 7.0 percent whereas 31 have dimensional stability less than or equal to 2.0. However, only fifteen species namely, Chinyok , Dwani, Hmyaseik, Hnaw, Kokko, Kuthan, Myaukngo, Myaukthwegyi, Nabe, Sit, Taukkyan, Taungmeok, Taungpetwun, Tawthayet and Yemane have both the dimensional stability equal or less than 2.0 and tangential shrinkage equal or less than 7.0 percent. In considering the transverse shrinkage, the tangential shrinkage is mainly taken into account since it is the major factor which can influence the dimensional change of a wood product in use and almost all of the lumber used in daily practice are flat-sawn (i.e. tangential cut) lumber. These fifteen LUS can be assessed as the best suited LUS for making high quality wood products among the tested fifty-four LUS of Myanmar. Pictures on tangential section of the selected fifteen LUS are given in Plates A, B, C and D.

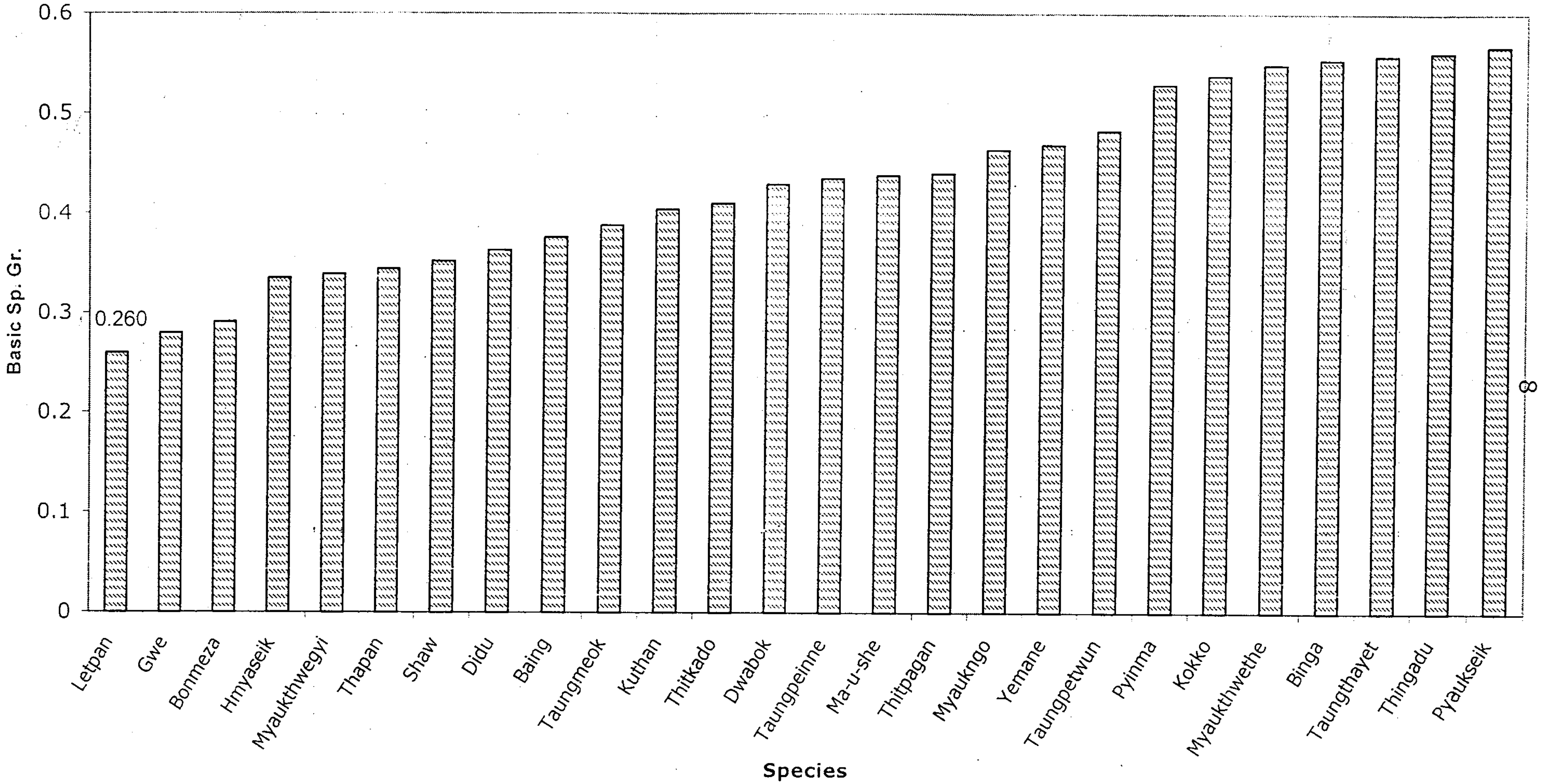
Out of the above mentioned species, the basic specific gravity of Hmyaseik, Kuthan and Taungmeok are low. Thus, they will not be suitable for use as construction materials or some wood products where strength is to be considered as the prime factor.

Table 1. Dimensional Stability and Some Physical Properties of Fifty- Four LUS of Myanmar

Sr. No.	Species	Basic Specific Gravity	Air Dry Density (Kgm-3)	Shrinkage (Green to Oven-Dry) Radial (%)	Tangential (%)	Volumetric (%)	Dimensional Stability
1	Baing (*Tetrameles nudiflora*)	0.376	449	3.5	8.5	10.8	2.43
2	Binga (*Mitragyna rotundifolia*)	0.554	665	4.0	8.2	12.0	2.2
3	Bonmeza (*Albizzia chinensis*)	0.291	340	2.2	6.2	7.5	2.82
4	Chinyok (*Garuga pinnata*)	0.601	716	3.3	6.1	10.6	1.8
5	Didu (*Salmalia insignis*)	0.363	429	2.8	5.9	9.2	2.1
6	Dwabok (*Kydia calycina*)	0.429	508	3.0	6.6	10.1	2.20
7	Dwani (*Eriolaena candollei*)	0.719	857	4.2	6.9	10.8	1.64
8	Gwe (*Spondias pinnata*)	0.280	330	2.1	5.6	8.7	2.67
9	Gyo (*Schleichera oleosa*)	0.938	1157	5.0	10.8	15.9	2.16
10	Hmyaseik (*Antiaris toxicaria*)	0.335	394	2.7	5.3	8.7	1.96
11	Hnaw (*Adina cordifolia*)	0.601	713	3.6	6.5	9.9	1.81
12	Kokko (*Albizzia lebbek*)	0.538	633	3.0	6.0	8.6	2.00
13	Kuthan (*Hymenodictyon excelsum*)	0.404	479	3.2	6.1	9.7	1.91
14	Kyetyo (*Vitex peduncularis*)	0.761	918	4.9	9.2	12.7	1.88
15	Lein (*Terminalia pyrifolia*)	0.644	793	5.9	9.2	16.0	1.56
16	Letpan (*Salmalia malabarica*)	0.260	304	2.1	5.9	7.9	2.33
17	Leza (*Lagerstroemia tomentosa*)	0.583	702	4.9	7.6	12.4	1.55
18	Ma-u-lettan-she (Anthocephalus cadamba)	0.438	524	3.8	8.0	11.9	2.11
19	Myaukchaw (*Homalium tomentosum*)	0.776	950	5.6	10.7	14.9	1.91

Sr. No.	Species	Basic Specific Gravity	Air Dry Density (Kgm-3)	Shrinkage (Green to Oven-Dry) Radial (%)	Tangential (%)	Volumetric (%)	Dimen- -sional Stability
20	Myaukngo (*Duabanga grandiflora*)	0.464	546	3.2	5.1	8.7	1.59
21	Myaukthwegyi (*Myristica spp*)	0.339	407	4.0	7.0	11.5	1.75
22	Myaukthwethe (*Myristica angustifolia*)	0.549	655	4.3	8.4	11.5	1.95
23	Nabe (*Lannea coromandelica*)	0.672	787	3.5	6.0	8.3	1.71
24	Panga (*Terminalia chebula*)	0.779	960	5.4	11.0	15.6	2.04
25	Petthan (*Haplophragma adenophyllum*)	0.745	897	4.4	7.5	7.1	1.70
26	Pyaukseik (*Holoptelea integrifolia*)	0.567	686	3.8	8.5	12.9	2.24
27	Pyinma (*Lagerstroemia speciosa*)	0.529	630	3.1	7.4	11.1	2.39
28	Seikche (*Bridelia retusa*)	0.583	678	2.2	5.9	6.5	2.68
29	Shaw (*Sterculia versicolor*)	0.352	412	1.9	5.9	7.2	3.11
30	Sit (*Albizzia procera*)	0.720	845	2.8	5.5	7.8	1.96
31	Taukkyan (*Terminalia tomentosa*)	0.815	992	5.7	8.4	13.8	1.47
32	Taungmeok (*Alstonia scholaris*)	0.388	462	3.5	5.5	10.2	1.57
33	Taungokshit (*Elaeocarpus* spp.)	0.691	829	3.0	8.1	11.6	2.67
34	Taungpeinne (*Artocarpus chaplasha*)	0.435	506	1.8	4.3	6.6	2.39
35	Taungpetwun (*Pterospermum acerifolium*)	0.483	577	3.8	6.7	10.4	1.76
36	Taungthaye (*Swintonia floribunda*)	0.558	655	2.7	5.9	7.9	2.19
37	Tawthayet (*Mangifera* spp.)	0.582	780	3.6	5.6	8.3	1.56
38	Thabye (*Eugenia* spp.)	0.674	819	4.3	9.3	13.7	2.16

Sr. No.	Species	Basic Specific Gravity	Air Dry Density (Kgm-3)	Shrinkage (Green to Oven-Dry) Radial (%)	Tangential (%)	Volumetric (%)	Dimen- -sional Stability
39	Thadi (*Protium serratum*)	0.697	856	5.8	10.2	15.6	1.76
40	Thande(*Stereospermumpersonatum*)	0.725	875	4.8	8.4	12.5	1.75
41	Thapan (*Ficus* spp.)	0.344	405	2.7	6.7	8.5	2.48
42	Thingadu (*Parashorea stellata*)	0.561	671	3.8	7.4	13.1	1.95
43	Thitkado (*Cedrela toona*)	0.410	479	3.1	6.4	9.2	2.06
44	Thintmagyi (*Albizzia odoratissima*)	0.803	949	2.9	6.3	9.4	2.17
45	Thitpagan (*Millettia brandisiana*)	0.440	574	6.7	14.5	23.0	2.16
46	Thitpayaung (*Nauclea sessilifolia*)	0.720	907	6.6	15.3	19.6	2.32
47	Thitsein (*Terminalia bellerica*)	0.717	883	6.4	9.7	15.7	1.52
48	Thitswele (*Schrebera swietenioides*)	0.710	840	4.5	7.1	10.9	1.58
49	Yemane (*Gmelina arborea*)	0.469	551	3.0	5.5	8.2	1.83
50	Yindaik (*Dalbergia cultrata*)	0.792	982	6.2	10.1	16.8	1.63
51	Yinma (*Chukrasia tabularis*)	0.781	946	5.2	9.7	13.1	1.87
52	Yinzat (*Dalbergia fusca*)	0.704	853	4.2	9.7	13.5	2.31
53	Yon (*Anogeissus acuminata*)	0.762	926	5.4	9.4	13.6	1.74
54	Zaungbale (*Lagerstroemia villosa*)	0.597	721	4.7	7.1	12.9	1.51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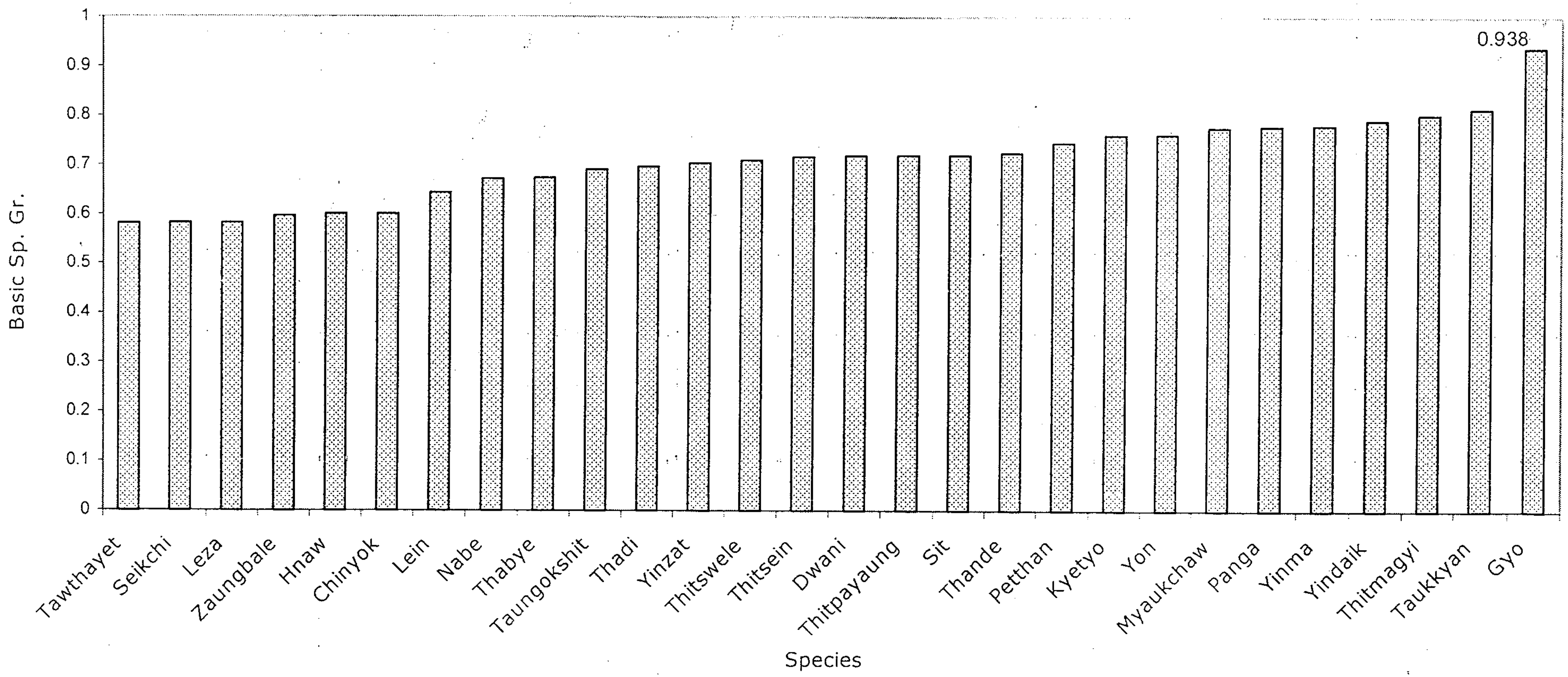
0.4
0.3
0.2
0.1
0
0.260
Letpan
Gwe
Bonmeza
Hmyaseik
Myaukthwegyi
Thapan
Shaw
Didu
Baing
Taungmeok
Kuthan
Thitkado
Dwabok
Taungpeinne
Ma-u-she
Thitpagan
Myaukngo
Yemane
Taungpetwun
Pyinma
Kokko
Myaukthwethe
Binga
Taungthayet
Thingadu
Pyaukseik
Species

Fig. 1 (a)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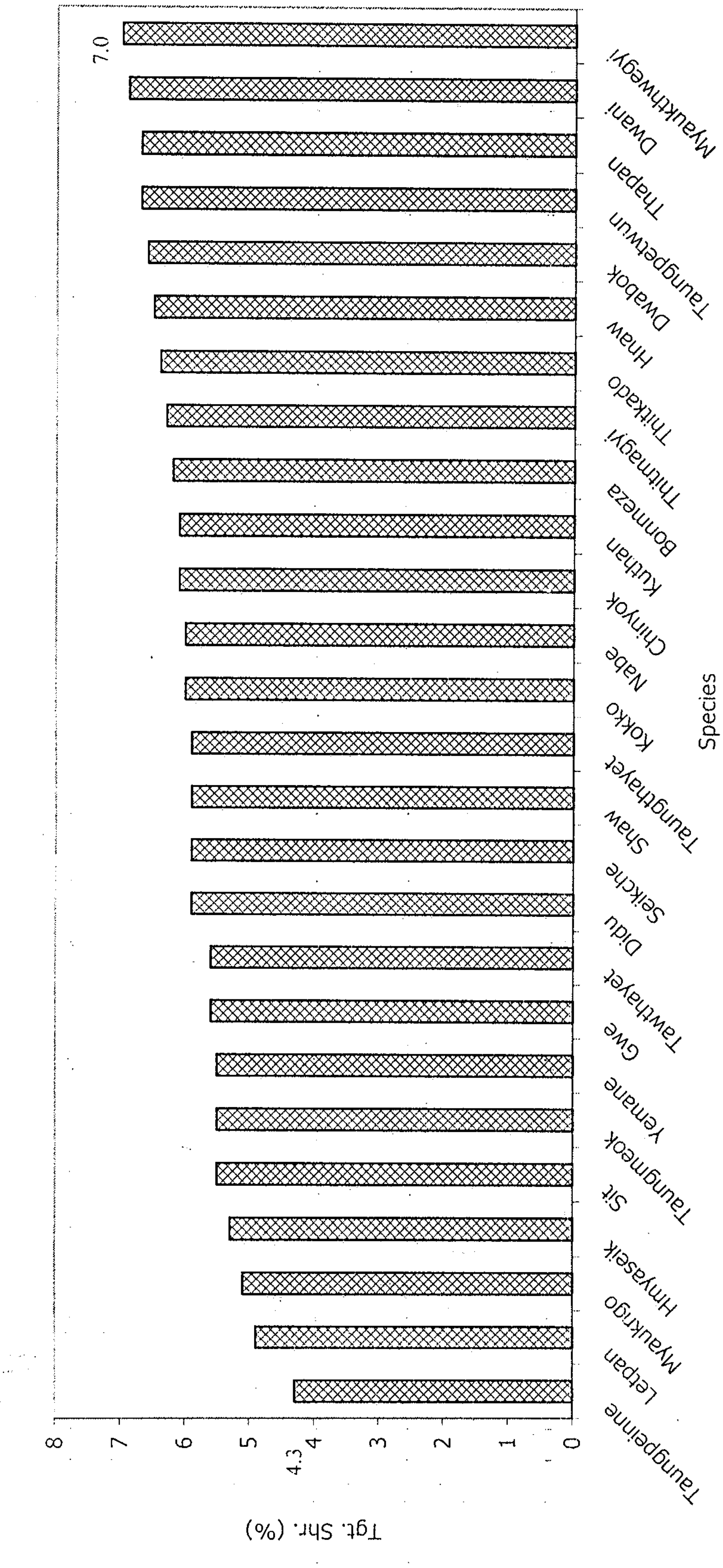
0
Tawthayet
Seikchi
Leza
Zaungbale
Hnaw
Chinyok
Lein
Nabe
Thabye
Taungokshit
Thadi
Yinzat
Thitswele
Thitsein
Dwani
Thitpayaung
Sit
Thande
Petthan
Kyetyo
Yon
Myaukchaw
Panga
Yinma
Yindaik
Thitmagyi
Taukkyan
Gyo
Species

Fig. 1 (b)


Tgt. Shr. (%)
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1
2
3
4
4.3
5
6
7
8
7.0
Species
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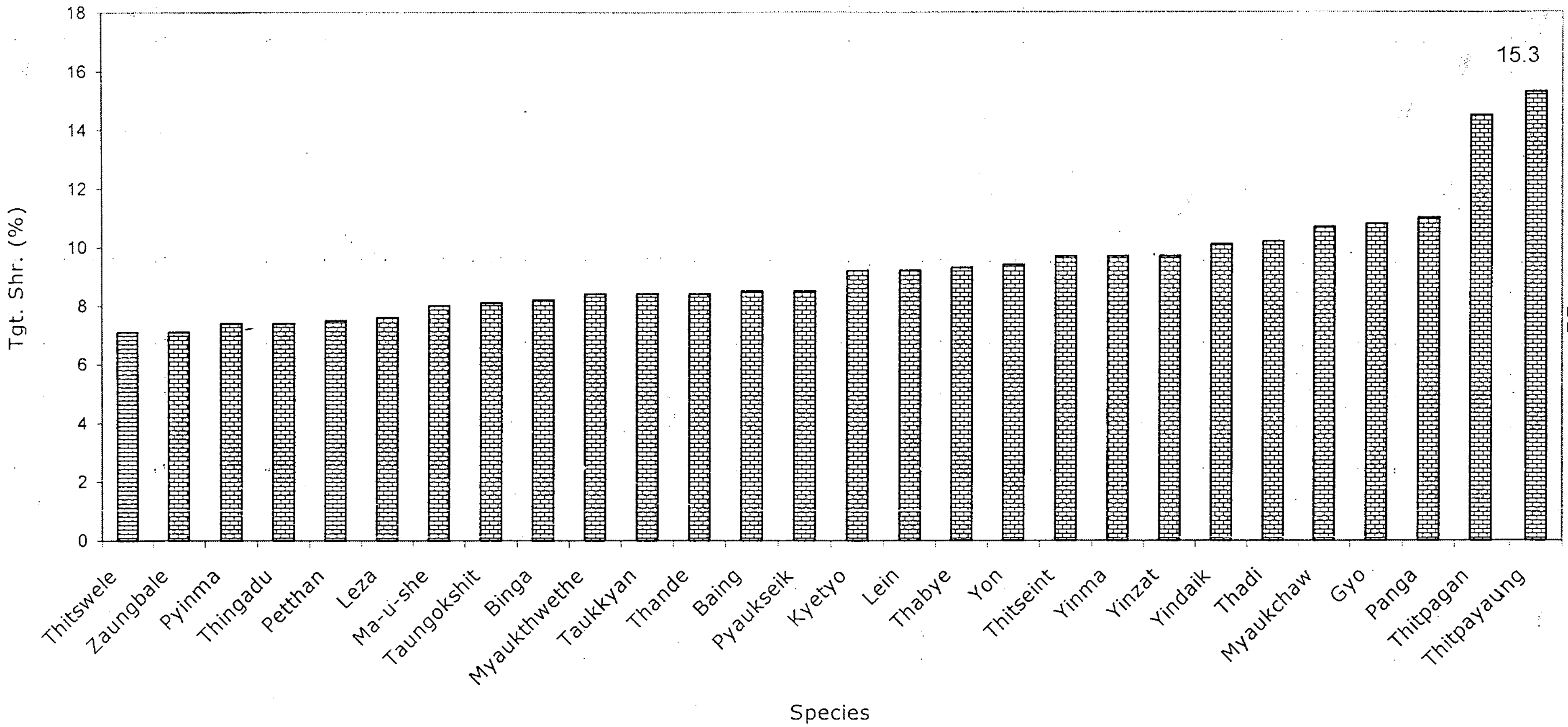
Letpan
Myaukngo
Hmyaseik
Sit
Taungmeok
Yemane
Gwe
Tawthayet
Didu
Seikche
Shaw
Taungthayet
Kokko
Nabe
Chinyok
Kuthan
Bonmeza
Thitmagyi
Thitkado
Hnaw
Dwabok
Taungpetwun
Thapan
Dwani
Myaukthwegyi

Fig. 2 (a)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Tgt. Shr. (%)
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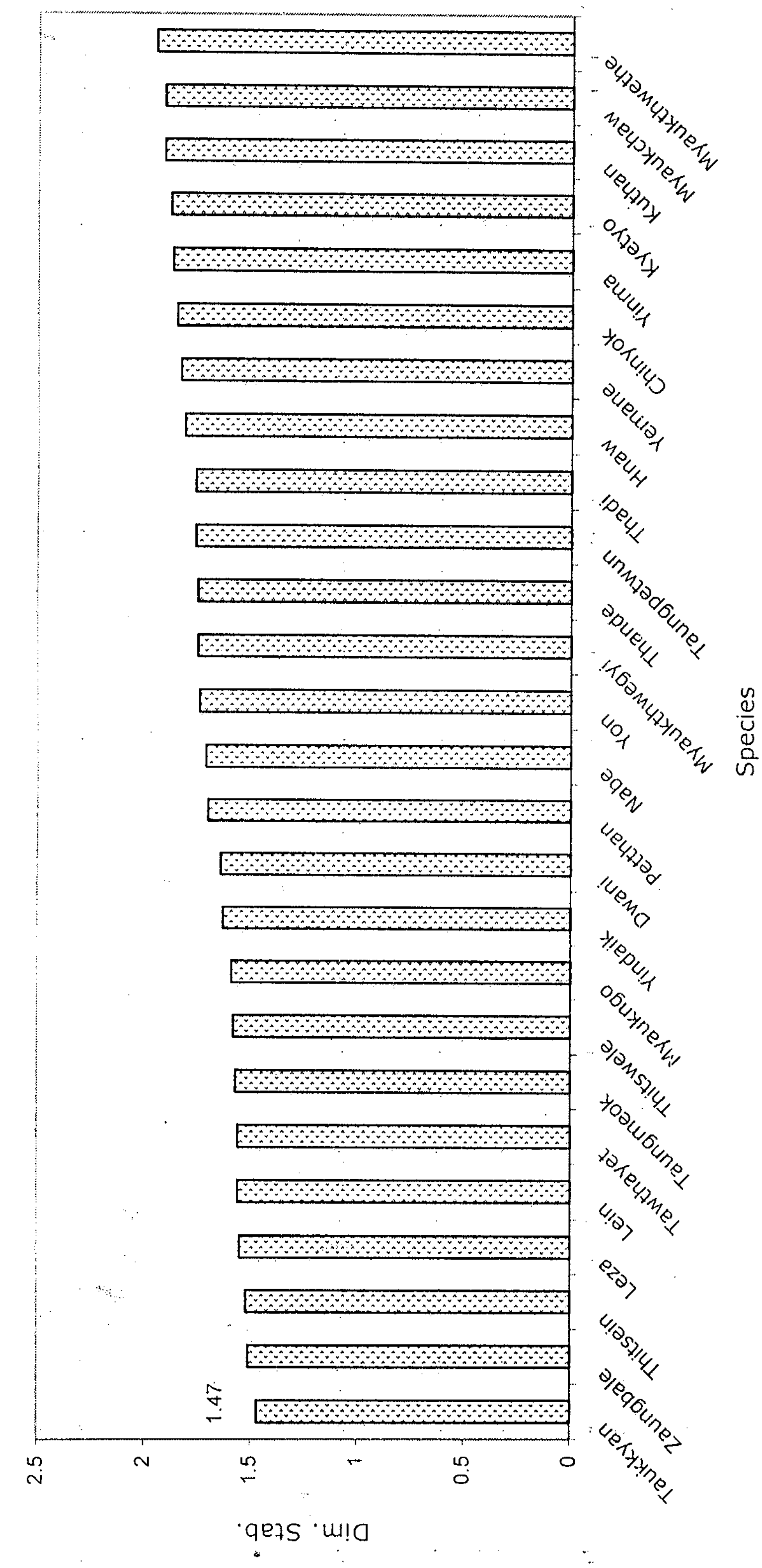
16
14
12
10
8
6
4
2
0
Thitswele
Zaungbale
Pyinma
Thingadu
Petthan
Leza
Ma-u-she
Taungokshit
Binga
Myaukthwethe
Taukkyan
Thande
Baing
Pyaukseik
Kyetyo
Lein
Thabye
Yon
Thitseint
Yinma
Yinzat
Yindaik
Thadi
Myaukchaw
Gyo
Panga
Thitpagan
Thitpayaung
Species

Fig. 2 (b)


Dim. Stab.
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0.5
1
1.5
2
2.5
1.47
Taukkyan
Zaungbale
Thitsein
Leza
Lein
Tawthayet
Taungmeok
Thitswele
Myaukngo
Yindaik
Dwani
Petthan
Nabe
Yon
Myaukthwegyi
Thande
Taungpetwun
Thadi
Hnaw
Yemane
Chinyok
Yinma
Kyetyo
Kuthan
Myaukchaw
Myaukthwethe
Species

Fig. 3 (a)

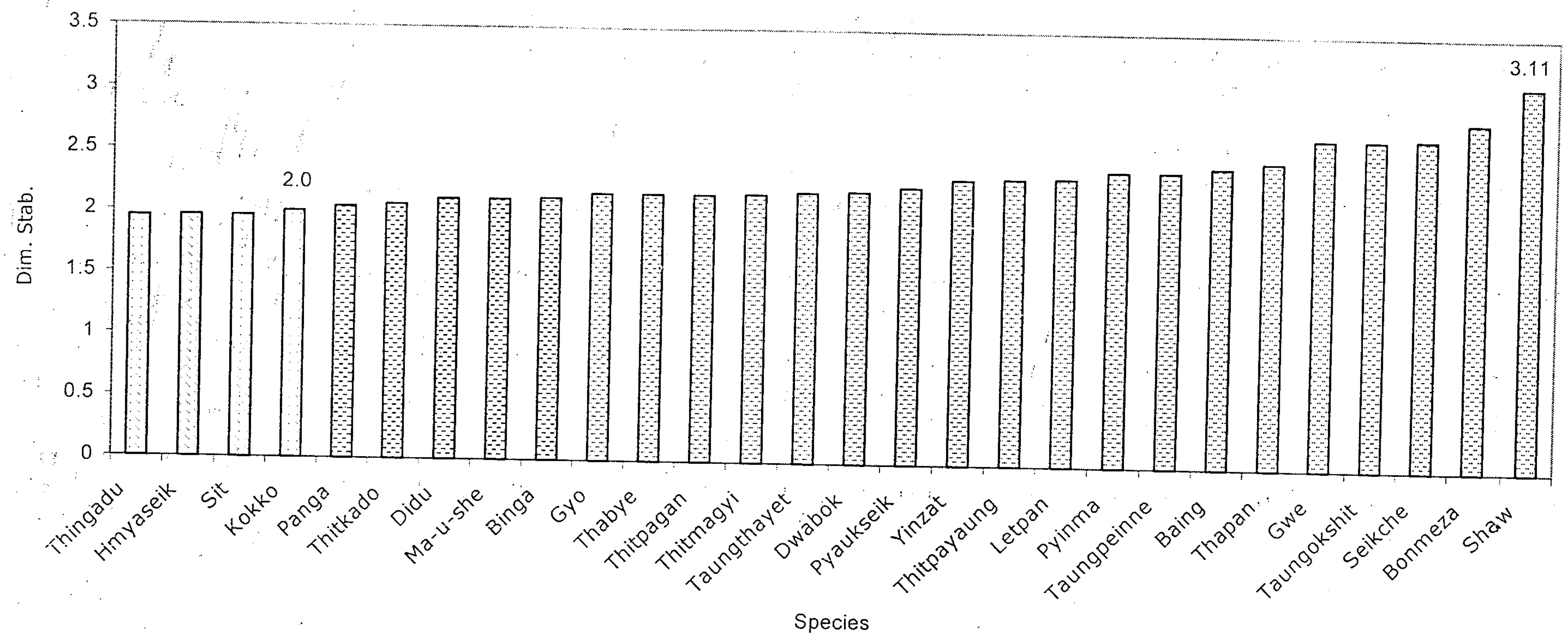
3.11
2.0
Dim. Stab.
3.5
3
2.5
2
1.5
1
0.5
0
Thingadu
Hmyaseik
Sit
Kokko
Panga
Thitkado
Didu
Ma-u-she
Binga
Gyo
Thabye
Thitpagan
Thitmagyi
Taungthayet
Dwabok
Pyaukseik
Yinzat
Thitpayaung
Letpan
Pyinma
Taungpeinne
Baing
Thapan
Gwe
Taungokshit
Seikche
Bonmeza
Shaw
Species

Fig. 3 (b)

Leza, Pethan, Pyinma, Thingadu, Thitkado, Thitmagyi, Thitswele and Zaungbale can be taken as the second best suited timbers among the tested LUS since their dimensional stability and tangential shrinkage are close to 2.0 and 7.0 percent.

It is to be expected that the degree of shrinkage across the grain would be more or less, proportional to the specific gravity of the wood since both are functions of cell-wall thickness. The ratio of tangential shrinkage to radial shrinkage appears to be more or less independent of structure (Brown & Panshin, 1952). From Table (1), it can be seen that dimensional stability of Bonmeza, Gwe and Letpan which have the lowest basic specific gravity among the tested LUS are found to be greater than 2.0 whereas dimensional stability of Kyetyo, Myaukchaw, Taukkyan and Yinma which have high basic specific gravity are found to be less than 2.0. Statistical analysis on simple linear regression method was tested on specific gravity Vs tangential shrinkage and specific gravity Vs dimensional stability. It was found that the tangential shrinkage of the tested 54 LUS are significantly correlated to the basic specific gravity at .05 α - level as shown in Figure (4). However, there is no correlation between dimensional stability and basic specific gravity of 54 LUS (Fig.5).

In this study, the selection of the best suited timbers is mainly based on the dimensional stability and tangential shrinkage. However, the mechanical properties such as MOE. MOR, compression stress, hardness have to be taken into account to get precise decision. For the decorative wood products, color, texture and feature of the wood have to be taken into consideration. The method applied in this study can be used as a quick and easy approach in selecting the suitable species from the newly introduced species. To get a comparison, physical properties together with the dimensional stability of some commercially important timbers of Myanmar are shown in Table (2). It can be seen that tangential shrinkage of Hmyaseik, Myaukngo, Sit, Taungmeok Tawthayet and Yemane are close to that of Padauk which is one of the most popular species for making fine furniture and construction materials in Myanmar.

Dimensional stability of some Malaysian timbers are computed based on the data obtained from " 100 Malaysian Timbers" (1986). These values together with the air-dry density, radial shrinkage and tangential shrinkage are given in Table (3). Radial shrinkage and tangential shrinkage given are based on the green condition to 15 percent moisture content. Therefore, care must be taken when these data are compared with those from Tables (1) & (2) where the values are based on green to oven-dry conditions. If the fiber saturation point of the Malaysian timbers is assumed as 30 % MC. radial shrinkage and tangential shrinkage can be estimated as twice of those values given in Table (3). By taking this estimation, tangential shrinkage and dimensional stability of Merpauh, Semayur and Ketapang are found to be less than 7.0 percent and 2.0 which are in agreement with the data of the aforementioned fifteen selected Myanmar's LUS. It has been reported that, these timbers are suitable for making high class joinery and furniture, interior finishing, paneling, partition, parquet flooring, boat construction, post, beams, door and window frames. Therefore, it can be expected that the

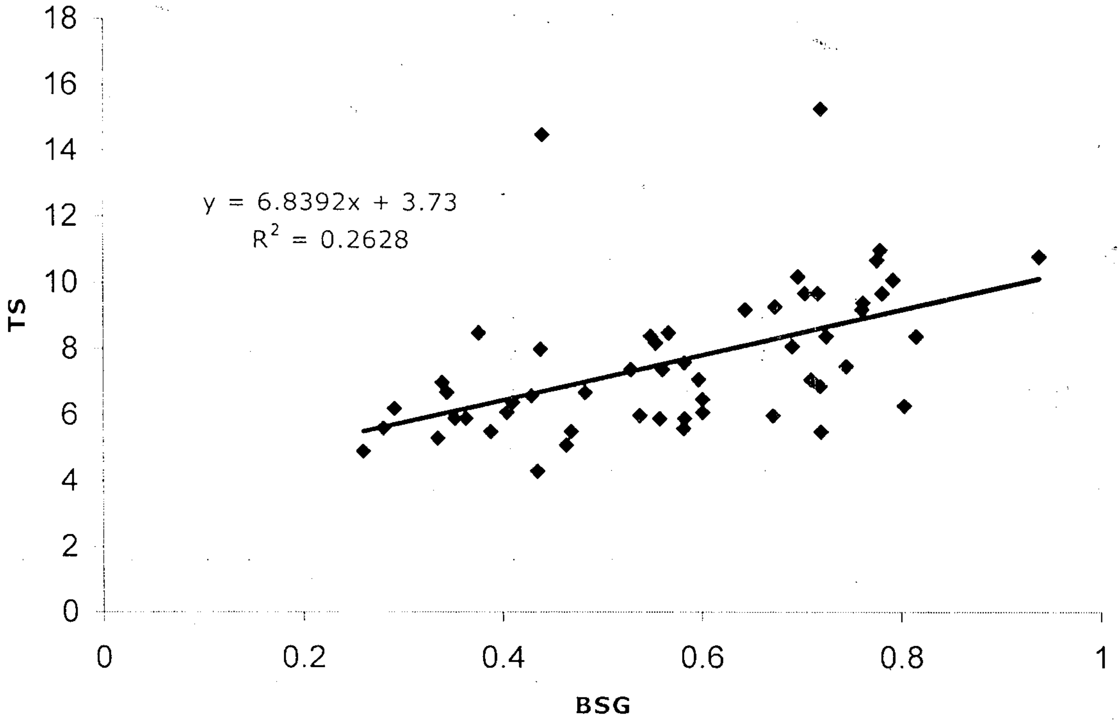

Fig.4 Correlation between Basic Specific Gravity and Tangential Shrinkage

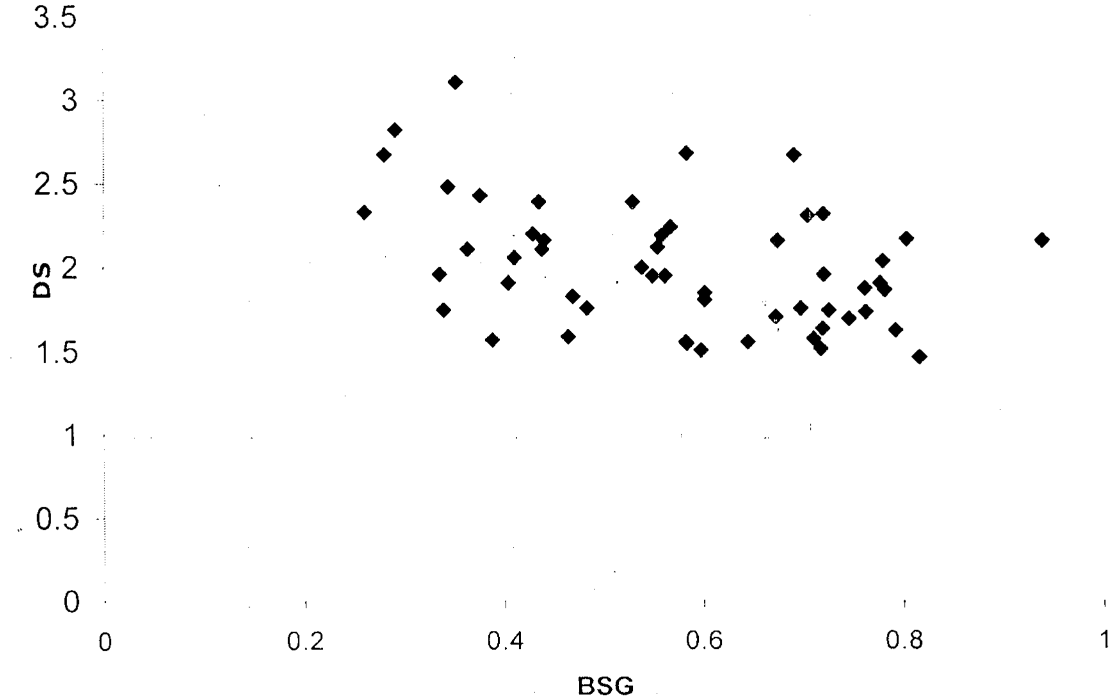

Fig. 5 The Relationship between Basic Specific Gravity and Dimensional Stability

fifteen selected Myanmar's LUS could be used as the above mentioned wood products.

Table 2. Dimensional Stability and Physical Properties of Some Commercial Important Timbers of Myanmar

Sr. No.	Species	Basic Specific Gravity	Shrinkage (Green to Oven-Dry)		Dimensional Stability
			Radial (%)	Tangential (%)	
1	Kyun *(Tectona grandis)*	0.598	2.3	4.2	1.83
2	Pyinkado *(Xylia dolabriformis)*	0.779	3.3	6.7	2.03
3	Padauk *(Pterocarpus macrocarpus)*	0.752	3.4	5.1	1.50
4	Thitya *(Shorea oblongifolia)*	0.858	5.4	9.7	1.80
5	Ingyin *(Pentacme siamensis)*	0.779	4.8	8.9	1.85
6	In *(Dipterocarpus tuberculatus)*	0.726	4.4	9.1	2.07
7	Kanyin *(Dipterocarpus alatus)*	0.574	3.6	8.6	2.39

Source: Physical and Mechanical Properties of Some Myanmar Timbers (1993)

Table 3 . Dimensional Stability of Some Malaysian Timbers

Sr. No.	Species	Air Dry Density Kgm^{-3}	Shrinkage (Green to Oven-Dry)		Dimensional Stability
			Radial (%)	Tangential (%)	
1	Balau/Selangan Batu *(Shorea spp.)*	850 - 1155	1.7 - 2.1	3.5 - 3.9	1.9 - 2.1
2	Balau, Red /Selangan Batu Merah (shorea spp.)	800 - 880	1.4 - 2.2	3.2 - 3.6	1.6 - 2.3
3	Gian *(Hopea spp.)*	865 - 1220	1.4 - 2.0	2.6 - 4.4	1.9 - 2.2
4	Kedang Belum/Tulang Daing *(Milletia spp.)*	595 - 815	1.4	3.8	2.7
5	Keledang *(Artocarpus spp.)*	495 - 945	0.8 - 1.0	1.7 - 2.6	2.1 - 2.6
6	Merpauh *(swintonia spp.)*	640 - 880	0.8 - 1.4	1.5 - 2.0	1.4 - 1.9
7	Semayur *(Shoria inaequilateralis)*	784 - 960	1.7	3.2	1.9
8	Alan Bunga *(Shoria albida)*	575 - 640	1.6	4.5	2.9
9	Ketapang *(terminalia spp.)*	385 - 850	0.9	1.6	1.8
10	Meranti, Dark Red /Obar Suluk *(Shorea spp.)*	560 - 865	1.1 - 2.1	2.9 - 4.4	2.1
11	Meranti, White / Melapi *(Shorea spp.)*	495 - 915	0.6 - 1.8	1.4 - 3.0	1.7 - 2.3
12	Meranti, Yellow /Yellow Seraya *(Shorea spp.)*	575 - 735	0.9 - 1.2	3.1 - 3.8	3.2 - 3.4

Source: 100 Malaysian Timbers (1986)

4. CONCLUSIONS

As a result of the study, the following conclusions can be drawn.

(i) Fifteen lesser-used timber species of Myanmar namely, Chinyok, Dwani, Hmyaseik, Hnaw, Kokko, Kuthan, Myaukngo, Myaukthwegyi, Nabe, Sit, Taukkyan, Taungmeok, Taungpetwun, Tawthayet and Yemane are found to be suitable for making high quality wood products. They have the market potential for both domestic as well as world market.

(ii) Tangential shrinkage of the fifty-four LUS are significantly correlated to their basic specific gravity at .05 α -level.

(iii) Dimensional stability of the fifty-four LUS are not correlated to their basic specific gravity.

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CONTENTS

INTRODUCING NEW SPECIES TO THE DOMESTIC AND EXPORT MARKETS

U Myo Myint Aung
Assistant General Manager
Wood-Based Industries Department
Myanma Timber Enterprise

SUMMARY

The utilization of LUS, has the potential to improve the economic value of topical forests.

The situation in Myanmar attempts at the introduction, and the obstacles and constraints to be encountered, are also presented. In the light of such circumstances, outlook for the future prospects, survey for the current domestic market, appropriate steps to gain effective introduction together with strengthening marketing efforts simultaneously will enhance to achieved the ultimate goal of successful introduction of LUS.

INTRODUCING NEW SPECIES TO THE DOMESTIC AND EXPORT MARKETS

U Myo Myint Aung, Assistant General Manager
Wood-Based Industries Department
Myanma Timber Enterprise

1. Introduction

The utilization of new timber species which were formerly lesser known or lesser used is significant. It is so because it has the potential to improve the economic value of tropical forests. It also increases the capacity of the forest for the sustained production of timber products: to develop added value product technologies, and to open up marketing opportunities for these products in both the domestic and international markets. It was also anticipated that the study might help to identify tropical forestry opportunities based on the use of new forest species. This in turn would contribute to improved forest management practice and forest ecosystem conservation.

2. The Myanmar scenario

By providing employment opportunities and earning a major portion of income from export, forestry functions as a major contributor to Myanmar's economy. There is an urgent need to capture the opportunities offered by specialized high value end-use sectors, markets for value added products, and for products made of new species which were formerly lesser known or lesser used.

3. Attempts to introduce the lesser used timber species to the world market.

3.1 The Forest Department of Myanmar, with the help of ITTO is at present implementing the ITTO Project PD 31/96 Rev 2.(M.F.1). The development objective is to increase the economic contribution of Myanmar's forest resources by emphasizing the introduction of underutilized timber species. There are also two specific objectives. (1) To gather information of lesser used species (LUS) for industrial planning purpose with particular reference to the stand class distribution and regeneration status. (2) Experimental scale introduction of 50-60 LUS to the market through indentification of wood properties and further processing.

3.2 A few examples of similar initiatives.

3.2.1 An ITTO project (PD 37/88) "Industrial utilization of New Forest Species in Peru" was undertaken by the National Institute for Natural Resources (INRENA) and the National Forestry Chamber, a private forest sector organization of producers, forestry professionals and conservation institutions. The aim of the project is to increase the economic value of forest resources and improving the returns and productivity of tropical forest utilization in Peru.

3.2.2 Utilization of Lesser Used Species (LUS) as alternative raw materials for forest based industries project PD 47/88 Rev 3.(1). The executing agency being the Forest Products Research and Development Institute (FPRDI) of Philippines.

4. Obstacles and constraints to be encountered

4.1 Lack of a sufficient quantity of a single specie in a particular area is the main obstacle for the economically viable use of a lesser used species. If continuity of supply is not assured, no lesser used species will ever be successfully introduced to any market at all. However, some of the LUS possessed properties equal or superior to known commercial species.

4.2 Constraints for forestry investments.

4.2.1 Uncertainty of the level of resources at divisional and sub divisional levels.

4.2.2 Uncertainty about the continuity of supply to support high level investment for domestic processing.

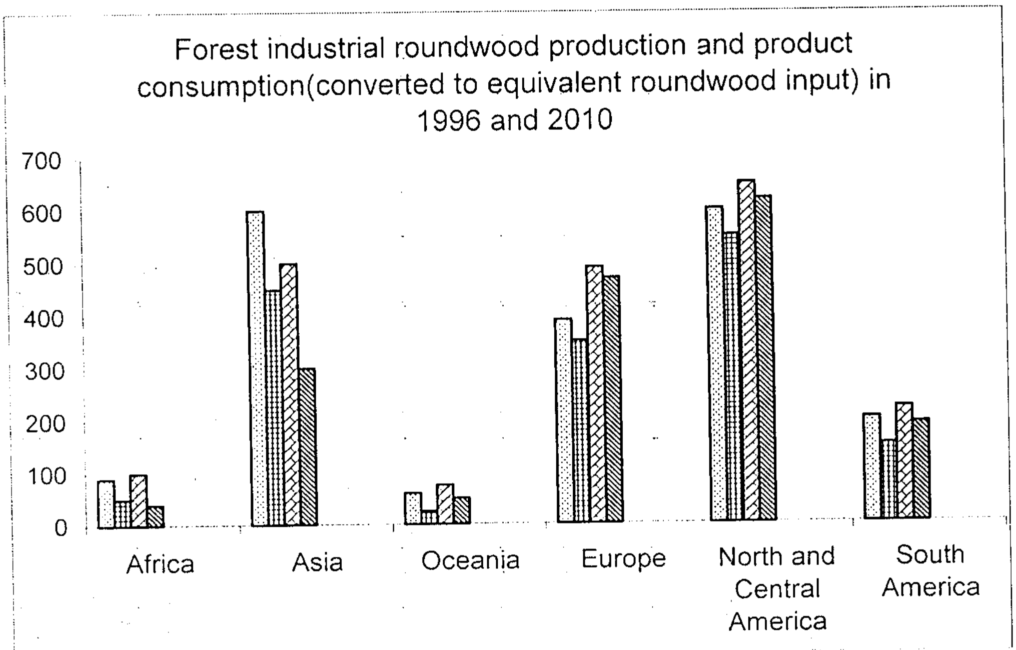
4.2.3 Lack of knowledge by the global market about the lesser used species of source country.

4.2.4 Multiplicity of merchantable species.

4.2.5 Lack of marketing strategy to solve marketing issues.

5. Situation and Outlook to the year 2010 for forest resources and roundwood supply.

5.1. Forecast industrial roundwood production and product consumption (converted to equivalent roundwood output) in 1996 and 2010.



A greater proportion of commodities such as sawnwood and panels will be processed further into furniture and joinery products. An expansion of domestic markets is expected as developing countries' economies grow and mature. This in turn will give rise to economies of scale in processing, product design, assembly, manufacture and distribution. The increasing specialization, market segmentation and competition will promote higher levels of trade, both within regions and internationally. The market for paper and paperboard is expected to have the most rapid growth. Production of pulp for paper is expected to grow by a lesser percentage. This reflects an expected increase in the use of recovered paper in the total fibber furnish in the future.

Source: State of the World's Forests 1990 (FAO)

5.2. Comparison of changes between 1995 and 2010 related to some indicators.

Continental South-East Asia: Changes between 1995 and 2010 related to some indicators

Unit	000ha								
	Forest and w. lands			Nat. exploit. forests			Plantations forests		
Country	1995	2010	%	1995	2010	%	1995	2010	%
Myanmar	47,124	42,062	-11	20,442	18,058	-12	519	894	72
Vietnam	23,084	22,122	-4	3,052	2,794	-8	1,050	1,950	86
Laos	20,800	19,000	-9	2,495	2,277	-9	11	26	136
Thailand	13,630	10,588	-22	7,957	5,609	-30	779	1529	96
Combodia	13,083	11,399	-13	4,984	4,341	-13	7	10.5	50
Total	117,720	105,172	-11	38,930	33,079	-15	2,366	4,410	86

Unit	00m3								
	Total fellings			Stock increment			Ratio SI/ felling		Weight*
Country	1995	2010	%	1995	2010	%	1995	2010	%
Myanmar	42,886	57,196	33	55,933	53,430	-4	1.3	0.9	36
Vietnam	35,516	46,862	32	25,736	34,615	34	0.7	0.7	29
Laos	4,583	6,481	41	10,539	9,737	-8	2.3	1.5	4
Thailand	33,807	39,736	18	28,224	34,547	22	0.8	0.9	25
Combodia	8,718	10,721	23	10,904	9,685	-11	1.3	0.9	7
Total	125,511	160,996	28	131,337	142,013	8	1.0	0.9	100

*Countries relative weight related to fellings by year 2010

Isular Asia: Changes between 1995 and 2010 relateed to some indicators

Unit	in 000ha								
	Forest and w. lands			Nat. exploit. forests			Plantation forests		
Country	1995	2010	%	1995	2010	%	1995	2010	%
Indonesia	139,950	126,922	-9	74,166	65,208	-12	5,184	8,434	63
Malaysia	20,327	15,556	-23	11,255	8,510	-24	155	305	97
Philippines	12,577	10,125	-19	2,202	1,605	-27	761	1,511	99
Total	172,854	152,604	-12	87,624	75,324	-14	6,100	10,250	68

Unit	in000m3						Unit		
	Total fellings			Stock increment			Ratio SI/ felling		Weight*
Country	1995	2010	%	1995	2010	%	1995	2010	%
Indonesia	194,183	234,173	21	201,804	228,356	13	1.04	0.98	73
Malaysia	47,163	35,035	-26	31,412	28,888	-8	0.67	0.82	11
Philippines	40,209	49,974	24	27,106	30,887	14	0.67	0.62	16
Total	281,554	319,182	13	260,332	288,130	11	0.92	0.92	100

*Countries relative weight related to fellings by year 2010

Unit	000ha
	Total country land area
Country	1990
Indonesia	181,157
Malaysia	32,855
Philippines	29,817
Total	243,829

Unit	000ha
	Total country land area
Country	1990
Myanmar	65,797
Vietnam	32,549
Laos	23,680
Thailand	51,089
Combodia	17,652
Total	190,767

6. Market survey for lesser used species at nineteen domestic markets.

A survey was carried out to evaluate the importance of different factors related to the introduction and acceptance of LUS. The study was undertaken at eight townships in the Mon State, four townships from the Ayeyarwaddy Division, four township from the Sagaing Division and three from the Northern Shan State. The survey is primarily based on observation of the present market situation of LUS from (201) furniture and household commodities mart. Studies have shown that it is of utmost importance to obtain gradual constant supply of LUS and extension on utilization of LUS is wholly related to knowledge and experience of end-users. Out of the (201) furniture marts and wood based industries visited, (73) used teak only, (128) was using teak and LUS. Yet it was very encouraging to know that (159) were willing to manufacture products of LUS.

7. Initiatives on value added processing of Taungtha-yet.

7.1 Santi Forestry Co., Ltd. of Thailand, a long time customer of the Myanma Timber Enterprise helped launch a renovation programme for processing at the No(3-K) factory of the furniture industries department. The LUS chosen was Taungthayet (Swintonia floribunda). High quality indoor furniture value adding processing was finally achieved. Initial shipment for export was made. Strong competition is foreseen in the world market among other species produced in a similar process. In any way, even if we may not be able to compete in the export market, we can at least promote increase sales in the domestic market, thereby releasing the more valuable teak for export.

7.2 Results from experiments in which a number of LUS were stained with a variety of appropriate colour of wood stains were also successful. This step forward will surely pave the way for further processing value added furniture out of LUS for domestic as well as export markets.

8. Appropriate steps to attain effective introduction of LUS.

8.1 Industrial research.

The selection of timber species should be based on their harvestable forest volume as determined through national forest inventories as well as their stem characteristics and technological timber properties. We should also consider the industrial processing of the various timber species with a view to assessing industrial yield levels, productivity, cost, technical problems and potential for the development of that would effectively compete in both national and international markets. Whatever variety of species were selected or obtained, they should be divided between the following industrial research areas: sawnwood; structural timber; tongue-and-groove joints; packing; dried and planed timber; plywood; decorative veneer; solid timber flooring; parts and components; and housing.

8.2 Technological properties.

Information on the technological properties of selected timber species must be obtained including data on basic density, shrinkage, stress grading, hardness, log-form, colour, grain, texture and tension. In addition, industrial processing characteristics of the selected timber species should also be studied, including sawing, natural durability, drying, preservation, workability and recommended uses which may extend to pulp, paper, and MDF etc.

8.3 Industrial yield and productivity.

Industrial yield, i.e., the percentage of end-product obtained from the raw materials (logs) should be ascertained for various species and industrial processes for the production of sawnwood, in terms of quality, log form and health and sawing thickness should also be considered. Industrial yield levels for LUS tested and industrial productivity levels achieved should be recorded and data should be provided for reference in further downstream processing.

8.4 Training programme.

Workshops and specialized courses should be held to address loggers, timber industrialists, carpenters and builders, etc. Specialized technical and marketing consultations on the use of the new timber species should also be arranged.

9. Strengthening Marketing efforts.

In the light of the above circumstances, while addressing all the needs to bring about a successful introduction , marketing efforts must also be attended to simultaneously . The most logical steps to be projected can be summarized as follows:

9.1. To assess the current and future supply of forest produce against the resource availability of Myanmar.

9.2. To estimate the current and potential future demand and market opportunities for the forest products of Myanmar.

9.3. To plan wood industries against the background of forest resources and global market demand.

9.4. To assess the specific market and marketing information needs in the Myanmar wood based industries in consistent with the government policies committed towards sustainable forest management, resource conservation, environmental protection, social and economic development.

9.5. To implement a management process responsible for identifying, anticipation and satisfying customer requirements profitably for both the private and state owned industries.

10. Conclusion

By strengthening marketing efforts, for catering in the above manner, the following benefits can be attained.

10.1 Releasing more locally available teak resources for export, especially to high value end use segments.

10.2 Marketing better use of available resources by introducing a mix of lesser known, lesser used species to the market.

10.3 Supporting value added downstream processing at cottage and industrial levels.

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CONTENTS

INTRODUCTION OF LESSER-USED TIMBER SPECIES TO THE WORLD MARKET: AN INDIVIDUAL'S PERSPECTIVE

U Kyaw Lwin
General Secretary
Myanmar Forest Products & Timber Merchants' Association

SUMMARY

Myanmar forests contains a wealth of LUS tree species. There are still some constraints to be worked out in the extraction, processing and research work. The most important is the institutional strengthening in the research and the governing body of the development of the healthy timber industry and marketing. Forest law enforcement and public participation will be prerequisite.

INTRODUCTION OF LESSER-USED TIMBER SPECIES TO THE WORLD MARKET: AN INDIVIDUAL'S PERSPECTIVE

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1. Introduction

1.1 In Myanmar forests, there exist a wealth of species with diverse silvicultural characteristics and wood properties. Among the (475) timber species identified by the Forest Department, there is a large number of species broadly termed as " Lesser-Used Species (LUS)" or species that are not yet put to its best advantage.

1.2 Due to growing scarcity of the more desired timber species, utilization of some of the LUS start to gain acceptance in the international market. In the case of Myanmar, there is a vast resource of LUS which may account for 75-80% of the total growing stock. However, in Myanmar, people engaged in the forestry sector have had considerable discussion and research publications on the utilization of LUS but very little have been done in planning and practical implementation on the marketing and commercial utilization of LUS. The present on-going ITTO Project PD 31/96 Rev.2 (M.F.I) will begin a new era for LUS and Forest Research Institute, Yezin.

1.3 Introduction of Myanmar LUS to the international market will consume a vast amount of effort on time, research work, dissemination of information, market strategy, market intelligence and follow-up matters to obtain international market share where the Malaysian and Indonesian LUS have already set foot. On the other hand it is obvious that the state sector alone cannot develop in the promotion and utilization of LUS. There should be a tripartite collaboration between the Forest Department (FD), Myanma Timber Enterprise (MTE) and the private sector.

1.4 Since LUS cannot have a beneficial return within a short period, there should be some incentive given to those who invest in the development of LUS. Private concessionaires should be allowed to extract, process, market non-teak hardwoods including LUS with the responsibility of setting up forest plantations schemes in the area.

1.5 Introduction of LUS is part of the development of the timber industry and markets. For this reason a whole scope of the forest based industries has been discussed in the paper. To develop a healthy timber industry there should be a governing body which will oversee and regulate, control, promote, improve, coordinate, encourage and assist in all the matter related to the timber industry.

2. Species Composition of the Natural Forests

2.1 With a total land area of 676,577 km^2, Myanmar is still endowed with one of the most extensive natural forest cover in the world with 43 percent of its land area under closed forests and when combined with degraded forests, the actual forest cover constitute 50.81 percent of the country's land area.

2.2 These forests are rich in plant species. There are 1347 species of big trees, 741 species of small trees, 1696 species of shrubs, 96 species of bamboo, 36 species of rattan and 841 species of orchids so far recorded (Annon, 1993). Out of the 2088 tree species, 475 species have been identified with 85 species classified into groups and have been accepted as producing multiple-use timber of premium quality. Table-1 shows growing stock position where it is numerically checked on tree species composition and number in different size classes.

Table 1- Species Composition and Tree Number (Stand Table)

Tree	Tree numbers in thousand in girth classes						Composition		Tree numbers/acre	
Species group	2'.0"- 3'.11"	4'.0" - 4'.11"	5'.0" - 5'.11"	6'.0" - 6'.11"	7'.0"& over	Total	%	No acre	6' & over	7' & over
TEAK	22759	9486	634	4078	3270	45933	6.21	1.95	0.31	0.14
Non-Teak Hardwoods										
Group I (6 Species)	73929	17571	10016	5884	7684	115084	15.56	4.88	0.57	0.33
Group II (6 Species)	103889	23446	11820	5939	7548	152642	20.63	6.47	0.57	0.32
Group III (6 Species)	58378	14073	7382	4131	5037	89001	12.03	3.77	0.39	0.21
Group IV (6 Species)	22723	6871	4083	2249	3206	39132	5.29	1.66	0.23	0.14
Group V (6 Species)	11832	2177	1064	530	816	16419	2.22	0.70	0.06	0.03
Group VI (6 Species)	21629	34315	15302	7487	8232	281623	38.0	11.93	0.67	0.35
Grand Total	509797	107939	56007	30298	35793	739834	100.00	31.36	2.80	1.52

Source: *Stand Table for Myanma (Pre-investment Inventory 1981-88) covering an area of 23,605,330 acres, Forest Department, Myanmar.*

3. Justification for Utilization of Lesser-Used Species in Myanmar

3.1 In Table -1, percentage composition of teak is only 6.21 % and the number of trees per acre is less than 2 trees. Even teak together with non-teak hardwood (NTHW) Group I and II species which are the premium timbers for domestic as well as for export, their composition is around 41% and only 13 trees per acre. When the selection felling of exploitable trees of girth classes of 7' for teak and 6' and up for NTHW are considered, it is only 0.14 trees/ acre for teak and 1.28 trees/ acre for teak together with Group I and II hardwoods.

3.2 This sparse population of valuable exploitable trees in our natural forests will certainly pose a big problem for the future.

3.3 From Table – 1, Lesser-Used Species (LUS) of hardwood group III, IV, V and VI combined to a total composition of 59% and 18 trees per acre. Trees of girth class 6' and up is 1.34 trees per acre. Successive commercial logging of teak and NTHW groups I and II will result in increasing the composition percentage which will proportionately thicken the population of non-merchantable trees in our natural forest.

3.4 Table –2 describes the Annual Allowable Cut (AAC) for NTHW as 3,236,071 cubic meters. Since the present harvesting volume for NTHW is 1621800 cubic meters, there is still a sufficient room to harvest LUS species.

3.5 In Myanmar, extraction of LUS can be implemented together with the existing logging operations. Therefore, there will be no additional cost added to the extraction cost. In fact, extraction and utilization of LUS will enhance yield per acre and this can even be expected to reduce extraction cost to a certain extent. In addition, the Forest Department will also have the advantage of silvicultural operations as improvement being carried out by felling LUS trees provided the extraction of LUS will not damage the environment to an unacceptable level. If Myanmar LUS are marketed with firm marketing plan and least marketing error, they will be widely accepted in the market. Furthermore, foreign investors and local manufacturers should be encouraged to invest in the wood industry and manufacture finished products and components utilizing LUS. In Myanmar, there are (5) plywood mills and (85) public owned (30) cooperative owned and about 20000 private owned saw mills mostly recutting mills. Myanmar has neither Particle Board nor Medium- Density Fiber board (MDF) plant and no wood chip industry. If LUS utilization is the case, wood-composite industries including the above mentioned are good prospective wood-based manufacturing businesses which should be considered. In the long run, with wider domestic acceptance of commodities produced from LUS, our country will be able to increase export of value added products made from high valued timber species.

Table – 2 Annual Allowable Cut (AAC) of Teak and Non Teak Hardwoods (NTHW) by State/Divisions (1996 estimates)

State/ Division	Teak			Non Teak Hardwoods (NTHW)		Remark
	No. of trees		Volume in cubic meter (1996)	No. of trees	Volume in cubic meter	
	up to 1996	Revised in (1996)				
Kachin	14,000	11,300	32,588	45,600	82,189	
Kayah	3,850	3,850	5,551	21,600	38,932	
Kayin	7,860	7,860	24,084	8,800	15,861	
Chin	5,280	2,640	9,041	8,700	15,681	
Sagaing	33,170	35,000	126,168	452,800	816,123	
Tanintharyi	-	-	-	99,300	178,978	No teak forest
Bago	42,070	19,670	77,997	400,221	721,358	
Magway	31,260	6,560	21,282	383,046	690,402	
Mandalay	14,370	6,920	23,697	176,757	318,587	
Mon	550	-	-	18,100	32,623	Teak forests depleted
Rakhine	-	-	-	45,000	81,108	No teak forest
Yangon	1,150	250	901	6,000	10,814	
Shan	23,110	25,000	72,096	54,800	98,772	
Ayeyarwaddy	2,080	1,170	3,374	74,700	134,639	
Total	178,750	120,220	396,779	1,795,424	3,236,071	

Source - *Forestry Fact Sheet, July, 1996*

4 My Past Experience

4.1 In 1994 one irrigation project was undertaken near Okkan village in Yangon Division. Myanma Timber Enterprise (MTE) took charge of clear cutting and stumping at the dam site. Majority of the felled species can be widely categorized as Lesser-Used Species. The Ministry of Forestry assigned Myanmar Forest Products Joint Venture Corporation (MFPJVC) to implement log hauling from car base landing points to all weather road head. During the log hauling season of January to May 1995, FJVC hauled about 8000 hoppus tons of logs comprising about 60 LUS species. Since it was from the clear cutting area, the harvested logs are of mostly bad log form and shape.

4.2 FJVC decided to sell the logs to the local timber industry on whole lot package basis at a reasonable price. In 1993, I set up a timber products factory jointly with a foreign company to produce value-added timber products. As we can utilize LUS species in manufacturing the products, we decided to purchase about 6000 hoppus ton (10800 cubic meters).

4.3 During the log hauling job to our wood products factory, it was found that logs were scattered along Phalon village, on the agriculture land and in the paddy fields. After completing final negotiation with FJVC we started to haul the logs to the factory in August 1995. The hauling was done in the raining season and took about four months. Saw milling of these LUS logs took about (2) years during which some of the non-durable logs perished. From this we can evaluate the following-

- High transportation cost compared to the timber value.
- Logs attacked by insects and fungi due to no treatment with preservatives at the time of logging.
- Logs hauled out form the forest 4-6 months after felling due to inaccessibility during the raining season.
- Saw milling outturn low due to various defects such as pin holes, borer holes and stains form fungal attack.
- Difficulty in drying of some species.
- Difference in density of the species makes unable to utilize mix species in a product.

5. Utilization of Lesser-Used Species –Pre-requisite requirements

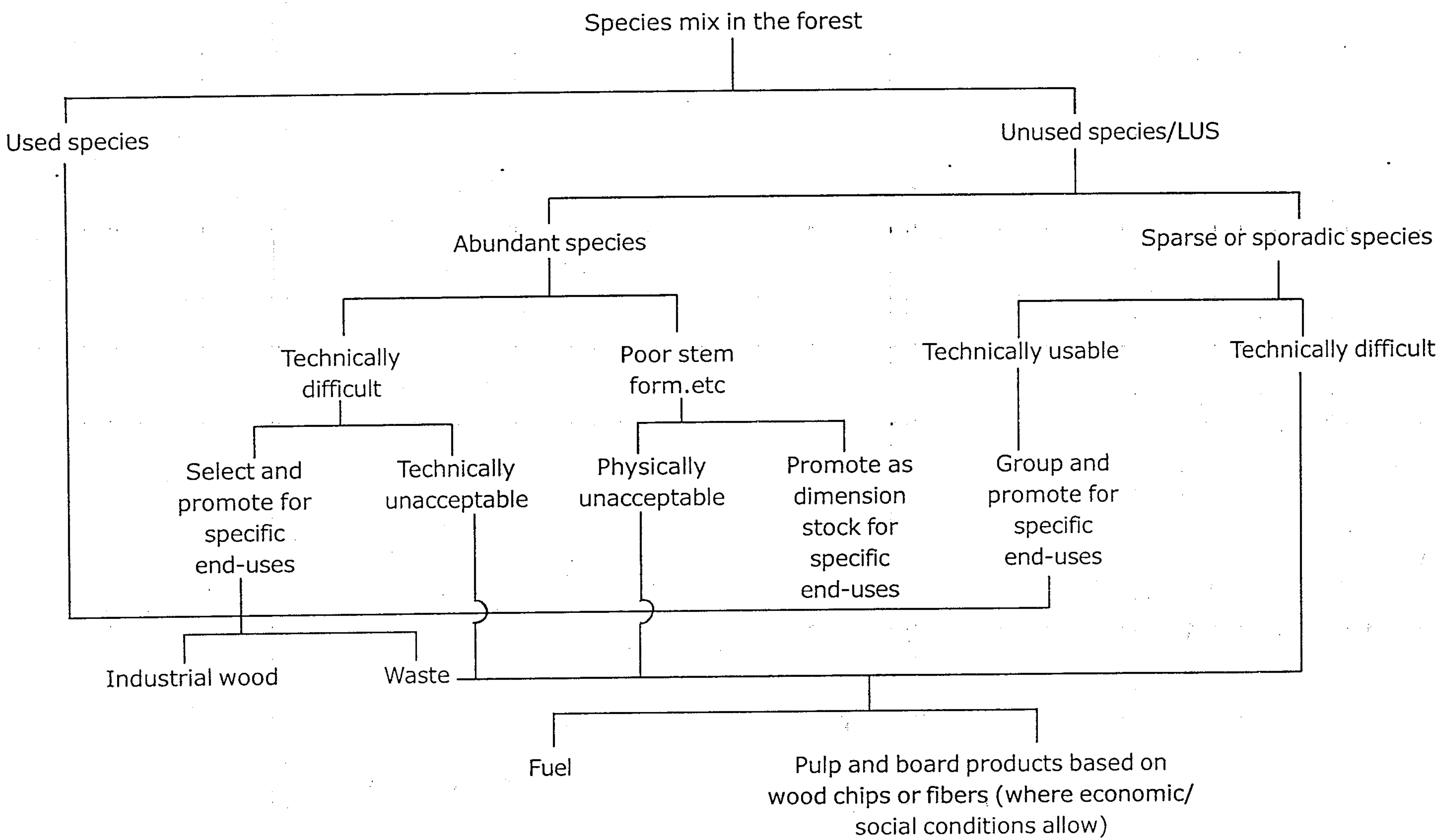
5.1 The Stakeholders

5.1.1 Among the three sectors involved in the timber business / industry in Myanmar namely, MTE, FJV and private sector, the latter is presently the weakest in terms of technology, investment, exposure to the international market and human resource. Whoever is assigned to initiate the development and utilization of LUS, there are important requirements and constraints that needs to be sorted our as a prerequisite.

5.2 Segregation for the Utilization of Lesser-Used Species

5.2.1 Figure (1) outlines an operational procedure to approach the various stages involved in promoting the utilization of the LUS (Brazier, 1978). The first stage is to group the LUS into species of abundant and sparse occurrence. The non-utilization of the abundant species is normally indicative of either technical difficulties or poor stem/timber quality or form. Those with technical constraints need careful evaluation in order to select and promote for specific end-uses, while LUS with poor stem or timber form quality could be evaluated and promoted as dimension stock among other things. Sparse LUS have to be studied with a view to group and promote them for specific end-uses. At the lower end of the utilization chain, LUS are used as raw material for pulp and board products based on wood chips and lastly as fuel wood.

Figure -1 Operational procedure of promoting the utilization of the Lesser Used Species



Source: Brazier, 1978

5.3 Resource Base

5.3.1 National Forest Inventory data should provide information or resource base in order to be able to classify the LUS into abundant and sparse species. It is quite difficult to define these two groups quantitatively, but availability of about $1000m^3$ per year has been suggested as a possible dividing line (FAO, 1976). But for Myanmar condition, it is a point to be considered. In addition the inventory data should indicate total volume species wise for each forest division to facilitate subsequent promotion, industrial investment decision and marketing for which continuity of supplies at predictable levels mush be assured.

5.4 Properties Data

5.4.1 Under ITTO Project PD 31/96 Rev.2 (MFI), physical and mechanical properties, anatomical features of (58) LUS species are determined. Since LUS can be utilized in the manufacture of particle board and medium-density fibre board (MDF), wood pH value, extractives, extraneous material and wood chemical properties such as contents of cellulose, hemicellulose, ash etc, should also be carried out.

5.5 End-Use Grouping

5.5.1 Various authors have emphasized on the marketing of LUS by end-use grouping rather than by species such an approach provides a product rather than by species. As an example in Malaysia, under the name of 'dark Red Meranti' some 408 timber species have been introduced to the international market (FEC. Yeom). A few hundred of other mixed species have been marketed as Mixed Light Hardwood (MLH).

5.5.2 In determining the end-use grouping, property requirement for end-use are considered to be vital. An end-use classification defines significant properties in qualitative and quantitative terms for each type of timber product, so that timbers meeting such requirement can be expected to give a satisfactory performance (Brazier and Wester 1977). Timber with roughly equivalent properties can thus be grouped and marketed together for a particular end-use.

5.5.3 The single most important end-use can be assessed from the demand in the international market. If veneering is the important end-use, wood grain formation, color, texture, peeling and slicing characteristics properties are of prime importance. If for moulding and furniture, wood density, color, texture, drying characteristics, timber movement, and finishing results are to be considered. If composite wood is the end use, wood density, pH value, wood chemistry, chipping characteristics are vital. For housing construction and structural application, drying properties, mechanical properties and timber movement shall be considered.

6. Marketing

6.1 If I have to quote from an UNIDO publication " The objectives of the industrialisation can be achieved not by establishing the mills and factories, but by developing the markets. However, penetrating a new market is not that easy." In the international timber trend, end-users as a whole might be skeptical about the benefits which they could derive from using "new" LUS to their commercial species. They will be reluctant to look actively for LUS species. Therefore, they tend to wait until the availability of their usual timber species becomes problematic and thus hastily start looking for alternative species. Therefore there is strong opinion that the major problem of the LUS is not technical, but lies in the marketing area.

6.2 LUS producers should build up dynamic, aggressive and resourceful attitudes in promoting to market the LUS. The marketing of LUS involves a series of activities such as extraction, grading, etc. in a chain of processes. Hanson (1983) discussed various aspect of industrial marketing of forest products and emphasized the need for LUS having a price advantage over species with similar properties, particularly through marginal pricing. However Kalafatis (1985) stressed that each LU species compared with a specific market established species on the following aspects namely; price, supply condition, job suitability, shipping and grading. The analysis of the comparisons showed that price advantage alone was not sufficient to make LU species successful. Rather, it was found that suitability for a specific use, combined with price advantage were of prime importance.

6.3 Kalafatis (1985) stated that producers can do little to influence overseas end-users because they do not possess the expertise and intimate knowledge of end-users. It is therefore, obvious that ultimate responsibility of the marketing of LU species will also rest with timber merchants.

6.4 The fact that market are so fragment and the considerable variation of products means that the customer-supplier relationship is very important. Obviously, there are no simple answers for improving the utilization of the LUS. Co-operation and understanding between consumers and producers are indeed vital.

6.5 From the above, it is obvious that developing market information network is of prime importance to touch the international market. To operate this network needs reports from professionals, periodical market reports such as the ITTO Timber Market reports, reports from Myanmar Embassies. Simultaneously, based on the research finding, dissemination of information has to be carried out to the embassies and potential timber dealers worldwide. After studying the market information feed back reports, selected dealers should be appointed as commissioned agents.

Recommendations

7. Institutional Strengthening

7.1 Forest Research Institute Myanmar

7.1.1 Forestry research was an old activity in Myanmar and subsequently strengthened with the establishment of the Forest Research Institute (FRI) in Yezin, Pyinmana in 1978. FRI is in fact, a department under the Forest Department. While the world's population is increasing and the timber demand and consumption on the ever ascending trend, it is imperative for effective and increased utilization of forest resources. The global issue for sustainable forest management is the responsibility of the producer countries. In this respect a strong and effective role of forest research is essential for the sustainable forest management. Forestry research is mostly academic in nature and needs to be user driven. Forestry research touches the whole range of forestry activities and should be aware that forestry research work should goes in equilibrium with the other sectoral activities. Research programmes continuity is often lost as the researchers are transferred to the Forest Department on a rotational basis. Ultimately, the FRI suffers from a clear lack of staff, equipment, financial and research plan/programmes to identity research priorities for the short, medium and long term needs of the country.

7.1.2 In the light of this, it would be a very positive and correct step for the country to study the feasibility of assigning the Forest Research Institute an independent entity or department with its own staff of dedicated scientists and researchers.

7.1.3 The Forest Research Institute Myanmar should have the following objectives.

- Recruit dedicated persons and send abroad for higher degrees and qualifications which would give maximum benefits to research works.
- Draw short term and long term research plans/programmes to develop appropriate technology for the conservation, management, development and utilization of forest resources.
- To provide research-based services to meet the needs of the industry.
- To commercialise Research and Development findings and results.
- To acquire and disseminate information.
- To create awareness on the environmental and conservation roles of forestry.

8. From Firm Market to Healthy Industry- The Governing Body

8.1 MTE, FJV and private sector combined, Myanmar is exporting approximately US $ 200 million worth of timber product mainly teak log. MTE is the leading organisation in Myanmar with regard to timber business. During the last (50) years of establishment of MTE, it has not developed wood industry to a satisfactory level due to various circumstances. According to MTE export data of 1996/97, value-added timber product export was 2 percent of the total export value which is very low compared to the super structure of MTE.

8.2 With regard to the whole timber industry of the country, it is of urgent matter to promote, improve, co-ordinate, encourage, assist regulate and control for the development of the wood industry. Although the Myanmar Forest Products and Timber Merchants' Association which is a private sector association exists, the private timber business/ industries are unorganized and MTE is beset with its own task of fulfilling its annual target of foreign exchange earning, there is a question that who is there to promote, improve, coordinate, encourage assist regulate and control for the development of the wood industry.

8.3 The Ministry of Forestry has been putting a generalised effort for the development of wood industry which will not be enough. Forestry is a large sector with a variety of products and markets. Each product requires aggressive efforts to promote and develop. The amount of work will be too big. In this instance a specialized organization will be required to oversee and monitor the whole timber business and industry as well as export. This will include the LUS promotion. This organization can be formed under the guidance of the Ministry of Forestry. The members shall be from the Ministry of Forestry, Forest Department, Myanma Timber Enterprise (MTE), Myanma Forest Products Joint Venture Corporation (MFPJVC), Myanma Forest Products and Timber Merchants' Association.

9. Timber Industry Restructuring

9.1 To obtain a stable and firm markets share of Myanmar LUS in the international market it will take a long period of time. Ultimately logging, saw milling and timber processing production management, costs and others will be the same volume of time and cash to be utilized compared with teak. Private sector business is to make profit. So for the introduction of LUS private sector would be quite reluctant to take up the LUS alone. Instead, in line with the market-oriented economy, private sector should be permitted to work under lease/concession system to extract all merchantable size hardwood including LUS within the Myanmar selection system. Subsequently, the concessionaire will have the obligation to set up forest plantation schemes within the area. The concessionaire will have the right to saw-milling, processing, domestic sales and export value-added products.

9.2 In Myanmar more than 80 percent of the industry are Small to Medium Enterprises (SMEs). It is apparent that SMEs play a leading role in the country's economy. Also in the forestry sector, it would be very beneficial for the country and the enterprises to promote SMEs. In this instance SMEs can sustainably rely on the concessionaires for the supply of LUS timber raw material.

10 Public Participation and Transparency

10.1 Every private sector person as one of the stake holders should participate in the events of the forestry sector activities. Promotion of private initiative means promoting socio-economic values and it is directing a country towards the right direction of development. Government sector cannot alone struggle through the economic turmoil. She has to rely and struggle together with her people and survive together.

10.2 For increased participation of private sector in the forestry activities, it will also need to educate them. Educating the public on the vital role of trees and woody vegetation, wildlife and national parks in socio-economic development, forest conservation, logging code of practice, timber industrial processes and lastly sustainable forest management and timber certification including chain of custody.

10.3 Transparency and intimation should be built up between the departments under the Ministry of Forestry FJV, and the Timber Merchants' Association (MFPTMA). There should be periodical meetings, seminars, workshops and exchange views and information and joint marketing. These activities will contribute to more understanding and will lead to the development of the country's forestry sector which will automatically include the promotion of LUS.

10.4 Simultaneously, together with the above, forest law enforcement is imperative. It is certainly necessary that the capacity and authority of forestry enforcement officials, as well as their effectiveness in actually apprehending and punishing forestry violations. Reward system to keep down the illegal trade should be re-introduced and all service personnel in these operations deserve to be honoured in kind and with accelerated promotion.

11. Future ITTO Projects

11.1 With the kind assistance of ITTO that this ongoing project has been implemented successfully. The research work done under this project is quite comprehensive. However, there are still some works to be extended for further enhancement of LUS market development.

11.2 With the present trend of technology and sustainable forest management concerns, utilization of wood composite is increasing. In the scope of the present project in Myanmar, determination of wood chemical characters has not be included. This is very important for the composite wood as wood chemistry of each species will have huge effect on the cost of composite production.

11.3 ITTO should extend this ongoing project into the second phase project touching the marketing aspect.

12 Conclusion

12.1 Intensive research work on timber characteristics and properties, market intelligence and marketing-network is a vital parameter in the introduction of Myanmar LUS. It would be beneficial only if the research findings are disseminated for commercial application. We have to be aware that Globalization and regionalisation is coming into effect and we have to catch up for good with the changing trend at a faster pace. As our country still needs to develop its own wood industry, the author have the concept that proper utilization of LUS and other species including teak cannot be differentiated. It should come together to save the forest resources and the eco-system.

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PART III

THE PLENARY SESSION

The plenary session was held at 1300 hr. in the Taw Win Convention Hall. It was headed by the following chairpersons:

1. Dr. Hwan Ok Ma, Projects Manager, ITTO,
2. U Myat Thin, Advisor, Ministry of Forestry,
3. Mr. Songsak Vitayaudom, Chief of Planning Division, Royal Forest Department, Thailand,
4. U Htein Win, Deputy Managing Director, Myanmar Forest Products and Timber Merchants' Association.

The session was introduced by Dr. Hwan Ok Ma by reviewing the recommendations made during the previous National Workshop (1999) in Yangon. Respective groups had raised three key issues and the members of the group had proposed recommendations. Recommendations on the first issue, "Improvement of Logging Practices to Promote LUS Market", had been presented as follow;

1. to conduct forest inventory and dissemination of information on availability of LUS,
2. to review girth limit of LUS,
3. to privatize harvesting of LUS gradually,
4. to speed up logging and transportation of LUS, and
5. to develop extension services, R & D, and transportation.

Recommendations on the second issue, "Proper Utilization and Processing of LUS", had been proposed by the second group and the recommendations were;

1. to strengthen capacity building in timber research and extension,
2. to organize short training courses and to establish permanent training schools for technology know-how of wood science,
3. to develop grading rule for LUS,
4. to promote establishment of wood-based industries, and
5. to form a National Timber Advisory Board.

The third and the last recommendations had been proposed by the last group on the issue of " Trade Promotion of Domestic and Regional LUS Products Market ". The recommendations were;

1. to collect and disseminate market information of world timber trade,
2. to develop groupings of LUS according to the end-uses,
3. to consider long-term concessions for *bona-fide* timber traders,
4. to initiate domestic trade before attempting LUS export market,
5. to develop short, medium and long term strategies to infiltrate export market,and
6. to conduct market research

Then the session was continued to discuss four major agendas presented in this workshop as shown below;

1. forestry aspect,
2. research on LUS promotion,
3. timber harvesting and processing, and
4. strengthening marketing effort.

Under the "Forestry Aspect" four issues have been identified such as;

1. availability of resource information on LUS
2. current status of forest management system on harvesting of LUS and other hardwoods
3. timber certification process and C & I for LUS in line with SFM and environmental conservation and
4. people's participation and poverty alleviation.

Responding to the issues a number of discussions have been made by the participants. Highlighted points were; to develop a field manual for forest inventory to enhance the inventory work more reliable, to include bole length by tree species and correct identification of species in forest inventory, to introduce GIS techniques to survey the extent of forest cover and the quantity of LUS in a relatively short period, either to modify the programme of harvesting to extract LUS as quickly as possible or to use fungicide spray on the logs at the time of felling in order to prevent deterioration, and to relocate the portable saw mills near the forest so as to hasten the process of extraction and conversion of LUS, to develop groupings of LUS depending on end- uses since individual species of LUS is scarce for commercial exploitation, to review the girth limit of LUS for commercial exploitation of LUS, and to enumerate and include the future yield of LUS in the district management plan.

Then the session was continued to discuss with the Certification and C&I of timber and timber products. In **Myanmar Timber Certification Committee** was formed in 1998. Since Myanmar become the member of ITTO the process of formulation of certification is mainly based on the ITTO guidelines. The participants agreed upon the importance of peoples' participation on SFM. Controversial outlooks have been discussed on how people could be able to manage the valuable forests without having any knowledge of resource management. It was agreed that without public awareness on the value of natural resources nobody can manage the forest properly. It was continued that eventual privatization of forests could be one of the options to solve the problem.

Then the session proceeded to the next agenda, " Research on LUS Promotion". Out of seven issues proposed by the respective committee it was decided by the panel of chairpersons to combine some overlapping items to form only five issues as,

1. identification of research areas on LUS,
2. human resource development and promotion of research career,
3. upgrading research facilities and technology,
4. international co-operation and collaboration, and
5. technology transfer and education.

The resource person from the Philippines presented the experience of similar ITTO project. Among others 25 to 30 species of LUS had been identified worthy of further investigation for probable end-uses during the pre-project period. One of the problems facing the utilization of LUS is kiln drying of mixed species. After through examinations three characters,

1. initial relative density or specific gravity,
2. initial moisture content, and
3. lumen width influence the rate of drying.

Having these properties examined it is easy to predict the drying rates of timbers. Timbers could be divided into three groups for kiln drying depending on their rate of drying. Those dry less than 0.4 % moisture content per hour is considered very difficult to dry and those dry more than 0.5 % moisture content per hour is considered easy to dry, in between them is regarded as moderately difficult to dry. The resource person from Japan suggested that to extend the drying period one-day more than the normal schedule. One Myanmar participant recommended that market research is very important that it should go parallel with the property research.

Regarding the second issue, " HRD and promotion of research career", a number of Myanmar participants pointed out that FRI has insufficient qualified and permanent staff which reflect the need of incentive and various supports. According to his experience the Philippines resource person suggested that two different careers, scientific and administrative, should be divided permanently and the scientific part should be given qualified staff and adequate incentives. The resource person from CSIRO, Australia suggested to develop strong ties between the University and other academic institutions to fill up the gap of insufficiency of qualified researchers instead of waiting long period for HRD. Many participants recommended that research results should be commercialized. One chairperson suggested that some mechanism should be developed rather than formal means. He said it would require reviewing the regulations in order to open up the window for private sector.

Then the session opened the floor to discuss the fourth issue, " upgrading research facilities and technologies". Most of the discussions under this issue focused on poor telecommunication accessibility between the research institute and other parts of the countries. One suggestion was made by the Philippines resource person that to form a **Technical Advisory Board** which may include representatives from wood industries, research institutions, universities, etc. This board would hold regular meetings to provide suggestions relevant to the progress of forestry research.

The session went on to discuss matters relating to " International co-operation and collaboration" issue. Many participants pointed out the need for modern communication facilities such as fax, e-mail, web site, etc. for the development of research. Having these facilities researchers all over the world can contribute their opinions and exchange knowledge. One participant from Myanmar pointed out the need for regular attendance to series of international workshops and meetings only by the respective responsible parties so that each party could be able to keep in touch with the progress of the subject. Shortage of fund to attend the various international conferences and meetings is another draw back for the development of co-operation among the scientists. The resource person from the Philippines suggested that Myanmar should join the international organizations as much as possible as a member country. Most international organizations provide fund for the developing countries to attend the meetings. ITTO representative suggested that development of regional co-operation such as ASEAN is very important. He added that there are several areas of research projects to be identified even in the regional scale.

Regarding the final issue " technology transfer and education, " one participant stressed the need for educating local populace who are closely related to the forest. Several arguments have been made among the participants regarding the level of the technology transfer and education. Finally, it was agreed upon that there are many modes of translating this issue such as establishing a training for industrial workers, dissemination of information, distribution of publication, providing technical assistance, giving consultation free of charge and so on.

Then the session continued to proceed to the third agenda, " Harvesting and Processing ".

Although seven issues were proposed under this agenda a number of issues were recategorized under appropriate agenda. So there were only two issues to be discussed under this topic as:

1. Privatization of LUS harvesting, and
2. Increased utilization efficiency of LUS

The issue, " privatization of LUS harvesting " was discussed in detail by a private entrepreneur. He explained that LUS commercialization in Myanmar is in its juvenile stage. At this moment cost and benefit ratio is too high that the private sector could not harvest LUS alone economically. He added that it would be possible if private sector is allowed to exploit both LUS and commercial hardwoods simultaneously. Even then subsequent felling of trees by private sector after extraction of teak by MTE in the same area could damage the forest. And, if two agencies work together on the adjacent forest would create the problem of differences labour cost. Therefore, privatization of LUS harvesting, at the moment, should not go too wide. Only feasibility study should be made in a selected area where assessment of timber certification process had been made. Only the selected *bona-fide* timber traders should be allowed to harvest the timber. The principal chairperson added that actually all species at limited girth is obligatory to be cut by MTE. But due to various constraints only the premier species are being harvested.

Regarding the second issue, " increased utilization efficiency ", one private sector personnel requested that authorities concerned to reconsider the limit of recovery rate of timber products depending on the efficiency of manufacturing. It varies widely from lumber to flooring pieces. They should not be categorized in the same order of product recovery. Reconsideration of this factor would greatly enhance down stream production of timber products and hence increase the utilization efficiency. The resource person from Japan proposed that to increase the utilization efficiency of LUS there are many ways to do it. For instance, making charcoal from the forest and factory waste and fertilizer from the bark of the logs. Japan is using such kind of bio-fertilizer but it takes long time to make it. In tropical countries it would be much easier to do it.

The fourth and the final agenda was, " Strengthening Marketing Effort for LUS ". After several discussion four issues were identified as:

1. Improvement in dissemination of information,
2. Consistent supply of quality products,
3. Development of marketing strategy, and
4. Training on marketing efficiency.

With respect to the first issue, " improvement in dissemination of information", the ITTO representative pointed out that it is very important to promote LUS market and through information service there are many ways to disseminate information. For instance, trade promotional materials such as video tape, pamphlets, handbook, wood samples and database CD-ROM produced by this project are very effective materials for information dissemination. Such information should be disseminated worldwide or at least locally. In this connection, he suggested, to establish an association responsible for publication of news letter, updated market information regularly. Distribution of these materials should be interconnected between government, private and public sectors.

" Consistent supply of quality products " is another issue in the promotion of LUS market. The resource person from Japan said that Japan is importing timbers from the countries very far away from Japan because of the assured supply of material at a competitive price. Grading rule, in this case, is something to support the quality products. Regarding the export of Myanmar timbers, one of the Myanmar participants suggested, units of conventional measurement should be changed to metric system as it is well recognized worldwide and more accurate in measurement. One private sector observer, supporting the issue, requested that availability of raw material is very important once the market demand for a particular LUS sample product.

Then the session proceeded to the next issue, " development of marketing strategy ". Under this issue several recommendations were made by the participants. Involvement of Myanmar in international trade fairs was interesting topic among the participants. In fact, Myanmar has participated in limited number of international trade fairs. Suggestions were made that trade promotional materials should be distributed in these occasions. Much more exposure to these trade fairs is still needed to compete with the other countries. Pointing out the examples of neighboring countries like Malaysia and Singapore, the representative from ITTO suggested that Myanmar should establish branch offices abroad especially in the consumer countries so that expansion of timber trade can be promoted. Another example in Thailand is that they invite joint venture companies from Japan and produce rubber wood furniture and export it. Learning from these experiences Thailand gained production techniques and market information. Then they produced their own products and expand their market. Again, in the Malaysian case, one participant pointed out that their collaborative efforts among different bodies such as MTIB, MTC, and private sectors to promote the timber trade. Responding to this case, Myanmar participant explained that Myanmar is also drafting a similar organization and it will be materialized very soon. Almost parallel in this matter, the representative from ITTO suggested that **establishment of information network system** is very important through which dissemination and collection of market information could be made possible.

The last issue of this agenda was " training on marketing efficiency " Under this issue the resource person from the Philippines recommended that promoting marketability of products improvement in design is important. In the Philippines design development centre which is under the department of training industry has been established and working in collaboration very closely with timber furniture industry. Similarly, Myanmar should develop unique teak furniture design, which no other can do it. In spite of the timber species, whether teak or LUS, attractive design is one of the key components of infiltrating the world market. Therefore, **establishment of furniture design centre** is a must for the promotion of LUS market. Responding to Myanmar participant's experience in getting lower price of the products the resource person from TRADA suggested that there should be trained persons who can negotiate price of his products. Again, there is a need for training in marketing and price negotiation.

In conclusion of the session the chairpersons encouraged the audience that many lessons have been learned from countries having the same situation about LUS in Myanmar. Rubber wood is one of the examples in achieving to become a premier species from LUS. There are many similar stories about the idea of poor man's timber become well known timber. Even the bamboo is now no more poor man's timber. Production of flooring and panel from bamboo is now well understood. Therefore, despite various constraints, we can combine to-gather to get through with collective efforts.

CLOSING REMARKS

by

Dr. Kyaw Tint, Director-General
Forest Department

- Distinguished Guests,
- Participants,
- Ladies and Gentlemen,

It is indeed a great pleasure and honour for me to make the closing remarks at the end of this auspicious International Workshop and Exhibition (2000) of the ITTO Project PD 31/96 Rev.2 (M.F.I).

The project started on the 1st April 1997 and terminates by the end of this month. The government of Myanmar expended about 10 million Kyats and ITTO about 0.5 million US Dollars.

The project has identified one development and two specific objectives. The development objective is to increase the economic contribution of Myanmar's forest resources by emphasizing the introduction of underutilized timber species while the specific objectives are: -

(1) Together the information on LUS for industrial planning purposes with particular reference to the stand class distribution and regeneration status, and

(2) To introduce on an experimental scale of 50-60 LUS to the market through identification of wood properties and further processing.

Covering more than half of the total land area of the country, the natural forests of Myanmar contain about 1400 species of big trees. However, as of today teak constitutes 80% of the total volume of timber export, with most of other species remaining as lesser used. Increased utilization of these LUS would mean not only increased foreign exchange earning but better conservation of teak as well. In this perspective the project is fully justified.

In course of its implementation, there have of course some delays and shortcomings. But major achievements are commendable which include among others: -

(1) 55 LUS have been tested for anatomy, physical, mechanical and working properties, drying, treatability and durability and properly documented.

(2) Recommended LUS have been industrially processed to end use products,

(3) Wood working machineries and research facilities have been strengthened.

(4) Capabilities of the staff have been promoted through further training in forest inventory, management, timber mechanics, wood preservation, wood anatomy, timber seasoning and wood-based industries.

▸ Distinguished Guests, Participants, Ladies and Gentlemen,

This workshop is the third workshop conducted by the project and it marks the successful completion of the project.

The success of the project has contributed many individuals and organizations. The FD is deeply indebted to ITTO for its financial and technical assistance. Special thanks are due to Dr. Hwan Ok Ma, the Projects Manager of the organization for his relentless support and encouragement through out the three years period of the project.

I would also like to express my highest regards to the following resource persons of the workshop. Dr. Emmanuel Bello, retired Director of the Forest Products Research and Development Institute, the Philippines, Dr. Lionel Jayanetti, Timber Research and Development Association (TRADA) United Kingdom, Dr. Yoji- Kikata, Professor at Nagoya University, Japan, and Dr. R. H Leicester, Common Wealth Scientific and Industrial Research Organization, Australia, for their excellent contributions to the workshop.

Active participation in the deliberations, sharing experiences, concepts, views and opinions of all the participants – thereby enriching the workshop are also very much appreciated.

We are also greatly delighted to have our Thai counterparts with us at this auspicious occasion.

Many wood industrialists and staff of F.R.I had made relentless efforts and spent many sleepless nights to make the Exhibition (2000) and the Workshop accomplished successfully. To them and also to all those who had contributed to this event in whatever way they could I wish to extend my deep appreciation and gratitude. With this, Distinguish Guests, Participants, Ladies and Gentlemen, I conclude my closing remarks.

Thank you for your kind attention.

CLOSING STATEMENT

by

Dr. Hwan Ok Ma, Projects Manager,
Forest Industry
International Tropical Timber Organization.

Dr. Kyaw Tint, Director-General of the Forest Department, the respective Advisors of the Ministry of Forestry, respective research persons and members of the Myanmar Forest Products and Merchants' Association, distinguished guests, ladies and gentlemen;

It is a great pleasure for me to be here from the beginning to the end of this workshop over two days I was with you. I think this workshop produced something very special to the advance of utilization of LUS, I hope that this recommendation can be followed by the Forest Department and the Ministry of Forestry so that all our discussion can go the next stage. So I here just like to congratulate all the people including in this workshop and I would like to congratulate all the participants for their opinions, valid recommendations and detailed descriptions made during the last two days. I would like to thank all people who left earlier than our schedule from Thailand and I also remember the Philippines participants. I thank for their participation in this International Workshop. I also would like to thank all to our resource persons from U.K TRADA Dr. Lionel Jayanetti and Dr. Emmanuel Bello from the Philippines, the former Director of the Forest Research Institute, Philippines and Dr. Yoji Kikata from Nagoya University and also Dr. Leicester for their participation and they took a lot of great effort to read here to provide great guidance for this workshop.

I appreciated very much for their dedication and their strong support in this workshop. In this case I would like to invite all the participants to congratulate their excellent participation and contribution in this workshop. May I invite all participants our big hand for respectful and excellent work. Also I would like to congratulate all the Forest Department staff despite all the difficulties facing the Forest Department. I observed as well their enthusiastic arrangement as mentioned by Dr. Kyaw Tint. I think FRI, they did a lot of reserves without sleeping to prepare the LUS product demonstration here I very much appreciate their effort made by FRI particularly in the very difficult situation they made good presentation here.

I very much appreciated particularly our Project leader Mr. U Win Kyi, all the time he is working very much without sleeping. I think, during the workshop he and U Zaw Win dedicated all the work very much, I very much appreciated. I would like to thank all the secrètariat who assist this workshop very much. They work very much behind the scene. I would like to thank very much made by their talent to this workshop.

So I am very pleased to announce, this workshop was very successful and I am looking forward to working with you in the near future with this topic for the development. So I wish all the success of this workshop and then follow as you told I wish you a pleasant join again at home and thank you all the support again.

Thank you so much.

PART IV

Annex (1)

Introducing Myanmar's Lesser Used Timber Species to the World Market

International Workshop and Exhibition (29, 30 March 2000)

Programme

Taw Win Convention Hall
Forest Department

29-3-2000 (Day 1)

Opening Session

0830	-	Registration.
0900	-	Inaugural speech by H.E. Col. Thaik Tun, Deputy Minister, Ministry of Forestry.
0910	-	Opening statement by Dr. Hwan-Ok Ma, Projects Manager, ITTO
0915	-	Closing of the opening ceremony.
0920-1000	-	The LUS Products Exhibition.
		Refreshment.

Technical Session (1)

Chairman	-	U Shwe Kyaw, the Deputy Director-General of the Forest Department
1030-1115	-	Sustainable Forest Management Perspective. (U Thein Win, U Myint Swe and U Kyaw Htun)
1115-1200	-	Ecological implications of Increased Harvesting of larger Number of Lesser Used Species. (U Chit Hlaing)
		Lunch

Technical Session (2)

Chairman - U Win Kyi(1), Pro-Rector, Institute of Forestry.

1300-1345 - Structural Utilization of Timber, Including Reference to Lesser Used Species.
(Dr. R.H. Leicester)

1345-1430 - Research Frame work to Increase Utilization of LUS.
(Dr. E.D. Bello)

- *Refreshment*

Technical Session (3)

Chairman - U Win Kyi(1), Pro-Rector, Institute of Forestry.

1500-1545 - The Establishment of the Database of Tropical Industrial Lesser Used Wood Species.
(Dr. Yoji Kikata)

1545-1600 - Demonstration of LUS Database of Myanmar.
(U San Htwe Ko, U Saw Dannel, U Phone Htut)

1600-1645 - Lesser Used Timber Species in Construction.
(Dr. L Jayanetti)

30 March 2000 (Day 2)

Techanical Session (4)

Chairman - U Htein Win, Deputy Managing Director, Myanmar Forest Products & Timber Merchants' Association.

0900-0945 - Dimensional Stability of Fifty-Four LUS of Myanmar.
(U Win Kyi -1)

0945-1030 - Introducing New Species to the Domestic and Export Markets.
(U Myo Myint Aung)

Refreshment

1100-1145 - Introducing Myanmar Lesser Used Timber Species to the World Market : An Individual's Perspective
(U Kyaw Lwin)

1145-1200 - Video presentation on processing of timber in Myanmar.

- *Lunch*

Plenary Session

Panel of Chairman	-	Dr. Hwan Ok Ma, Projects Manager,ITTO. U Myat Thin, Advisor, Ministry of Forestry. Mr. Songsak Vitayaudom, Chief of Planning Division, Royal Forest Department. U Htein Win, Deputy Managing Director, Myanmar Forest Products & Timber Merchant's Association.
1300-1310	-	Introductory speech by Dr. Hwan Ok Ma, Projects Manager, ITTO
1310-1410	-	Discussion and recommendations on the first agenda, " The Forestry Aspect ".
1410-1510	-	Discussion and recommendations on the second agenda, " Research on LUS Promotion ".
1510-1600	-	Discussion and recommendations on the third agenda, " Harvesting and Processing ".
1610-1710	-	Discussion and recommendations on the fourth agenda, " Strengthening Marketing Effort for LUS".
1710-1720	-	Conclusion remarks by the Director-General of the Forest Department.
1720-1730	-	Conclusion remarks by Dr. Hwan Ok Ma.

Annex (2)

LIST OF RESOURCE PERSONS

1. Dr. R.H. Leicester
   Chief Research Scientist
   CSIRO, Melboume
   Australia.

2. Dr. Yoji Kikata
   Emeritus Professor
   Nagoya University
   Japan.

3. Dr. E.D. Bello
   Director (Retd.)
   F P R D I
   Philippine.

4. Dr. L. Jayanetti
   Head of TRADA
   Technology
   United Kingdom.

5. U Win Kyi (1)
   Pro-Rector
   Institute of Forestry
   Myanmar.

6. U Chit Hlaing
   Professor
   Forest Department
   Myanmar.

7. U Kyaw Lwin
   General Secretary
   M F P T M A
   Myanmar.

8. U Myo Myint Aung
   Assistant General Manager
   Myanma Timber Enterprise
   Myanmar.

9. U Thein Win
   Deputy Director
   Forest Department
   Myanmar.

10. U Myint Swe
    Deputy Director
    Forest Department
    Myanmar.

11. U Kyaw Htun
    Assistance Director
    Forest Department
    Myanmar.

Annex (3)

LIST OF PARTICIPANTS

1. U Saw Kelvin Keh
   Advisor
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   Myanmar

2. U Saw Eh Dah
   Professor
   Teaknet, Forest Department
   Myanmar

3. U Austen Nyunt
   Deputy Director
   Forest Department
   Myanmar

4. U Tun Paw Oo
   Deputy Director
   Forest Department
   Myanmar

5. U Khin Maung Oo
   Deputy Director
   Forest Research Institute
   Myanmar

6. U Thein Kywe
   Deputy Director
   Forest Research Institute
   Myanmar

7. U Khin Maung Nyunt
   Assistant Director
   Forest Department
   Myanmar

8. U Maung Maung Than
   Assistant Director
   Forest Department
   Myanmar

9. U Win Hlaing
   Assistant Director
   Forest Department
   Myanmar

10. Dr. San Win
Staff Officer
Forest Research Institute
Myanmar

11. U Htein Win
Deputy Chairman
Myanmar Forest Products and Timber Merchants' Association (MFPTMA)
Myanmar

12. U Kyaw Lwin
General Secretary
Myanmar Forest Products and Timber Merchants' Association (MFPTMA)
Myanmar

13. U Kaung Yin
Member
Myanmar Forest Products and Timber Merchants' Association (MFPTMA)
Myanmar

14. U Nyunt Aung
Member
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Myanmar

15. U Aye Lwin
Member
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16. Dr. Sein Win
Member
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17. U Khin Ko Latt
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18. U Thein Win
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19. U Khin Zaw
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20. U Tin Tun Aung
Deputy General Manager
Myanma Timber Enterprise
Myanmar

21. U Ohn Kyaw
Deputy General Manager
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Myanmar.

22. U Myo Myint Aung
Assistant General Manager
Myanma Timber Enterprise
Myanmar

23. U Ko Ko Naing
Manager
Myanma Timber Enterprise
Myanmar

24. U Win Zaw
Manager
Myanma Timber Enterprise
Myanmar

25. Mr. Songsak Vitayaudom
Chief of Forest Economics
Royal Forest Department
Thailand.

26. Mr. Pricha Aramphonphun
Director of Planning Division
Royal Forest Department
Thailand.

27. Mr. Anawat Sukhotanang
Technical Forest Officer
Royal Forest Department
Thailand.

28. Mr. Sopon Nakapon
Technical Forest Officer
Royal Forest Department
Thailand.

29. Mr. Taweechai Senisrisant
Director of Forest Land Resources Division
Royal Forest Department
Thailand.

Annex (4)

LIST OF MEMBERS OF THE ORGANIZING COMMITTEE

1.	U Shwe Kyaw	Deputy Director-General Forest Department	Chairman
2.	U Win Kyi (1)	Pro-Rector Institute of Forestry	Member
3.	U Than Swe	Director Planning & Statistics Department Ministry of Forestry	Member
4.	U Ye Tint	Director Administration Division Forest Department	Member
5.	U Kyi Maung	Director Planning & Statistics Division Forest Department	Member
6.	U Chit Hlaing	Professor ASEAN and International Affairs Forest Department	Member
7.	U Aung Tin	Director Finance Division Forest Department	Member
8.	U Aung Min Kyaw Thu	Deputy General Manager Forest Products Joint Venture Cooperation	Member
9.	U Aye Win	Assistant General Manager Myanma Timber Enterprise	Member
10.	U Kyaw Lwin	General Secretary Forest Products and Timber Merchants' Association	Member
11.	U WinKyi (2)	National Project Manager ITTO Project PD 31/96 Forest Department	Secretary

LIST OF MEMBERS OF THE TECHNICAL COMMITTEE

1. U Saw Eh Dah
   Professor
   Teak Net Coordinator
   Forest Department

2. U Tun Paw Oo
   Deputy Director
   Forest Department

3. U Thein Kywe
   Deputy Director
   Forest Research Institute

4. U Myo Myint Aung
   Assistant General Manager
   Myanma Timber Enterprise

5. U Kyaw Htun
   Assistant Director
   Forest Department

6. U Maung Maung Than
   Assistant Director
   Forest Department

7. U Sein Tun Linn
   Assistant Director
   Planning and Statistics Department
   Ministry of Forestry

Annex (6)

LIST OF MEMBERS OF THE SECRETARIAT

1.	U Win Kyi	Director Forest Research Institute	Chairman
2.	U Saw Eh Dah	Professor Teak Net Coordinator Forest Department	Member
3.	Daw Yin Yin Kyi	Assistant Director Forest Research Institute	Member
4.	U Maung Maung Aye	Staff Officer Forest Department	Member
5.	U San Htwe Ko	Range Officer Forest Department	Member
6.	U Zaw Win	National Consultant ITTO Project PD 31/96	Secretary
7.	U Hlaing Min Maung	Range Officer Forest Research Institute	Joint Secretary