PROCEEDINGS OF THE SEMINAR AND WORKSHOP ON IMPROVED UTILIZATION OF TROPICAL PLANTATION TIMBERS

23 – 25 March 2010
Kuala Lumpur, Malaysia

ITTO PROJECT ON IMPROVING UTILIZATION AND VALUE ADDING OF PLANTATION TIMBERS FROM SUSTAINABLE SOURCES IN MALAYSIA
PROJECT NO. FD 30594(1)

Editors
K.S. Gan, Y.E. Tan & S.C. Lim
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These proceedings form part of the output of the project jointly funded by the International Tropical Timber Organization (ITTO) and the Malaysian Government. The project was a collaborative research effort undertaken by the Forest Research Institute Malaysia (FRIM) as the leading agency, and the Timber Research & Technical Training Centre (TRTTC), Sarawak, and Forest Research Centre (FRC), Sabah, as collaborative partners. The Forestry and Forest Products Research Institute (FFPRI), Japan, the international collaborator of the project, provided technical guidance and expert training to project members through the dispatch of their experts to Malaysia.

The project, with a duration period of 36 months, was started on 15 September 2006. It focused on improved utilization and value adding of selected plantation-grown resources in the three regions of Malaysia, namely Peninsular Malaysia, Sarawak and Sabah. The overall development objective was to improve the end-uses of Malaysian forest plantation resources through the systematic evaluation of their basic physical and other properties. The timber species identified were *Acacia mangium* from Peninsular Malaysia, engkabang jantong (*Shorea macrophylla*) from Sarawak, and teak (*Tectona grandis*) from Sabah.

During the seminar and workshop held on 23–25 March 2010, a total of 10 papers were presented on the first day and 12 papers on the second day. The presentation on the first day covered topics ranging from sustainable forest plantation, policy, roles of ITTO, to product development from plantation in Japan. Unlike the first day where most of the speakers were well-known scientists and policy-makers from ITTO member countries, speakers on the second day were from the three collaborating agencies in Malaysia. Topics discussed were testing methods formulated and adopted, ie (a) sampling of trees, (b) wood anatomy and quality studies, (c) mechanical properties, (d) sawing and machining properties, (e) accelerated durability studies, (f) treatability assessment, (g) veneering properties, (h) drying properties, (i) finger-jointing and bonding properties and (j) chemical properties. It is hoped that the harmonized methods of testing discussed will be used by the international communities in the testing of their respective forest plantation species.

The seminar and workshop attracted a total of 150 participants who included scientists, academicians, members of the timber industries and their associations, students, foreign scientists from Papua New Guinea, Japan, China, India, Thailand, Philippines, Myanmar and others.

Finally, we would like to express our sincere appreciation to ITTO, Government of Japan and the Malaysian Government for funding the project; the Director General, Forest Research Institute Malaysia (FRIM); the Director, Forest Department, Sabah; the Director, Forest Department, Sarawak, for their support; and the Forestry and Forest Products Research Institute (FFPRI), Japan, for providing the training facilities.

K. S. Gan, Y. E. Tan & S. C. Lim
SPEECH BY Y BHG DATO’ DR ABD LATIF MOHMOD

ON THE OFFICIAL OPENING OF THE
“SEMinar and Workshop on improved utilization of tropical plantation Timbers”

THE LEGEND HOTEL, KUALA LUMPUR
23 MARCH 2010

Saudari Pengacara Majlis,

Yang Berusaha Dr Tan Yu Eng, Chairman of the Organizing Committee/National Project Director,

Dr Tetra Yanuariadi, representing the International Tropical Timber Organization (ITTO), Japan,

Dr Koichi Yamamoto, representing the President, Forestry and Forest Products Research Institute (FFPRI), Japan,

Y Berusaha, Dr Peter Koh, representing Dr Lee Hua Seng – CEO, Sarawak Timber Association (STA), Sarawak,

Distinguished guests, media representatives, conference participants, ladies and gentlemen,

A very good morning to all of you,

1. First and foremost, I would like to thank the FRIM; TRTTC, Sarawak; and FRC, Sabah; as the organizers of this conference for inviting me to say a few words and officiate at the Seminar and Workshop on Improved Utilization of Tropical Plantation Timbers today. At this juncture, I would also like to extend a very warm welcome to all our guests and participants who have taken time off from their hectic business and work schedules to be with us today. To overseas’ delegates, I wish you all, “Selamat Datang” or welcome to Malaysia. I hope you will enjoy your stay in Kuala Lumpur.

2. May I also take this opportunity to thank the International Tropical Timber Organization (ITTO) as the main sponsor of this seminar and workshop. I
have also been informed that the seminar and workshop is also strongly supported by (1) the Forestry and Forest Products Research Institute (FFPRI), Japan, (2), the Asia Pacific Association of Forestry Research Institutions (APAFRI) and (3) the International Union of Forest Research Organizations (IUFRO). I am very grateful indeed to witness this great spirit of local and international cooperation that I believe is very vital in charting the course of our forestry industries in the long run. This kind of concerted effort is highly regarded by the government as it is crucial to being the catalyst or driver for our economic growth. I hope that in the future, more strategic collaborations on similar or other pertinent subjects will be initiated so as to make our forest products sector world class and competitive.

Distinguished guests, ladies and gentlemen,

3. This seminar and workshop is considered very timely for the forest-based industries considering the onset of globalization, fluctuating oil prices, diminishing supply of logs from the natural forests, the uncertain climate changes and environmental issues today. With all these issues, the challenges to the forest-based industries will be mounting and the pressure towards achieving higher standards of products without compromising the environment is considered vital towards product acceptance.

4. It is therefore my hope that this seminar and workshop will bring about an effective forum in planning and strategizing **Improved Utilization of Tropical Plantation Timbers** which has been wisely chosen to be the theme of this seminar. I believe the theme is very appropriate for forest products experts dealing with tropical plantation timbers, to impart their know-how and update themselves with as much information as possible, for the sustainable development of our forest-based industries. It is also vital that all parties concerned take part in this seminar/workshop in shaping up the action plan towards strengthening our forest products sector. That is, in the context of utilizing our forestry resources sustainably through the use of plantation-grown timbers while conserving our precious environment.

Ladies and gentlemen,

5. In view of its national economic share, the forestry sector has been a constant major presence over the years. With regard to year 2008, this sector generated in excess of RM22.79 billion in foreign exchange income and RM7.6 billion in domestic sales which represent about 8.4% of the country’s gross domestic products (GDP). In addition, about 300 000–450 000 employment
opportunities were made available through this sector. As you are aware, during the last five decades, the Malaysian timber industry has witnessed a transformation from being a producer of sawlogs, sawn timber, plywood and veneers in the 1970s to a major exporter of downstream value-added products such as furniture and new engineered timber products for a variety of applications, builders’ carpentry and joinery and wood-based panel products. Currently, the wood-based industry contributed consistently more than RM20 billion per annum in export earnings during the last decade and it has become the fourth largest export earner for Malaysia.

6. However, with the onset of globalization and liberalization, the timber industry faces intense competition not only from the low-end producers but also from high-technology economy. Thus, the wood-based industry today finds itself squeezed between these two polarities thereby requiring strong R&D back-up on forest products to remain competitive in the world market.

Ladies and gentlemen,

7. As we are already aware, in the developed countries, R&D plays an important role to produce innovative ideas and designs before they are turned into tangible products. To remain competitive today, the timber industry has to adopt new technologies to overcome production bottlenecks and shorter product life cycles. As such, it is inevitable that our timber industry must evolve newer and more sophisticated products. Raw materials from the natural forests are no longer the only source of raw materials for the production. Therefore, the industries need to prepare themselves for the use of alternative materials such as wood of younger trees from the plantation, small-diameter logs, shorter- and smaller-dimension stocks, oil palm trunks and EFB, and the greater use of technology for the processing.

Distinguished guests, ladies and gentlemen,

8. The R&D on forest products should focus on enhancing the competitiveness of wood-based products, diversifying the use of timber products, improving the production technology and quality of products, maximizing utilization of wood including wood residues and agricultural by-products for the production of biocomposites, pulp and paper and as sources of alternative energy. In short, the industry should aim at 100% utilization of this precious lignocellulosic material.
9. Emphasis of R&D should also be placed on attaining an ergonomic working environment in the wood-based industry by improvement of efforts to reduce dust, noise, chemicals, volatile organic compounds (VOC) and other types of pollutants. These efforts should be supported through effective R&D networking among all stakeholders of the timber industry, locally and internationally. I am optimistic that strategic collaboration is the key towards combating emerging challenges and issues such as stricter international standards, emission control and carbon sequestration.

Distinguished guests, ladies and gentlemen,

10. I am delighted to note that today's seminar is the result of cooperation among the FRIM in Peninsular Malaysia; TRTTC, Sarawak; and FRC, Sabah. This spirit of cooperation is in line with our YAB Prime Minister's vision of 1Malaysia. I believe the hard work put in by the scientists from east and west Malaysia will greatly benefit the plantation sector, not only in Malaysia but also countries with tropical forest plantations. As such, I wish that the R&D in forest plantation and forest products will continue to progress, and be creative, innovative and commercializable from time to time. Such attempts to utilize sustainable resources are highly regarded by the government.

11. Nevertheless, I believe more work can still be done in improving the overall utilization of our resources including wood residues and thinning materials from the forest plantation by coming up with improved processes, more efficient technologies or high-value premium products.

12. On top of that, it is my hope that more strategic alliances will be initiated between the government and private sectors to tackle global issues and challenges such as those of the need to adhere to regional market labelling and to adopt more environment-friendly processes.

Distinguished guests, ladies and gentlemen,

13. Before I end my speech today, once again I would like to stress that it is the hope of my ministry that this seminar/workshop will contribute to enhance our R&D achievements in the plantation forestry sector to serve as a driver for the economic growth of the nation. It is therefore incumbent on our R&D programmes and projects to ensure that the research findings are crucial prerequisites towards improving our approach in managing the forest plantation resources. With all the mandate given, the NRE will continue to play its role and support any pertinent R&D in forestry and forest products including forest plantation. The government has identified R&D as one of the important elements to drive our economic growth in the years ahead, especially in the wake of an unknown economic climate.
14. I believe that with the presence of the stakeholders coupled with the interesting deliberations from the papers presented, this important gathering will provide invaluable information on the methods of evaluating the properties and uses of tropical plantation timbers. And should there be any constructive suggestions arising from this seminar and workshop which need serious attention, please forward them to us for our consideration.

15. Last but not least, ladies and gentlemen, once again I wish you all a very successful and fruitful seminar and workshop. I, on behalf of the Malaysian Government, would like convey our sincere thanks to ITTO and the Government of Japan for providing the required funding and all the support for the project.

With this note, I declare the Seminar and Workshop on Improved Utilization of Tropical Plantation Timbers officially open.

Thank you.

Y BHG DATO’ DR ABD LATIF MOHMOD,
DIRECTOR GENERAL FRIM
CUM CHAIRMAN OF THE PSC
23 MARCH 2010
Terima kasih saudari/saudara Pengacara Majlis.

Yang Berhormat Dato’ Dr Abdul Rashid Malek, Timbalan Ketua Pengarah (Penyelidikan), FRIM, Ahli-Ahli Lembaga MFRDB, Dif-Dif Jemputan, Y Bhg Dato’-Dato’, Tuan-Tuan dan Puan-Puan yang saya hormati sekalian,

Selamat Pagi dan Salam 1Malaysia.


Distinguished guests, ladies and gentlemen,

3. First and foremost, I would like to take this opportunity to thank Y B Dato’ Dr Abdul Rashid Malek, Deputy Director General (Research), FRIM, in his behalf of the Director General, FRIM, for his presence and commitment to address the participants at this very auspicious occasion and officiate at the opening of the **Seminar and Workshop on Improved Utilization of Tropical Plantation Timbers** this morning. And I am honoured and grateful today to be invited and convey our greetings to all the distinguished guests and participants attending this three-day seminar and workshop. It is indeed my pleasure, on behalf of the Seminar/Workshop Organizing Committee, to wish a warm “Selamat Datang” to all the distinguished guests and participants to the conference. To foreign delegates, we are especially proud to be receiving all of you; we hope Kuala Lumpur would offer an exciting and memorable experience during your short stay in Malaysia.

4. May I take this opportunity to also convey my sincere appreciation to the International Tropical Timber Organization (ITTO) for providing the research grant amounting to about US$500 000 and sponsoring this seminar and workshop in Kuala Lumpur. I am also very glad to acknowledge the support given by the Forestry and Forest Products Research Institute (FFPRI), Japan, the Asia Pacific Association of Forestry Research Institutions (APAFRI) and the International Union of Forest Research Organizations (IUFRO) to this seminar.

Distinguished guests, ladies and gentlemen,

5. The project entitled **IMPROVING UTILIZATION AND VALUE ADDING OF PLANTATION TIMBERS FROM SUSTAINABLE SOURCES IN MALAYSIA** was funded by ITTO for a period of slightly more than three years and I am glad that it has been successfully completed within the stipulated time. I wish to take this opportunity to inform you that this seminar and workshop is the result of research cooperation among scientists in the FRIM, Peninsular Malaysia; the Timber Research and Technical Training Centre (TRTTC), Sarawak; and the Forest Research Centre (FRC), Sabah. During the project period, there were a lot of interactions and discussions among the scientists from the three organizations. In addition to the scientific works, friendship and goodwill have been developed among the scientists and I hope the cooperation will not end with the end of this project. The project also provides the opportunity for the Malaysian scientists to travel to Japan to learn from their respective counterparts the latest technology in wood utilization. For this, I wish to record my sincere appreciation to the FFPRI for accommodating the training of 18 Malaysian scientists in Japan.
Distinguished guests, ladies and gentlemen,

6. The forest products sector has been one of the most important sources of revenue for the country since Malaysia achieved its independence. The wood-based industry is the fourth largest export earning sector for the country. In 2008, the sector contributed RM22.79 billion in export earnings and RM7.6 billion in domestic sales. It also provides employment opportunities for more than 300,000 people. However, the economic dependence on products from the forests, timber in particular, has given rise to intense pressure on our forests more than ever before. This is especially true when the earth is facing increasing threats from global warming, unpredictable weather patterns, water shortages and declines in raw material supplies.

7. Demand for goods and services from the forests, on the other hand, continues to be on the rise because of population growth and economic development. For a small country like Malaysia where substantial economic activities are dependent on forests, a total ban on forestry activities would be catastrophic to the economy. A balance therefore has to be struck between competing uses and conservation of the forests.

Ladies and gentlemen,

8. To ensure sustainability for future needs, forests in Malaysia are well managed and it is in the best interest of the country that this practice is adhered to. In striking the balance between protecting our natural forests and providing enough raw materials for the forest products sector, plantation forests have been established since the 1980s. By the end of 2002, a total of 0.28 million ha of forest plantations had been established and of these, 0.08 million ha were established in Peninsular Malaysia, with the balance of 0.15 million ha and 0.05 million ha being established in Sabah and Sarawak respectively. In addition, the government, through the Ministry of Finance in 2006, has allocated a sum of RM1.045 billion as loan for private companies to establish forest plantations in Peninsular Malaysia, Sabah and Sarawak.

Distinguished guests, ladies and gentlemen,

9. Realizing the challenges and issues that our forest products sector is facing, I believe somehow, they could be dealt with at the R&D stage. This would enable R&D activities to be tailored to the needs and to the best interests of the industry and the country. In other words, R&D goals are geared towards addressing the challenges faced by the industry and more importantly, conforming to the market needs.
10. In the past, we have also successfully conducted numerous collaborative projects with international and local agencies. Some of the projects, especially those with applied R&D, have been commercialized. Others are essentially pertinent in addressing the need to balance the uses of forest resources for economic, social and conservation of environment purposes. These achievements, to me, are very significant as they fulfill our hopes to always meet the customers’ expectations by ensuring advancements in science and R&D.

Distinguished guests, ladies and gentlemen,

11. The theme for the seminar and workshop has been chosen as **Improved Utilization of Tropical Plantation Timbers**. This theme has been aptly chosen to reflect the many challenges facing the forest products sector, both locally and internationally. This sector is facing increasing competition due to globalization and changes in consumers’ demands. Besides that, declining raw material supplies, labour shortages, soaring energy costs and lack of modern technologies for timber processing are some of the pressing issues confronting the forest products sector at the moment.

12. I therefore look forward to effective discussions and deliberations on the seminar theme by the number of leading scientists present who are knowledgeable and expert in their respective fields. I am delighted to learn that a total of 10 technical papers will be presented during the first day covering topics such as the use of plantation timbers in Japan, R & D of plantation timbers in China and Malaysia, utilization prospects of some plantation species and the promotion of sustainable forest plantation by ITTO as well as a few pertinent technical papers. On the second day, a workshop will be conducted by the scientists from the FRIM, TRTTC and FRC on the harmonized testing methods on the properties of plantation timbers. Topics to be covered include sampling methods, wood anatomy and quality evaluation, drying, processing, sawing, product development and techno-economics.

13. Besides the oral presentations, an exhibition displaying products from the forest plantation sector and informative posters will also be available. I hope ladies and gentlemen, you will take some of your time to have a look at the products and posters in the exhibition hall. Thus, I am sure that the various technical papers and posters to be presented coupled with an array of products being exhibited are extensive enough to give us the hindsights and impetus towards strengthening our strategy to ensure the forest products sector remains competitive and sustainable.
Distinguished guests, ladies and gentlemen,

14. As in many other events, the task of organizing this type of event is very challenging, I am sure the committee has been working very hard to ensure the success of this conference. I was informed that more than 150 participants have registered for the three-day seminar/workshop including a post-/seminar/workshop visit to FRIM. In this regard, I wish to convey my greatest appreciation to the members of the Organizing Committee of this seminar and workshop for their persevered commitment and dedication.

15. To all co-organizers, exhibitors as well as other supporting agencies, I would like to express our sincere thanks for your utmost support and contributions. And it is our great pleasure to be collaborating with you.

Ladies and Gentlemen,

16. Before I end my message today, I would urge all scientists and participants to take part actively in the deliberation of issues and subjects that pose the many challenges to the utilization of forest plantation species. I therefore look forward to this seminar imparting some important resolutions and consensus in charting the course of the forest plantation sector in the years to come.

17. Last but not least, I would like to take this opportunity to once again convey my deepest appreciation to ITTO, FFPRI, APAFRI and IUFRO for their gracious support and contributions in organizing this seminar and workshop. Thanks are also due to all the PSC members, stakeholders as well as Dr Hoi Why Kong, the ex-National Project Director, and Dr Mohd Nor Yusof, incumbent Director of the Forest Products Division, for their valuable assistance throughout the implementation of the project. I am also thankful to our collaborating agencies, ie the TRTTC and FRC, as well as my colleagues from the FRIM, for contributing immensely to the success of the project. I hope this strategic collaboration would lead to meaningful strategies and action plans that would benefit our forest products sector. To all participants, I wish you all a fruitful deliberation and an enjoyable meeting.

Thank you.

DR TAN YU ENG
CHAIRMAN
CUM NATIONAL PROJECT DIRECTOR
ITTO is mandated to promote the conservation and sustainable management, use and trade in tropical forest resources. ITTO is the only intergovernmental organization that brings together countries that produce and consume tropical timber to discuss and exchange information and develop policies on all aspects of the world tropical timber economy and the management of the tropical timber resources.

ITTO is an action-oriented organization. It formulates policies relevant to its objectives and assists members to implement those policies through a programme of pre-projects (or scoping studies), projects and other activities. Projects are an important aspect of the Organization’s work and a primary means of assisting member countries to implement initiatives.

To promote the development of forest industry and improvement in the utilization of forest resources, the Forest Industry Division of ITTO has been working on project implementation in the Producer Member Countries. Types of forest industry project include:

- utilization of plantation timber, for instance in Malaysia, China and India;
- promotion of lesser-used wood species in Ghana and Guyana;
- biomass energy in Malaysia and Cameroon;
- testing laboratories for wood products in Brazil, Mexico, China, Malaysia and Indonesia;
- community-based forest enterprises in Ghana, Gabon and Guatemala;
- promotion of forest industry efficiency in Indonesia, Malaysia and China;
- intermediate technologies for sustainable forest harvesting and reduced impact logging in Peru, Guyana, PNG, Cambodia, Indonesia and Ghana;
- utilization on NTFPs (non-timber forest products) in Brazil, Philippines, China, Cambodia, Thailand, Indonesia and India.

In the years to come, ITTO will continue its work to improve the forest industry sector. Effective forest industries provide a crucial link between sustainably managed forests (both natural and plantation forests) and international markets for forest products.
ROLE OF INNOVATIVE USES OF PLANTATION TIMBER IN JAPAN

Koichi Yamamoto

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Several new topics related to the importance of wood utilization have been discussed recently as the awareness of climate change becomes larger and larger in Japan. The Long-life Housing Promotion Act (2009) is enforced to form a safe and high-quality housing stock and long-service-life housing. The Wood Use Promotion Plan (2009) by the Ministry of Agriculture, Forestry and Fisheries intends to accelerate wood utilization, especially in the public sector. The Revival Plan of Forest and Forestry (2009), also by the Ministry of Agriculture, Forestry and Fisheries, raises a target to increase the percentage of domestic wood supply up to 50% from 24% (2008) in 10 years. Despite the strong tail wind to wood use, the amount of wood utilization still stays at a low level. This presentation is on how the forestry and wood industry sectors in Japan combat climate change through the intensive utilization of wood resources, especially from plantations. Several areas exploring the new horizon of wood use are: 1) development of fields of wood use by innovative research and technology, 2) improvement of regulations to facilitate appropriate wood use, 3) harmonization of material use and energy use of wood resources, 4) promotion of local wood products which can mitigate climate change through lower energy consumption of sustainable local resources, 5) decreasing the construction cost of house/year by prolonging the service life of housing, and so on.

INTRODUCTION

Under the Kyoto Protocol based on the United Nations Framework Convention on Climate Change, Japan’s target of greenhouse gas emission is 6% reduction from the 1990 levels, and 3.9% of the 6% target should be achieved through forest sinks. To accomplish the 3.9% value, the Forestry Agency of Japan has executed a policy (10-y forest sink measures to prevent global warming) since 2002 to promote the fostering of forests and utilization of wood. Although the carbon storage effect of harvested wood products helping
the reduction of atmospheric carbon level is ignored in the first commitment period of the Kyoto Protocol (2008–2012), it might be taken into account in the next commitment period (Tonosaki 2009). The utilization of wood as both material and energy has begun to attract interest from various sectors such as forestry, wood industry, civil engineering industry, building industry and power industry. Although environmental consideration encourages greater use of wood from sustainable forest management (Falk 2009), wood supply and demand in Japan still has not expanded yet. Expanding the utilization of domestic wood resources, especially from sugi (*Cryptomeria japonica*) plantations, will be discussed in terms of research.

**BACKGROUND OF WOOD UTILIZATION PROMOTION IN JAPAN**

In 2008, Japan’s demand for industrial roundwood went down to 79.5 million m$^3$, with the gradual decline from 110 million m$^3$ during 1989–1997. Figure 1 shows the supply of domestic industrial roundwood after 1967 (Statistics information, Ministry of Agriculture, Forestry and Fisheries 2009). Since 2002, the supply of domestic wood has slightly risen, and the self-sufficiency rate of it reached 24% in 2008. The number of housing construction (Statistics information, Ministry of Land, Infrastructure, Transport and Tourism 2010) (Figure 2) has decreased because of the recession due to the collapse of Lehman Brothers, and is expected to decrease in future because of depopulation. In spite of pessimistic figures in the statistics, intensive wood use is an important political issue to mitigate global warming through activation of the local economy. Many policies, action plans and activities appear as follows.

![Figure 1: Supply of domestic industrial roundwood in Japan (m$^3$)](image-url)
The Revival Plan of Forest and Forestry was announced by the Ministry of Agriculture, Forestry and Fisheries in 2009. The target of the plan is to increase the percentage of domestic wood supply up to 50% from 24% (2008) in the coming 10 years. In order to achieve the plan, we should realize the target value not only by the stable supply of roundwood through effective and low-cost harvesting-transporting system, but also by the expanded demand of various wood products based on innovative science and technology.

**Promotion of wood utilization in public construction and civil engineering sections**

The Wood Use Promotion Plan was shown by the Ministry of Agriculture, Forestry and Fisheries in 2009 to accelerate wood utilization, especially in public construction work such as groundsills, slope protection work, framework of check domes and fences. In order to develop sustainable forestry through positive utilization of wood, the Ministry of Agriculture, Forestry and Fisheries and the Ministry of Land, Infrastructure, Transport and Tourism will propose the Wood Promotion Act in Public Constructions in the coming session of the Diet.

**Promotion of long-life housing**

The Long-life Housing Promotion Act was enforced by the Ministry of Land, Infrastructure, Transport and Tourism in 2009 to form a safe and high-quality housing stock and to promote long-service-life housing. A committee on verification of wooden long-life housing was set up in 2009 to achieve the objective of the act.
Collaboration among academic societies

The Japan Society of Civil Engineers, the Japan Wood Research Society, and the Japanese Forest Society organized the Cross-sectional Research Committee of Intensive Wood Use in Civil Engineering in 2007 to expand wood utilization in the field of civil engineering through collaboration with different academic sectors. The Architectural Institute of Japan is also keen on the enlargement of wood utilization, and also set up the Working Group of Practical Wood Use in 2009 under the Global Environment Committee.

DEVELOPMENT OF SCIENCE AND TECHNOLOGY ON WOOD UTILIZATION

Data set for improvement of existing regulations

Improvement of existing regulations is not very easy, so we have to make efforts to increase requirements of the consumer and forest industry for timber use and to offer data on products that fit the regulatory performance requirements. The FFPRI and many research institutes have carried out a research project to improve the Japan Agricultural Standards for glue-lam (Miyatake 2006), and the revised JAS in 2007 describes lamina of L30 (3~4 kN mm\(^{-2}\)) and L40 (4~5 kN mm\(^{-2}\)) Young's modulus, and combination of lamina with different wood species (Figure 3), which contribute to the utilization of sugi lamina with lower strength.

Data set for development of thick plywood

The performance of thick plywood, including fire resistance (Figure 4), earthquake resistance and soundproofing, has been studied in a research project of the FFPRI on the utilization of sugi plantation resources (Aoki 2006).
The results of the project are presented in the instruction manual on thick plywood (Figure 5); the production of thick plywood (more than 12-mm thickness) reached 1 400 000 m$^3$ in 2008. Thick plywood is used mainly for horizontal and vertical shear walls.

**Environmental performance of wood**

The rapid decrease of population is expected to cause the shrinkage of cities, and the increase of social cost towards the 2040s. To minimize this social problem, it is necessary to improve the quality of existing housing against various deterioration elements (earthquake, fire, micro-organisms) and control new development of housing. Enhanced wood durability contributes not only to the mitigation of global warming through the contribution to sustainability of forest resources, but also might decrease the social cost in the housing system. It is important to demonstrate a good picture of wood and sustainability based on the least energy intensive use of material for construction and environmental contributions by CO$_2$ storage to relevant sectors.

**Collaboration among different sectors**

The partnership among industries, academia, government and people will be a fruitful approach to expanding the demand for wood products in future. At the moment, interdisciplinary collaboration in wood promotion is growing in different areas. Integration of these activities will be the next step to open up a new stage of wood utilization.
Highlighting successful cases and enhancement of publicity

There are many useful leaflets published by several agencies. For example, the publication *Encouragement of Wooden Building* issued in 2009 by Wooden Building Promotion Association shows many concrete examples of offices, shops, schools, gymnasiums, old-age homes, lodgings and assembly halls built with wood and the important regulations. Publicity is also important to broaden understanding of the outstanding performance of wooden products.

REFERENCES


Wood from Plantation in Japan—Challenges and Opportunities

Hideaki Takai
Assistant Director
Wood Products Trade Office
Forestry Agency, Ministry of Agriculture
Forestry and Fisheries

Timber plantation in Japan has a unique history and has been influencing the society, culture and economy, and vice-versa, since a thousand years ago. The importance of plantation timber in wood supply in Japan has grown since then. After World War II, the last significant conversion from natural forest to plantation forest took place, and as a result, the present structure of the age class of plantation forest is uneven. The major challenge of the forestry sector in Japan, which heavily depends on timber plantation, is its poor profitability in economic terms, as highlighted in “The Revitalization Plan for Forest and Forestry Sector”, released in December 2009 by the Ministry of Agriculture, Forestry and Fisheries (MAFF). The plan shows the strategy to revive the forestry sector as a whole, from forest to market. Trends in the debate on mitigation of climate change may support the utilization of wood biomass and wood products. Tropical plantation timber may have a bright future in this context, and should have more presence in the national and the international markets.
Overview - Current Status of Forest in Japan -

Plantation in Japan—History

- Oldest record of plantation: 866 A.D.
- Oldest private industrial plantation among those managed until now: Started in early 16th Century.
- Overharvest, felling ban and reforestation occur over time.
- The latest overharvest was after WW II—reviving without money for import.
- Reforestation in 1950s and thereafter brings about forests in the harvesting age now.

Nara - Ancient Capital of Japan

The Largest Wooden Building

Yoshino Sugi (Cryptomeria japonica)

Changes in Forest Area

Changes in Stand Stocks

Changes in Wood Supply and SSR
Forest Plantation by Age Class

Forest Plantation by Age Class 10 years later

Vicious Circle of Forestry in Japan

Deficit of Forest Management

- High costs for production, planting, and tending
- Low timber price
- Out of demand

Low Productivity

- 3-5 m³/1000 trees/day only
- Planting + Tending = $10/kha

Insufficient Investment

- Low density of forest road system
- Less performance machines

Aging of Workers

- Poor working conditions
- Low salary

Finding Breakthroughs — Revitalizing the Forest Sector

- "The Revitalizing Plan for Forest and Forestry Sector" released by the MAFF in December 2009
- Improving management and technology including improvement of forest road network
- Training for managers, foresters and operators
- Strategic legislation and policy revision including forest planning, subsidies and loans
- Target output 40 mil. m³ from 18 mil. by 2020

Promotion of Wood Use

- Substitution of non-wood products with wood products
- "The Law for Promotion of Wood Use in Public Buildings" jointly submitted by MAFF and MLIT to the Diet
- Public wooded buildings will be promoted as symbolic showcases
- Leading the private sector to follow public buildings

In the Context of Climate Change (1) — Plantation Forest

- Plantation: an ACTIVE Carbon sink (converts CO₂ into trees and other organic matters actively)
  - Significant sink/source
  - Foreseeable and consistent output
  - Risks of fire, pests/insects, natural hazards, etc
  - Carbon accounting depends on the rules to be agreed upon

In the Context of Climate Change (2) — HWP

- Harvested Wood Products (HWP): a PASSIVE carbon sink (HWP does not remove CO₂ by itself)
  - A carbon-friendly material
  - Less emission in the production process
    - Displacement factors: 3.71 CO₂e reduction per t of dry wood used
  - Maximum contribution to CC mitigation through:
    - SFM for production of wood
    - Efficient use replacing non-wood and fuels
  - Carbon accounting for HWP fully relies on the rules of forest: one of six carbon pools of forest

Superiority of Wood as a Material

- Easy to process: cutting, peeling, colouring, nailing, gluing, etc
- Comfortable touch
- Cascade use and recycling
- Insulation capability
- Carbon-friendly nature
Weaknesses of Wood
- Instability in shape
- Flammability
- Strength
- Durability
- Inconsistency/variability

Post-and-beam Housing

Opportunities and Breakthroughs
- Domestic Market: Attractive packages for housing made of plantation wood
  - Low price
  - Neat design, matching the lifestyle
  - Meet essential needs and musts
    - Earthquake durability (from brick to wood)
    - Internationally extendable
- Attractive business model for the investment
  - For solid wood products, not for paper
  - Small, medium or large scales may have respective strategy

Relevance of Tropical Plantation Timber
in the International Market—1
- High competitiveness with the high growth rates
- Room for the growth: more land, better management, better infrastructure, additional value, availability of workers, etc

Relevance of Tropical Plantation Timber
in the International Market—2
- Addressing the Impediments -
- Business environment for investment
- Quality of wood products
- Marketing
- Environmental concerns
  - Free from illegal logging
  - Biodiversity:
    - Agriculture < timber plantation < natural forest

Relevance of Tropical Plantation Timber
in the International Market—3
- Additional "soft" values
  - Carbon: Voluntary Effort by non-Annex I countries
  - Option for a sustainable economic development in rural areas in the tropics
  - Alleviation of the pressure for harvest in natural forest

Tropical Plantation Wood Products
- Sengon: Lunch box -

Hint 1:
Sengon: *Paraserianthes falcataria* for Japanese traditional food box
Conclusion

— For SFM, Our Endless Journey

- Coherent and holistic approach from forest to the markets
- Maximizing the benefits and rational distribution of them result in: more investment, motivation of local population for SFM, etc
- Full recognition of environmental aspects of timber plantation (positive and negative: biodiversity, carbon cycle, water, etc)
- Ensuring the status of timber plantation in social/economic terms as an essential piece for low-carbon society

Terima kasih atas perhatian anda.

Thank you for your attention.

ご静聴ありがとうございました。
The timber industry is one of the major contributors to the foreign exchange earnings of Malaysia. In order to ensure continuous supply of raw materials for the timber industries, alternative sources to natural forests need to be explored. The loss of commercial timber species due to the rapid development of areas to cater for the growing population and continuous depletion of natural forests have provided a solid reason to establish large-scale commercial forest plantations. In promoting this effort the Malaysian Government has initiated a special loan programme managed by the Special Purpose Vehicle (SPV) company known as the Forest Plantation Development Sdn Bhd (FPDSB) (wholly owned by the Malaysian Timber Industry Board, MTIB). Its major objective is to encourage private sectors, government-linked companies (GLC), government agencies and smallholders to establish sustainable rubber forest and forest tree plantations with yearly planting target of 25,000 ha for 15 years. Thus, the establishment of forest plantations is not only to mitigate the current and future log shortage but also to maintain and improve the environment and ecological systems.

INTRODUCTION

Traditionally, Malaysia has depended on natural forest as its source of timber. Today, we see that there is a decline in this resource as the country is moving towards more sustainable forest management by establishing more forest plantations.

The main driver to establishing more forest plantations is ensuring there will be sufficient timber supply and at the same time the ecology of the environment is preserved. The Malaysian Government is committed to preserving the biodiversity and ecosystems in line with international conventions.

This move from being dependent on timber from the natural forest to forest plantation is seen to be positive. Forest plantations in Malaysia have proven to provide better annual mean increments on average of 5 to 10 times those of natural forests. Other than that the production costs are lower and therefore have an impact on the selling price. This is one of the factors that give Malaysian timbers the competitive advantage.
BACKGROUND

In the past, most round log timber produced by Malaysia was exported because the processing activities were done mostly by the importing countries. This is shown by the 60 percent of export value of wood and wood products from primary activities which included harvesting of logs and the processing of sawn timber, plywood, veneer, fibreboard and particleboard, while 40 percent of export value came from secondary and tertiary activities such as manufacturing of furniture, mouldings, wood flooring and laminated veneer lumber and other related wood products.

However, with the changes in policy where there is restriction on logging and export of logs from the natural forest, there has been a decline in export in primary form and increase in supply to the secondary and tertiary activities locally.

The way forward

In February 2009 Malaysia launched its own National Timber Policy (NATIP). This policy envisions that in 2020 the target annual export earning would be RM53 billion. The graph below (Figure 1) shows the target income has risen from the normal estimation of RM38 billion to RM53 billion.

![Figure 1](current_forecast_future_forecast_wy_forward)

Figure 1  Current and future forecasts of Malaysian export earnings from wood products

The increased target value is because the policy has formulated a change in the percentage of the market it derives its income from where now 60 percent of the export earnings would be derived from secondary and tertiary markets and only 40 percent from primary processing. In order to achieve this target the estimated volume of wood raw materials needed by the downstream industries would reach 25 million m³.

Here, we are able to see that the policy has changed the current structure of the timber industries. Other than that, there is also a paradigm shift in raw material resources from the concentration on the natural forest to the establishment of
forest plantations. This can be easily summarized from Figure 2 which shows the future flowchart of raw materials starting from upstream to downstream activities.

![Flowchart of future operations from raw materials to wood products](image)

**Figure 2** Flowchart of future operations from raw materials to wood products

**Why change?**

Among the industries that are growing and recognized worldwide are the Malaysian wood industries. This can be seen through the rise of demand for wood products as shown in the graph (Figure 3) below. In order to support this growth the raw materials must be sufficient. Nevertheless to date we are able to see that there is a decline in log production from the natural forest. Therefore it has been agreed that more forest plantations need to be established in order to cater for the needs of the industries. The government today has taken this bold move despite some resistance from some groups of environmental activists.

![Graph showing domestic future forecasts of log production](image)

**Figure 3** Domestic future forecasts of log production from the natural forest and forest plantations and domestic requirement of logs
Forest plantations

What is a forest plantation

A forest plantation is defined as “a forest crop or stand raised artificially, either by sowing or planting”. However, different literature has given several descriptions which distinguish new planted forest.

The term afforestation refers to forest which is established artificially on land that did not carry forest for a duration of at least 50 years, while reforestation refers to forest established artificially on land which had carried forest within the previous 50 years. But there are instances where the term forestration refers to afforestation and reforestation.

Why forest plantation?

The choice of encouraging forest plantation is influenced by internal factors like the growing demand of timber industries and external factors that include international concerns about logging and degradation of tropical forests. In Malaysia, as outlined in the Seventh Malaysia Plan, the reasons for forest plantation are given as below:

1. To meet the anticipated deficit of timber supply
   It is acknowledged that timber is one of the bigger contributors to the foreign exchange earnings of Malaysia. As mentioned above the raw materials needed to support the industries demand would be 23 million m³ in the year 2020. In view of this fact, the government has taken the initiative to establish more forest plantations as they offer good prospects under year-round growing climatic conditions.

2. To reduce pressure on natural forests
   Aside from providing a promising source of timber, forest plantations also help in ensuring a good balance of forest for perpetuity including the preservation of biodiversity and the ecosystem functions.

3. To ensure better land use
   Forest plantations also help in ensuring better usage of land. In this instance degraded or underutilized agricultural land can be converted into forest plantations which will bring better yield and added benefit for the social development of the rural people.

The establishment and current status of forest plantations

Forest plantation development was factored by the expressed concerns over the loss of desired species in the forest. This concern has contributed to the establishment of forest plantations today.

The development of forest plantations in Malaysia varies in different parts depending on the type of wood demand and the geographical features of
the land like in Peninsular Malaysia where more rubber is planted as the industries need more rubberwood.

The total estimated areas for forest plantation development are as per Table 1 below:

<table>
<thead>
<tr>
<th>State</th>
<th>Forest reserve</th>
<th>Other reserves</th>
<th>State land</th>
<th>Alienated land</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perlis</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Penang</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Malacca</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>N. Sembilan</td>
<td>-</td>
<td>-</td>
<td>2893</td>
<td>-</td>
<td>2893</td>
</tr>
<tr>
<td>Kedah</td>
<td>61</td>
<td>132</td>
<td>2652</td>
<td>814</td>
<td>3659</td>
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<tr>
<td>Selangor</td>
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<td>5143</td>
<td>817</td>
<td>7902</td>
</tr>
<tr>
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<td>-</td>
<td>-</td>
<td>38902</td>
<td>12864</td>
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</tr>
<tr>
<td>Perak</td>
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<tr>
<td>Kelantan</td>
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<td>18550</td>
<td>27630</td>
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<tr>
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<td>344163</td>
<td>919075</td>
</tr>
<tr>
<td>Sarawak</td>
<td>66223</td>
<td>1459854*</td>
<td>na</td>
<td>na</td>
<td>1526077</td>
</tr>
<tr>
<td>Total</td>
<td>243247</td>
<td>1460049</td>
<td>625086</td>
<td>490801</td>
<td>2819183</td>
</tr>
</tbody>
</table>

(Sources: FRIM & FD 1996) * - native customary land; na - data not available

Future directions

The Malaysian Government through various changes in law and policy has provided a good foundation towards the development of forest plantations. These changes take consideration of the concerns voiced by the industries, especially in the areas of environmental conservation, land use, adequate supply of raw materials, labour and mechanization, and finance and private sector involvement.

Kementerian Perindustrian Perladangan dan Kommoditi (KPPK) (Ministry of Plantation Industries and Commodities) and all those involved in the development of forest plantation have taken several steps to further improve the current status using the following areas as guidelines with the details:

1. Environmental conservation

Further emphasis needs to be given to rehabilitate badly damaged land such as degraded forest, encroached forest, unproductive state land and poor forest reserve. This can be done by alienating the above land for the development of forest plantation which will maintain the biodiversity of forest in Malaysia.
2. **Species selection**
In order to meet the demand of the industries, it is suggested that the forest plantation programme should concentrate on a few high-value species with large market demand. This will ensure better management and more active participation.

3. **Private sector participation**
The government in promoting forest plantation has included the participation of private sectors to assist in achieving the target. Currently, the programme has attracted government-linked companies (GLCs) and private entities to develop forest plantations on a commercial basis.

One of the incentives is the financing approved by the Cabinet on 2 March 2005, which is to assist in promoting and providing funds to support the development of commercial forest plantations.

The Ministry of Plantation Industries and Commodities has in its planning included small- and medium-scale private enterprises to join in this forest plantation programme with the concentration on rubber (latex-timber clones, LTC).

4. **Land use**
The development of forest plantation will ensure better usage of land other than providing rehabilitation as idle land can be developed into an area that will not only be valuable commercially but also assist in maintaining the ecology of the area.

5. **Certification**
The sustainable forest management programme which is well planned and managed in accordance with the rules and regulations currently administered in the country will assist in expeditious certification.

6. **Adequate funding**
The need for funding is acknowledged by the government. Therefore as mentioned earlier, the government has established a soft loan programme which is administered by the Special Purpose Vehicle (SPV) known as Forest Plantation Development Sdn Bhd (FPDSB), a wholly owned company of the Malaysian Timber Board (MTIB).

Through this programme the government is targeting to establish a total of 375 000 ha in a 15-y cycle for approximately 25 000 ha forest plantation to be developed yearly.

7. **Human resource development and enhancement of technology**
KPPK is committed to ensuring that more human resource development and better technology are used to increase the productivity of forest plantation while maintaining the biodiversity.
CONCLUSION

Currently, all parties involved have realized the importance of forest plantation, especially to support the needs of industry and reduce the dependency on the natural forest. In addition to the use of degraded forest, state land and idle agricultural land can also be utilized for forest plantations.

In support of the initiative to promote forest plantations, the Ministry of Plantation Industries and Commodities has in 2006 initiated a financing programme for the development of commercial forest plantations. This programme is handled by a special purpose vehicle known as FPDSB, a wholly owned company by the Malaysian Timber Board (MTIB). The purpose of this soft loan is to encourage more plantation companies to participate in promoting forest plantations which promise attractive and profitable income opportunities, employment generation and contributing to the environmental enhancement through ecological balance.

Besides wood from forest plantations, other sources of raw material for downstream industries are rubberwood, oil palm trees, coconut trees and fruit trees. These materials are well suited for the production of some timber products such as MDF, particleboard as well as pulp and paper.

Commercial forest plantation programme is the way forward for the timber-based industry in Malaysia aimed to increase the production of raw materials in the future to meet the government’s target of national export earning of RM53 billion by 2020.

However, in ensuring the achievement of the programme, the quality of products must be maintained at international level where the planted trees need to be from good quality planting materials and maintained with good silvicultural practices such periodical fertilizer and chemical applications, pest and disease control and biodiversity preservation.

Finally, the development of forest plantations is expected to provide spin-offs in other activities such as training and human resource development.
RESEARCH AND UTILIZATION OF PLANTATION-GROWN TIMBERS IN CHINA

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The plantation area in China is the biggest in the world, poplar being one of main plantation species, distributed mainly in northern China, with plantation area of more than 8 million hm². The main tropical plantation species are eucalypt and rubberwood. The eucalypt plantation area is over 1.7 million hm², and rubberwood plantation area is over 0.78 million hm². Plantation timbers play a positive and important role in Chinese economic reconstruction, especially under the current environment where the natural forest is protected and forbidden from logging. Wood composites made of plantation poplar are very important in balancing the supply of and demand for timber in China, and solid wood products from eucalypt and rubberwood feature prominently in furniture and decorative materials. This paper summarizes the research and utilization of the main Chinese plantation timbers.

The characteristics of poplar wood are: low density, light colour, high and unevenly distributed moisture content, ease of deformation, and high stress proportion. Plantation poplar wood is widely used to manufacture plywood, block board, particleboard, MDF and reconstituted fancy veneer in China.

The present use of eucalypt plantation in China is primarily for the production of wood chips. Eucalypt is not easily utilized as solid wood, as high growth stress can result in end-splitting of logs during harvesting and considerable distortion during manufacturing. Along with research and development of processing technology, eucalypt wood could be used in manufacturing plywood, which can be converted into reinforced flooring base material, and for manufacturing furniture parts such as solid wood products.

Rubberwood has light colour, beautiful grain, even properties, low shrinkage rate and good dimensional stability. The strength of rubberwood is also good, and it is easy to process, such as sawmilling, peeling, drilling, adhesion and painting. It is suitable for manufacturing furniture and other products.
INTRODUCTION

Since the past decades, China’s economy has been growing at a high rate. The GDP in China was RMB33 535.3 billion in 2009, an increase of 8.7% over the last year (State Statistics Bureau 2010). The annual average growth rate of the GDP in China is 9% over the last 30 years, and expected to rise in the future. The rapid economic development and growth in investment and consumption have spurred wood consumption and therefore created a huge wood demand in China. The forest-related economy has grown very fast; the forestry-industry-related GDP was about RMB683.8 billion in 2008, the proportion of wood industry about 47.27%, ie RMB323.2 billion and the wood yield about 81.08 million m$^3$. The output value of wooden furniture exceeded RMB360 billion; wood-based panels reached 94.1 million m$^3$ and wooden flooring production reached 344 million m$^2$. The annual production of wood-based panels was 94.10 million m$^3$ in 2008, the annual growth rate of wood-based panels was about 20%, and now the yield of wood-based panels and furniture is the biggest in the world (Qian 2009).

China is a large country in wood and wood products production, and it is also a large consumption country, but its forest resource per capita is very low, the forest stock volume per capita is just 1/8 of the average level in the world and the average wood consumption volume per capita is 1/4 of the average level in the world. To protect the environment and ecological systems, the Chinese Government initiated the Natural Forest Conservation Programme (NFCP) in 1998, which covers the upstream regions of major river systems like the Yellow River and Yangtze River. With the implementation of the NFCP, timber harvest from China’s natural forests was reduced greatly. The timber harvest quota was cut down by 5 to 6 million m$^3$ year by year. It is obvious that this policy widens the gap between demand for and supply of timber in China. There exists a big shortfall of lumber; the annual shortage of lumber volume was up to 80 million m$^3$ in China in recent years.

The only way to solve this contradiction is to expand plantation forests and to better utilize plantation timbers. Therefore, the State Forestry Administration in China has launched the Fast-growing Commercial Plantation Programme, aiming at producing more timber for local markets. It is apparent that with the implementation of this programme, plantation timbers have played a positive role in meeting the national economic needs for wood materials.

Plantation forest has expanded rapidly in China, especially after the NFCP’s implementation. The plantation forest area was about 61.68 million ha, and the plantation growing stock was about 1.96 billion m$^3$ in 2008. In the same period, the overall forest area was 195.45 million ha with 20.36% of forest coverage, and forest growing stock of about 14.913 billion m$^3$ (State Forestry Administration 2010). It is hoped that the wood resources in China
will be transferred from natural forest to plantation forest, and timber stock volume, quality and species will be more flexible to meet market needs in the near future (Zhang 2002). The proportion of logging volume from plantation forest was 39.44% in 2008 and increased by 12.27% of that five years ago (State Forestry Administration 2010).

Table 1 Main plantation species in China

<table>
<thead>
<tr>
<th>Softwood</th>
<th>Hardwood</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chinese fir (<em>Cunninghamia lanceolata</em>)</td>
<td>Poplar (<em>Populus</em> spp)</td>
</tr>
<tr>
<td>Masson pine (<em>Pinus massoniana</em>)</td>
<td>Eucalypt (<em>Eucalyptus</em> spp)</td>
</tr>
<tr>
<td>Larch (<em>Larix</em> spp)</td>
<td>Acacia (<em>Acacia</em> spp)</td>
</tr>
<tr>
<td>Slash pine (<em>Pinus elliottii</em>)</td>
<td>Paulownia (<em>Paulownia</em> spp)</td>
</tr>
<tr>
<td>Yunnan pine (<em>Pinus yunnanensis</em>)</td>
<td>Locust (<em>Robinia pseudoacacia</em>)</td>
</tr>
<tr>
<td>Loblolly pine (<em>Pinus taeda</em>)</td>
<td>Birch (<em>Betula</em> spp)</td>
</tr>
<tr>
<td>Spruce (<em>Picea</em> spp)</td>
<td>Rubberwood (<em>Hevea brasiliensis</em>)</td>
</tr>
<tr>
<td>Mongolian Scotch pine (<em>Pinus sylvestris var mongolica</em>)</td>
<td></td>
</tr>
</tbody>
</table>

The main plantation species are listed in Table 1. As poplar is a major plantation forest species, and eucalypt and rubberwood are typical tropical plantation species, the research and utilization of these three species are discussed in this paper.

CURRENT SITUATION OF RESEARCH AND UTILIZATION

**Poplar plantation timber**

Poplar is one of the major forest plantation species in China. Since the 1960s, fast-growing poplar species and clones have been selected and bred, and fast-growing plantations have been developed from garden greening to windbreak establishment and agroforestry, to large industrial plantations in China. They are distributed over more than 10 provinces in China with the stock volume of poplar plantation in China being 426 million m$^3$. China has the largest area of poplar plantation forest in the world, over 8 million hm$^2$ (Zhang & Wu 2006), about four times of the total planted poplar area in other countries.

China has made great progress in the breeding, silviculture, wood processing and utilization of poplar. Poplar-related industrial chains have been established: local manufacturers have signed contracts with farmers; farmers have planted poplar plantation forests; logs of poplar are being cut down and transported to manufacturers for MDF, plywood, blockboard, etc. The annual production of industry, for example, reached RBM36 billion in Jiangsu province.
alone (Yangtze River valley). Now there are 400 000 ha of poplar plantation forests in Jiangsu province, and log production has reached 5.6 million m$^3$. This shows that the poplar plantation forest industry development has played an important role in meeting market requirements.

Poplar plantation forests grow very fast with DBH annual growth of 2–4 cm, needing only 10 years for large-diameter log production. Normally, the poplar plantation forest could reach 9–15 m$^3$ ha$^{-1}$ y$^{-1}$ with 6–10 y of rotation (Chinese Society of Forestry and China Poplar Committee 1990). Currently the poplar plantation wood has become one of the main raw materials for pulping and wood-based panels, and has made the greatest contribution to the wood industry in China.

Much more financial investments have been put into the research on basic wood properties and utilization of plantation poplar lumber; anatomical properties, physical and mechanical properties, and chemical properties have been studied systematically since the 1990s. Research results showed that plantation poplar material contains a higher proportion of juvenile wood than that of the natural forest; and therefore significant differences exist in wood property between timber from plantation and natural forest. The plantation lumber always has lower basic density (0.35 g cm$^{-3}$), shorter wood fibres and vessels, thinner cell walls, and more vessels (Dai et al. 2009). All these result in the plantation lumber’s disadvantages—low density, low strength and softness. Besides these, the plantation poplar lumber also have unevenly distributed moisture content, large longitudinal variation of main chemical composition (Qin et al. 2004), is easy to absorb moisture, and the dimensional stability is bad. So poplar plantation material is used for low-value and low-performance products, such as packaging, rural housing building materials, match- and chopsticks (Chinese Society of Forestry and China Poplar Committee 1990).

With the implementation of government policy, market demand and research undertaken, wood processing technology has improved greatly and the application of plantation poplar has expanded. Now it is widely used in making plywood, blockboard, MDF, particleboard and laminated lumber, and it is possible to make new composite products such as surface densified lumber, LVL and reconstituted fancy veneer and simulated lumber. Plantation poplar has become the main raw material for the wood composite industries in the valleys of the Yellow River and Yangtze River. There are a number of different-scale plywood factories which use poplar wood to make veneer, plywood, blockboard and laminated lumber as core veneer and core strips, and with tropical hardwood veneer as surface layer. Small-diameter logs, head logs, branches and processing residues are used to make particleboard and MDF. The poplar wood-based panels are further overlaid with either high-value hardwood sliced veneers or impregnated paper to make decorative plywood and multi-layer parquet.
Poplar veneer is used to make reconstituted fancy veneer with beautiful grains and patterns through bleaching, dyeing, assembling, flitch forming, conditioning and slicing procedures (Zhou & Wang 2006). Simulation technology is applied so that the colours, grains and patterns could be designed and manufactured according to market needs. Reconstituted fancy veneer made of plantation poplar material is widely used in decorative plywood manufacturing, interior decoration and furniture manufacturing to substitute for valuable veneers made of hardwoods from natural forests.

In solid wood utilization, the research and technology have mainly focused on modification to improve the plantation poplar wood characteristics such as low surface hardness, low strength and poor dimensional stability. One way is to impregnate water-soluble low molecular PF or isocyanate resins into the timber and harden the composite at high temperature and pressure to increase the density resulting in high MOE, MOR, surface hardness, antiwearing and dimensional stability. The machinability and painting properties of densified poplar lumber are greatly improved such as cross-cutting, planning, tenonning, and sanding (Chai et al. 2008a, b). PF-impregnated plantation poplar lumber’s properties are as follows:

- density: increased from 0.397 to 0.710 g cm⁻³;
- MOE: increased by 56.69% (from 8.57 to 13.43 GPa);
- MOR: increased by 112.98%;
- compressive strength parallel to grain: increased by 87.72%;
- hardness: increased by 284.95% (radial) and 82.86% (tangential);
- holding nail force: increased by 69.95% (918.6 to 1558.4 N);
- surface abrasion resistance: increased by 28.3%.

Heat treatment is an effective method to improve the wood dimensional stability and durability against biodegradation. The research results showed:

- dimensional stability significantly improved;
- decay resistance property increased remarkably (IV up to I grade);
- MOE increased after heat treatment processes; MOR increased with temperature below 185 °C, but decreased with temperature above 200 °C;
- hardness improved by heat treatment at around 200 °C for less than 3 hr. It decreased sharply with temperature above 200 °C;
- colour changed remarkably due to heat treatment;
- oven-dry density decreased after heat treatment.

In recent years, many studies have been conducted on the development of reinforced polymers with poplar wood powder due to the low cost, recyclability, biodegradability, low specific gravity, abundance, high specific strength and stiffness (Qin et al. 2005). Wood/plastic composites by the extrusion technology are developed to further explore application opportunities of the material. The wood powder of plantation poplar is prepared by milling, screened, and then dried to a certain moisture content. The wood powder is compounded with polymers by injecting into a mould. Polymers, wood powder and additives
(stabilizers) are preblended in a high speed mixer, and then compounded in a twin-screw extruder and the extruded strands are cooled in a water bath. The wood/plastic composite through extrusion technology can be made and shaped into end-products without any processing residues produced and could be used widely in outdoor applications without formaldehyde emissions and with excellent durability.

**TROPICAL PLANTATION TIMBERS**

**Eucalypt timber**

China ranks third in the world in the total planted area of eucalypts, just coming behind India and Brazil. The eucalypt plantation area is currently expanding at a rapid rate, and now there are over 1.7 million hm², with annual production of 22.5 m³ hm². At present most eucalypt plantations in China are managed for short-rotation pulpwood/fibre production. The main plantation species are *Eucalyptus urophylla* and its hybrids, *E. grandis* and its hybrids, and *E. globulus*. All these species are favoured for their fast growth, good stem form (straight unforked trunks with small branches) and the fact that their juvenile wood produces good quality short-fibred pulp. The areas of eucalypt plantations that are allowed to grow sufficiently long enough to produce larger diameter trees for sawn timber production are very limited. Those plantations currently available to provide larger diameter material for efficient sawn timber production were generally established prior to the mid-1980s, the main species being *E. citriodora, E. exerta, E. urophylla x grandis, E. urophylla x camaldulensis, E. urophylla x tereticornis*. Eucalypts are favoured plantation species in China on account of their versatile timber and the international demand for their products enabling earnings of foreign exchange from the export of the raw materials they provide.

With the strong demand for eucalypt woodchips in international markets in the 1990s, much research work was accomplished on the introduction, selection and improvement of eucalypt species enabling rotations for pulpwood production to be reduced down to as short as five years. Although most eucalypt fibres are exported as unprocessed wood chips, there is an increasing amount being bought by numerous new MDF fibreboard factories in China which have either recently been completed or are under construction.

In addition, the potential eucalypt species for solid wood products have been also studied in recent years. Some species have very good appearance and colour, and the mechanical properties are high enough to be suitable for the manufacture of wood frames; the machinability of eucalypt is also good. But there is disadvantage in the utilization of eucalypt as solid wood parts: the shrinkage rate is large, so caution should be paid in processing, or the wooden products will have checks or overexpansion.
Veneer products are the main utilization of eucalypt species; the veneer productivity can reach 95%, i.e., 0.95 m$^3$ veneer could be obtained per cubic meter of eucalypt log with diameter over 8 cm (0.55 m$^3$ grade I veneer + 0.4 m$^3$ grade II veneer). And common plywood, moulding plywood, flooring base, LVL, blockboard, wooden door, decorative board, etc are the main applications for the veneers, but knots inside the log are a key factor that influences veneer quality.

Rubberwood timber

Rubber plantations are located mainly in Hainan, Yunnan, Guangdong, Guangxi and Fujian, the total rubber plantation area being more than 0.78 million hm$^2$. The state-owned rubber trees are cut for replanting usually at 25–30 y after the rubber’s first harvesting, and for the private rubber trees the age for replanting is only 15–20 y because of bad cutting technique and poor management. The annual rubberwood yield is about 800 000 m$^3$ in recent years.

Research

The machinability (including planing, sanding, boring and shaping) and coating properties (adhesion and wearability of coating) of the rubberwood have been tested. The results showed that the machinability and painting properties are all excellent and within the grade I range, which are better than those of commonly used furniture species such as oak, walnut and birch. Therefore, from the aspect of machining and coating properties, the rubberwood is good for solid wood products such as furniture and flooring.

Utilization

Rubberwood has uniform colour, beautiful wood grain, medium density (about 0.6 g cm$^{-3}$), homogeneous texture, good mechanical processing properties and good dimensional stability, making it a high-quality raw material that can be used for furniture, veneer for decoration, as well as wood-based panels.

The utilization of rubberwood for sawn timber requires preservative treatment. Environment-friendly preservative treatment is widely used in big and medium-sized factories currently, and furnace-type hot air drying is used instead of normal kiln drying. Research on rubberwood preservation using environment-friendly preservative has been emphasized in recent years. The procedure of treating rubberwood with preservative containing only boric acid quickly followed by kiln drying is encouraged to be adopted by the industries in China. At present, rubber trees are usually felled, sawn into lumber, and the lumber impregnated and dried within about 7 to 10 days in most rubberwood processing plants in China.
Different specifications and grades of the preservative-treated sawn timber can be accordingly used for furniture, finger-joint glue lumber, blockboard, wood modelling, decorative veneer, handicraft products, etc. The preservative treatment is the key to the utilization of the rubberwood as sawn timber.

Due to the great differences in rubberwood diameter, the processing wastes and branches are usually processed into small-sized boards, then bleached by hot water, and finally finger-jointed into large timber whose price is RMB1800–4500 m$^3$, which adds 1.5–4 times value after the processing. Other value-added methods include producing small-scale wooden ware such as handicrafts, toys and cutlery. One more value-added method is to slice finger-jointed timber into veneers (thickness 0.3–0.5 mm, price RMB4–5 m$^2$), which adds value by two times.

**TRENDS AND SUGGESTIONS**

The value-added utilization of plantation timbers could supplement the diminishing supply of timber from natural forests. This has been acknowledged and accepted by the Chinese Government and common public. Thanks to the improved wood processing technology, application of plantation timbers has been much expanded and the materials are widely used in manufacturing various products in China. China is now carrying out intensive research and development of plantation timbers, aiming at improving the performance of their products by creative technology. The emphasis is placed on the following aspects in the future:

- studying the relationship among wood properties, suitable species and forest management systems, targeting to produce high-quality large-diameter plantation timber;
- studying the wood properties, high-efficient processing technology, and high-value-added utilization of plantation lumber to promote development of plantation timbers’ market;
- upgrading the key technology of plantation forest industries for high-value-added wood products.

**REFERENCES**


DEVELOPMENT OF PRIVATE COMMERCIAL FOREST PLANTATION IN MALAYSIA (CASE-STUDY)—A PERSONAL PERSPECTIVE

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The paper presents a case study of a private forest plantation development in Mentakab, Pahang, where the operations are ongoing and with internal financing. The government’s encouragement into private sectors’ participation in forest plantation development is to be commended and encouraged to meet the future shortfall in wood resources to the processing mills in the country. However, for the private sector to seriously embark on this kind of long gestation project with low returns on large scale, these companies have to be aware of various issues with regard to government administrative procedures and regulations that are hampering the smooth implementation of the forest plantation programmes as highlighted in the paper presented. The current government’s administrative procedures such as land rentals, forest taxes on forest plantation produce and management systems that have been in practice for natural forest and forest plantation developed by public funds need revision to suit the current environment, failing which it would be difficult to encourage private sector participation in the forest plantation project.

INTRODUCTION

The history of large-scale forest plantation in Malaysia is not more than half a century old, involving both the public and private sectors. On record, the first large-scale forest plantation development project commenced in the late 1970s in Sabah by Sabah Softwood Sdn Bhd (SSSB), a privately owned company of Sabah Foundation for the supply of small timbers and wood chips to the market whereas, in Peninsular Malaysia during the early 1980s, the Forest Department initiated the Compensatory Forest Plantation Programme (CFPP) for the purpose of providing plantation small wood to the processing mills in the peninsula in anticipation of the shortfall of raw materials from the natural forest. During the same period, another large-scale forest plantation of fast-growing species was established by the first private pulp and paper mill, Sabah Forest Industries (SFI) in Sipitang, Sabah, for the future supply of wood resource to the mill once the residual timbers of mixed hardwoods from land clearing within their concession are exhausted. However, all the three companies have different objectives in their approaches to forest plantation projects.

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Apart from these three projects and except for some smaller players, the development of private forest plantation projects has not taken off in a big way despite the fact that the wood industries in Malaysia are experiencing shortage of raw materials for the already established processing mills. Over the last few years, the government has realized the importance of the private sector’s participation in the development of forest plantation for the wood industries in the country. However, the current initiatives and measures implemented by the government have not encouraged tree farmers in this field be it for small-, medium- or large-scale forest plantation development. Therefore, it is now timely to re-examine why private sector has been reluctant to be involved in the programme.

Growing tree plantation is a business enterprise and for the venture to be sustainable and successful, the investors must at the end of the rotation derive economic benefits from the sale of the produce. Development of forest plantation is an economically viable business enterprise provided that there are proper planning and strategizing particularly where the upstream (tree farmer) and the downstream activities (processing mill) have direct linkages.

This paper puts forth the personal views, issues, constraints and recommendations from a case study experienced by the author during the course of the planning, development and management of a private forest plantation in the country for Robina Plantation Sdn Bhd (RPSB). Appropriately, the authorities should re-investigate and reformulate strategies in the existing policies and management systems that are currently being implemented so as to create a more favourable environment more conducive for the ‘serious’ private growers to invest in tree plantations in the country.

OBJECTIVE OF ROBINA PLANTATION SDN BHD

The principal objective of Robina Plantation Sdn Bhd in the development of the forest plantation is the production of small timbers of short rotation (six years) for the supply of wood resource to its medium density fibreboard mill at Mentakab, Pahang, at a reasonable cost.

BACKGROUND OF ROBINA PLANTATION SDN BHD

Robina Plantation Sdn Bhd is a subsidiary company of Robin Resources (M) Sdn Bhd, a company involved in the manufacture of medium density fibreboard with its mill located in the industrial area in Mentakab, Pahang Darul Makmur.

Robina Plantation Sdn Bhd was incorporated to develop and manage the tree plantation in the concession area for the future supply of the wood resources to the mill.

Concession area—initially awarded an area of 4000 ha of logged-over *Acacia mangium* forest in mid-2005 and in late 2009 an additional area of 2000 ha was included. Total area is 6000 ha to date.

The total area planted to date is approximately 3400 ha with *A. mangium*.
Currently, the mill obtains the raw materials 100% from the open market. Funding for the plantation development is internally generated because the company is not eligible for the ‘soft loan’ from the Malaysian Government which is meant for local companies.

Robina Plantation Sdn Bhd requires a minimum of 12,000 ha of plantation at maturity to be approximately 60% self sustainable based on the current growth rates on the chosen species at a 6-y rotation age.

ISSUES AND CONSTRAINTS IN THE CASE STUDY—ROBINA PLANTATION SDN BHD

Government policies and management systems

*Land area (concession area)*

RPSB to be self sustainable requires at least 12,000 ha at maturity based on the selected species and growth rates. Lack of adequate planting area in a suitable location and availability remain a big constraint for tree farm holders of commercial size tree plantation. Large-sized commercial tree plantation is expected to be more cost efficient with relatively lower production cost per hectare because of the economy of scale. This applies to all aspects of the tree business operations from site establishment to plantation maintenance up to harvesting.

Therefore, the authorities should seriously look into ‘idle concession holders’ that have not commenced their planting activities in their concession areas by giving them a time period to develop, failing which the authorities should revoke the licenses and then release these areas to more ‘serious’ plantation investors.

The land tenure security for the forest plantation at the Kemasul Forest Reserve is good, has a well-developed and excellent infrastructure besides being situated in the most ideal location with respect to the markets in Pahang State. The proximity of the markets from the wood source is a crucial factor to consider in a successful commercial farm forestry project. Where the forest plantation is sited beyond 100-km radius from the markets or processing mills then it is no longer financially profitable because of the heavy transport cost.

*Management system*

Forest plantation management plan

The management systems in managing the natural forest and the plantation forest have to be different though there may be some rules that overlap. Invariably, all concessionaires of large estates on long-term lease have to prepare the forest management plan (normally a 10-y plan) to be approved by the authorities before the commencement of their activities.
Once the approval is given, the concessionaire should be allowed to manage his tree farm based on the approved plan with minimal or no interference from the authorities. RPSB provides a yearly briefing on the progress of development and submits a quarterly progress report to the Forest Department.

Existing licensees

At the time when the concession license agreement was signed, there were few third party licensees issued earlier for the harvesting of the *A. mangium* wood. However, over the last four years, they continue to have their licenses renewed whilst no operation is being carried out in these areas. By right these licensees should be given a time frame to complete the harvesting and the land area handed over to the concessionaire for planting. The planting schedule has been much delayed as a result of this postponement.

Re-tendering within plantation area

In legal terms, once a plantation concession agreement is signed, the concessionaire is the rightful owner of all the standing trees within the concession area except where there are valid existing licensees. Any re-tendering for the removal of standing trees (natural or plantation) outside the existing licensees should be viewed as inappropriate. Probably, this system is being practised in the natural forest management by the authorities and should not be applicable in this case in the plantation concession area. RPSB should be given the first right of refusal.

Residual timbers from land clearing

Land clearing for planting involves the removal of existing vegetation by mechanical means. The vegetation consists of mass regenerated *A. mangium* seedlings and saplings interspersed with advanced regrowth (small diameter trees) of native mixed hardwood species.

Application to extract these utilizable residual timbers during land clearing to the MDF mill in Mentakab has been made since the plantation development commenced in late 2005. To date, no approval (for whatever reasons) has been given for the extraction and therefore, these trees are either left standing in the plantation or being pushed down and stacked in the windrows to decay during the land clearing.

Since burning is not allowed, the debris is stacked in windrows and these may pose as fire risks when they dry up. They also act as medium for the multiplication of various pests and diseases, particularly of fungal spores within the plantation area.

The slow decision to approve the extraction of the small wood is also a great loss of revenue to the state government and the wood industries.
Land rental

Forest plantation projects have long gestation periods with no intermediate income until final harvest except, maybe for rubber crop. Paying annual land rental for the use of the land to grow the timber crops is acceptable by the tree farmers. However, paying the quantum of land rental equivalent to the rental imposed for agricultural usage could be quite taxing for any tree farmer as the return on investment as compared to the agricultural crops is much lower besides being periodical. Therefore, the quantum on land rental and when payment is to be effected for tree farming are to be reviewed if this business is to be encouraged.

Diseased area

Three years after establishment, some areas within the concession were noticed to be affected by some kind of disease with large numbers of trees showing signs of dying in large groups. RPSB requested for assistance from the Forest Research Institute Malaysia to investigate the cause and the end result was that the plantation had been infected by various fungal diseases. Subsequently, a survey of the infected area was carried out and it showed that as high as 50% of the trees in the infected area had died and were at various stages of decaying.

As a temporary remedial measure to contain the spread of the fungal infestations, FRIM recommended ‘salvage’ felling as the area affected was too widespread for any kind of chemical treatment. Besides, RPSB would also be able to recover whatever sound timbers that could be utilized by the mill and then the cleared area to be allowed to lie fallow for sometime before planting. If possible, the debris at the site was to be allowed to burn (as a special case) so as to reduce the fungal spores that existed at the site.

Application for the ‘salvage’ felling to remove the small timbers was made and the slow decision to approve felling caused a large number of dead trees to fall to the ground due to decomposition and that was a great loss to RPSB. The authorities could have just allowed the concessionaire to mark out the affected area and submit for approval but instead requested their own staff to carry out the boundary demarcation which took a while before it was done. Almost nine months down the line, the ‘salvage’ felling has yet to commence.

Practice of intercropping

The main forest crop is *A. mangium*. The planting spacing adopted is 2 m within row and 3 m between rows thereby, giving a planting density of 1667 plants per hectare. The inter-row space of 3 m is sufficiently wide enough to allow the practice of intercropping with cash crops. Agricultural crops such as peanuts, corn and tapioca could be planted between the rows of tree seedlings whilst along the firebreaks bananas and papayas could be planted.
The adoption of intercropping of cash crops by the tree farmers also compels the farmers to constantly keep the site free of weeds and in return reduces the cost on the maintenance and fire risks besides being rewarded with intermediate cash returns for at least the first three years.

**CHOICE OF SPECIES**

Many potential plantation species have been trial planted for many years by the Forest Department, Malaysia, and Forest Research Institute Malaysia with lots of growth data available. However, to date, only a handful of the species on trials have the potential to be accepted by the private sector for planting, particularly based on their economic returns in a shorter rotation age. Invariably, most of the species chosen for large-scale planting are of the short rotation crop of not more than seven years although some medium rotation age species have been planted.

The criteria for choosing the species for the development of the forest plantation by a private company are governed mainly by their end-uses, growth that determines the rotation age and the ease of obtaining seeds in large quantities or vegetative planting materials at the lowest pricing. Presently, the species that have been chosen for large-scale planting are *A. mangium*, *Paraserianthes facaltaria*, *Hevea brasiliensis* and *Tectona grandis* although other species like *Neolamarckia chinensis*, *Khaya ivorensis* and *Acquilaria malaccensis* have been tried to a lesser extent.

The first choice of RPSB is *H. brasiliensis* (rubber) but the slower growth rate has resulted in the preference for *A. mangium* that has a faster growth rate and source of seeds is easily available. Since the plantation is facing some disease problems, RPSB is monitoring the situation closely and has taken measures in the treatment of the disease, but options to introduce other species are being looked into if the situation worsens. However, planting of disease-resistant improved planting materials through selection is one way of mitigating the problem but will take some time to see results.

**PROFESSIONALISM AND TRAINING**

The forest plantation in RPSB is managed by trained foresters. This private forest plantation provides a good training ground for budding foresters. Opportunities are plentiful for foresters who are interested to develop their career both in the upstream and downstream activities in forestry.

**RESEARCH AND DEVELOPMENT (PRIVATE INITIATIVE)**

RPSB does not believe in reinventing the wheel. The lack of supply of improved quality planting materials in the market has resulted in the company setting up her seed stand from the FI generation planted areas where the growth rates have been very promising. Selection of plus trees is now in progress and at a later stage a seed orchard will be established to supply improved seeds for the planting programme. A tree improvement programme will also be initiated in the near future.
CONCLUSION AND RECOMMENDATIONS

Lack of public land for reforestation (tree farming) on long-lease periods, low rental and land tenure security has always been an obstacle for the wood industries. More marginal public land has to be made available for interested tree farmers at low rentals.

Private sector participation and development of forest plantation can be much accelerated provided the government policies, incentives, management systems and support services are easily made available to the private investors.

Tree farming by the private sector on public or private lands should be market demand-driven, whereby the farmers (producers) enter into an agreement with the wood industries (purchasers) for it to become economically viable and sustainable. The authorities may be able to assist in marketing the produce for the small farmers by establishing timber depots.

Financial assistance at low interest rates is another key factor that has great impact on the tree farmers in their involvement on tree farming.

Intercropping (agroforestry) is to be encouraged particularly by the small farms where limited financing is the main constraint. Besides, this tree farming land would be put to optimum use.

The government should look seriously into making appropriate changes and improve the current policies, management systems and procedures that are currently being practised that would encourage more private plantation farmers to be involved in the programme.
WOOD PROPERTIES OF AND UTILIZATION OPPORTUNITIES FOR SELECTED PLANTATION-GROWN SPECIES IN MALAYSIA


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Like many other tropical nations, Malaysia has embarked on forest plantation activities since a few decades ago with the prime objectives to supplement the increasing timber requirement and to reduce pressure on the natural forest so that commitment to sustainable forest management could be maintained. Selected species such as Acacia mangium and Shorea macrophylla are among those planted during this period. Some of the plantation species are even in commercial production currently. Meanwhile since September 2006, Malaysia had initiated an ITTO project on the development of a set of harmonized testing methods for the determination of basic properties of plantation-grown timber species with particular reference to those from the tropical nations.

This paper aims to demonstrate how some of the technical data obtained on basic and working properties, together with current and expected future availability, could be associated with current and potential utilization for commercial applications. It is hoped that such attempt will not only illustrate the pertinence of the data derived, but may eventually lead to further product development. In some cases, the shortcomings exhibited may be overcomed to produce better quality products.

INTRODUCTION

Malaysia has been involved in large-scale forest plantations since a few decades ago. More established plantations are found in Sabah, especially with private sector participation, while other states in the country have also attained different degrees of success. In 2006, Malaysia was awarded a research grant by the International Tropical Timber Organization (ITTO) to establish a set of harmonized procedures to determine the basic properties of plantation-grown timbers with special reference to those from the tropical regions. In addition, limited activities on product development were also incorporated. Hence, at
the conclusion of the project, two different events are being organized: one for the stakeholders who are interested in the commercial aspects of the project, the other more on the technical experience gained in the application of the testing methodologies developed.

A total of three plantation species, namely *Acacia mangium*, *Shorea macrophylla* and *Tectona grandis*, were employed by the FRIM, TRTTC and FRC respectively, to test out and refine the methodologies developed. From the commercial perspective, there is a possibility to relate some of the technical data obtained with the utilization prospects or opportunities. In view of the fact that only limited data were derived for *T. grandis*, only the first two species will be focussed on.

This paper intends to examine the basic wood properties of both *A. mangium* and *S. macrophylla* based on the harmonized set of testing methodologies developed. This application of such unified set of test methodologies allows comparison of test results to be made. The results could also be related to the current utilization as well as other possible applications as a basis for product development or enhancement.

**AVAILABILITY**

Before a plantation species could be marketed or deserves any further attention, the few major concerns include its availability, either current or in the nearest future, basic and working properties, as well as unique selling points attached, if any.

Table 1 shows that a substantial quantity of *A. mangium* has been planted in various states as of 2010. The plantations are located in a few states in Peninsular Malaysia as well as in Sabah and Sarawak. A significant amount is also known to have reached maturity of more than 15 y in some plantation sites. Hence, some commercial activities of this species are also found in these areas. The table also shows that the planting area of *A. mangium* is significantly larger compared with other plantation timber species listed except for rubberwood derived from rubber plantations which runs into more than 1 million ha in area in the country. In addition, Sarawak, for instance, has earmarked 1 million ha of land for plantation forest and *A. mangium* is expected to take up at least 50% of it. This implies that *A. mangium* or hybrids could be a major source of raw material supply for the wood-based industries in the country in the near future.

On the other hand, *S. macrophylla*, or engkabang jantung, is only available in small quantities in some states in the country. The reason why it was chosen in this project is mainly because of its availability in suitable ages in these areas.
Table 1  Total planted areas (ha) of selected plantation species in Malaysia (2010)

<table>
<thead>
<tr>
<th>State/region</th>
<th>Acacia mangium</th>
<th>Shorea macrophylla</th>
<th>Teak</th>
<th>Khaya</th>
<th>Laran</th>
<th>Mixed species</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peninsular Malaysia</td>
<td>64 630</td>
<td>-</td>
<td>1664</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sarawak</td>
<td>191 891</td>
<td>3700</td>
<td>-</td>
<td>1340</td>
<td>3503</td>
<td>-</td>
</tr>
<tr>
<td>Sabah</td>
<td>72 925</td>
<td>-</td>
<td>6584</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

*Data compiled from personal communication with Hazani Othman (FPD) and http://www.fao.org/DOCREP/005/Y7209E/y7209e04.htm#TopOfPage

The questions are:
• Whether the scheduled planting will materialize as planned?
• Will the industry be able to absorb all these materials then?
• Will the current plantations be converted to other money crops due to low return on investment (ROI), as taken place in at least one of the plantations recently?
• If not properly utilized/ absorbed, will the utilization be confined to lower-end applications and in what form?

CURRENT UTILIZATION IN MALAYSIA

*Acacia mangium*

Being one of the major forest plantation species in Malaysia, its current utilization could be divided into furniture and non-furniture applications.

*Furniture applications*

As there is a global demand for sustainable wood species, our plantation-grown *A. mangium* appears to be one of the ideal options. Hence it has been promoted by some companies for the production of garden furniture and standard planks for bench tops (Figures 1 and 2). Limited effort has also been made in peeling of logs for moulded chair shells, with acacia veneers being used as core and/or face. Such products are being marketed as green products and are well accepted in many countries. The volume of material involved, however, may not be huge.
Owing to current availability, some sawn timber is being produced for general utility, and some logs have been converted into chips, particularly those of lower quality in Sabah where export of logs is allowed and a substantial quantity is being exported to Japan for panel products manufacture. In this state, one mill has even used it as the only feedstock for its particleboard production. Besides that, acacia is being utilized as raw material for a pulp and paper mill in the same state. In Peninsular Malaysia, some attractive flooring boards are also being produced and marketed. Nonetheless, a substantial amount is also being used for pallet production.

It is understood that some logs exported to Japan were also finger-jointed and laminated into truck flooring and truck body.

In short, there is a general lack of systematic commercial applications for *A. mangium*, especially in high-value applications.

*Shorea macrophylla*

This is one of the few plantation species planted mainly in Sarawak by the Sarawak Forest Department more than two decades ago. With the limited quantities available, its utilization has not yet reached commercial level. Should the basic working properties obtained be favourable, commercial planting may then be possible.

**WOOD PROPERTIES AND UTILIZATION**

Selected test results obtained for both *A. mangium* and *S. macrophylla* are given in the respective technical papers presented in this seminar/workshop. Some of the properties pertinent to current and future utilization are hereby discussed.
Quality of wood

Acacia mangium

Some incidence of heart rot has been reported earlier although it did not appear to be so in the two batches of A. mangium collected from two other sites from Peninsular Malaysia in this study. On the other hand, depending on the quality of silvicultural treatment, prevalence of knots could be a concern. However, from the sawing yield study conducted on logs of representative diameters based on the sampling approach developed as described in Chapter 1 of the manual (Tan et al. 2010), it was noticed that the average sawn timber recovery for both ages of A. mangium was approximately 38% (Wong et al. 2010) (Figure 3). When compared with rubberwood with an average recovery of 32%, the figure obtained appears to be comparable. When visually graded based on the Malaysian Grading Rules, it was found that A. mangium produced higher sawn timber grades of “Serviceable” and above as presented in Figure 4, thus a promising result. It should be noted that recently, better clones of Acacia sp are also being promoted among the plantation fraternities.

With regard to the density, as shown in Table 2, acacia seems to be comparable with while S. macrophylla shows a lower value than that of rubberwood (Lim et al. 2010b). A 20-y-old A. mangium exhibited superior mechanical properties such as bending, shear parallel to the grain, compression parallel to the grain and hardness compared with 25-y-old rubberwood. As expected, S. macrophylla showed otherwise. However, both are still acceptable for most non-structural applications.

In terms of colour, A. mangium produces distinctive contrast between its sapwood and hardwood (Figure 5) (Lim et al. 2010b). Though this appears to be a hindrance to some marketers, creative designers may project this as an aesthetic value either singly or in combination with other materials. This was clearly illustrated in the marketing of products as shown in Figures 1 and 2.

Acacia mangium is commercially claimed to be more durable than rubberwood. This allows garden furniture made from such timber to be just coated with linseed oil without the necessity to chemically treat the wood material as in the case of rubberwood. This is clearly illustrated in the durability results of the 20-y-old board which is classified under “Very resistant” for all the three types of fungi tested using the approach proposed (Salmiah & Lai 2010). In the case of 16-y-old board, slightly inferior durability qualification has been obtained. Test results showed that both age groups of A. mangium possess average treatability rating. Its treatability, however, is rated only “Average” (Lai & Salmiah 2010).
Figure 3  Sawing recovery (%) with respect to timber species

Figure 4  Sawing recovery with respect to sawn timber grades

Table 2  Average basic density values of different plantation species

<table>
<thead>
<tr>
<th>Species</th>
<th>Age group (y)</th>
<th>Average basic density (g cm(^{-3}))</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Acacia mangium</em></td>
<td>16</td>
<td>0.52</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>0.62</td>
</tr>
<tr>
<td><em>Shorea macrophylla</em></td>
<td>13</td>
<td>0.30</td>
</tr>
<tr>
<td></td>
<td>22</td>
<td>0.33</td>
</tr>
<tr>
<td>Rubberwood</td>
<td>25</td>
<td>0.54</td>
</tr>
</tbody>
</table>
*Shorea macrophylla*

No incidence of heart rot or prevalence of knots as in the case of *A. mangium* has been reported for *S. macrophylla*. In the similar sawing yield study, the mean recovery (volumetric yield) for both ages of the species was reported to be approximately 60% (Wong et al. 2010), which is much higher than that of *A. mangium*. Occurrence of severe end-splitting of slabs after sawing was observed. This was attributed to the release of internal stresses brought about by fast growth rates. In addition, the trees seem to grow much faster than *A. mangium* (Wong et al. 2010). The MGR grading conducted also showed that *S. macrophylla* generally produces much lower grades of timber quality, ie small amount of Standard grade but mostly Serviceable grade sawn timber. This should be taken note of when the species is considered for planting (Figure 4).

![Figure 5](image)

*Figure 5*  Acacia boards of contrasting colours

**Table 3**  Durability rating against different fungi

<table>
<thead>
<tr>
<th>Fungus</th>
<th><em>A. mangium</em> (16-y-old)</th>
<th><em>A. mangium</em> (20-y-old)</th>
<th><em>S. macrophylla</em> (13-y-old)</th>
<th><em>S. macrophylla</em> (22-y-old)</th>
<th><em>Hevea brasiliensis</em></th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Lentinus sajor-caju</em></td>
<td>Moderately resistant</td>
<td>Very resistant</td>
<td>Not resistant</td>
<td>Moderately resistant</td>
<td>-</td>
</tr>
<tr>
<td><em>Coriolus versicolor</em></td>
<td>Moderately resistant</td>
<td>Very resistant</td>
<td>Not resistant</td>
<td>Moderately resistant</td>
<td>Moderately resistant</td>
</tr>
<tr>
<td><em>Gloeophyllum trabeum</em></td>
<td>Very resistant</td>
<td>Very resistant</td>
<td>Very resistant</td>
<td>Very resistant</td>
<td>-</td>
</tr>
</tbody>
</table>
Also, since *S. macrophylla* is not yet commercialized, with the aid of durability result in Table 3 (Salmiah & Lai 2010), it could be deduced that 22-y-old timber of the species is equivalent in terms of durability to that of 16-y-old *A. mangium*. The 13-y-old material, however, may be considered for chemical treatment. This does not appear to be a problem as the treatability results indicated that both age groups of *S. macrophylla* could be easily treated.

**Working and other properties**

Many other properties are also essential for the utilization or marketing prospects of these species.

**Machining properties**

The results obtained are summarized in Table 4.

In the case of *A. mangium*, a closer look at the results reveals that the older age group (20-y-old) and flat-sawn boards have better machining properties than the younger age group (16-y-old) and quarter-sawn boards respectively (Wong *et al.* 2010). On the other hand, the results for *S. macrophylla* revealed that the older age group and flat-sawn boards have better machining properties compared with the younger age group and quarter-sawn boards (Wong *et al.* 2010).

For *A. mangium*, particularly since it is already being used by the industry for commercial application, it implies that its machinability is acceptable, if not surmountable, with modern machining technique, which is supported by the laboratory assessments carried out (Table 4) (Wong *et al.* 2010). Nevertheless, with a more inferior assessment result for *S. macrophylla*, it appears that more attention is needed for the species, particularly in terms of boring, mortising and turning properties.

**Table 4** Machining properties

<table>
<thead>
<tr>
<th>Machining property</th>
<th>Species</th>
<th>Planing</th>
<th>Sanding</th>
<th>Boring</th>
<th>Mortising</th>
<th>Shaping</th>
<th>Turning</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><em>Acacia mangium</em></td>
<td>Easy</td>
<td>Easy</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Excellent</td>
<td>Good to excellent</td>
</tr>
<tr>
<td></td>
<td><em>Shorea macrophylla</em></td>
<td>Easy</td>
<td>Easy</td>
<td>Fair to good</td>
<td>Fair to poor</td>
<td>Excellent</td>
<td>Fair to good</td>
</tr>
</tbody>
</table>
Drying properties

*Acacia mangium*

There have been requests from the industry to assist in the drying of *A. mangium* due to the incidence of wet pockets and its ‘refractory’ nature in drying. This was clearly portrayed in the initial application of the drying methodology as prescribed in the manual. The material reached a plateau at a rather high moisture content level after a period of six months during the air-drying test. Also, after the drying-schedule test, the timber demonstrated severe wet cores and even with extended period of drying the timber could not be dried satisfactorily (Gan *et al.* 2010). Subsequently it was evidenced that air-drying the boards to below fibre saturation point (~30%) prior to air-drying helped to reduce the incidence of wet cores (Gan & Zairul 2010). The latest drying trial produced moisture differential between shell and core moisture content of less than 3% in 81.3% of the boards.

The inherent drying characteristics of *A. mangium* gave rise to problems in the bonding tests subsequently carried out. While a special drying procedure for the species using a conventional drying method was being worked out, some batches of *A. mangium* were dried under a separate arrangement, using radio-frequency drying facility to the range of 10–12% moisture content. Bonding and finger-jointing samples were then prepared.

*Shorea macrophylla*

Being a low density wood, this species could be dried perfectly well in air-drying. The duration required to achieve air-dry condition for 27-mm and 54-mm thick boards varied from 6 to 10 weeks and from 11 to 23 weeks respectively. Again, the occurrence of drying degrade was very low. The quick-drying test (QDT) of this species reveals it as highly porous and dries relatively well under very harsh conditions without any severe drying degrades. The only possible drying defect arising from external checks may vary from ‘perfect to moderate’. The deformation of this species is small. Timber cut from this species is expected to be stable. As the timber is light and porous, drying duration is short with an estimated time of drying 6–8 days in a conventional dryer.

This positive drying characteristic facilitates bonding and finger-jointing was subsequently carried out.

Bonding and finger-jointing properties

The industrial feedback reveals that garden furniture sets from *A. mangium* have been produced commercially, besides truck flooring and truck body, using finger-jointing and lamination technology. This indicates that the bonding and
finger-jointing properties of this species could meet commercial needs. From the assessments carried out using various adhesives as summarized in Table 5, it appears that:

a) Both species upon finger-jointing using both indoor and outdoor adhesives, produced bending and tensile strengths surpassing all limits stipulated for non-structural applications (Ting & Ong 2010).

Table 5  Assessment of finger-jointed timber in bending under different accelerated conditions

<table>
<thead>
<tr>
<th>Type of test</th>
<th>Adhesive</th>
<th>Acacia mangium</th>
<th>Shorea macrophylla</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PVAc</td>
<td>EPI</td>
<td>PRF</td>
</tr>
<tr>
<td>Finger joint—bending</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry</td>
<td>Age grp. 1</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Age grp. 2</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Water soaking</td>
<td>Age grp. 1</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Age grp. 2</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Boiling test</td>
<td>Age grp. 1</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Age grp. 2</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Vacuum-pressure</td>
<td>Age grp. 1</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Age grp. 2</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Finger joint—tensile</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry</td>
<td>Age grp. 1</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Age grp. 2</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Water soaking</td>
<td>Age grp. 1</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Age grp. 2</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Boiling test</td>
<td>Age grp. 1</td>
<td>NR</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Age grp. 2</td>
<td>NR</td>
<td>✓</td>
</tr>
<tr>
<td>Vacuum-pressure</td>
<td>Age grp. 1</td>
<td>NR</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Age grp. 2</td>
<td>NR</td>
<td>✓</td>
</tr>
<tr>
<td>104 °C</td>
<td>Age grp. 1</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Age grp. 2</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>65% RH/ 16 °C</td>
<td>Age grp. 1</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>Age grp. 2</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

* NR = non-relevant

b) In the use as laminated products whereby block-shear test and delamination test were specified, mixed results were obtained for the category of adhesives tested. In this case, PVAc is more for indoor use while EPI is employed in a more humid but non-structural environment. PRF, a structural adhesive, could be taken as control.
Table 6  Assessment of laminated timbers in block-shear and delamination tests

<table>
<thead>
<tr>
<th>Adhesive</th>
<th>Test</th>
<th>Species</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Acacia mangium</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Shorea macrophylla</td>
</tr>
<tr>
<td>Block-shear test</td>
<td></td>
<td>Age grp. 1</td>
</tr>
<tr>
<td>PVAc</td>
<td>Dry</td>
<td>½</td>
</tr>
<tr>
<td></td>
<td>Water soak</td>
<td>½</td>
</tr>
<tr>
<td></td>
<td>104 °C</td>
<td>x</td>
</tr>
<tr>
<td>EPI</td>
<td>Dry</td>
<td>½</td>
</tr>
<tr>
<td></td>
<td>Water soak</td>
<td>√</td>
</tr>
<tr>
<td></td>
<td>Boiling</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Vacuum-pressure</td>
<td>√</td>
</tr>
<tr>
<td></td>
<td>104 °C</td>
<td>√</td>
</tr>
<tr>
<td>PRF</td>
<td>Dry</td>
<td>√</td>
</tr>
<tr>
<td></td>
<td>Boiling</td>
<td>√</td>
</tr>
<tr>
<td></td>
<td>Vacuum-pressure</td>
<td>√</td>
</tr>
<tr>
<td></td>
<td>104 °C</td>
<td>√</td>
</tr>
<tr>
<td>Delamination test</td>
<td></td>
<td>Age grp. 1</td>
</tr>
<tr>
<td>PVAc</td>
<td>6-hr</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>24-hr</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Boiling</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Vacuum-pressure</td>
<td>x</td>
</tr>
<tr>
<td>EPI</td>
<td>6-hr</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>24-hr</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Boiling</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Vacuum-pressure</td>
<td>x</td>
</tr>
<tr>
<td>PRF</td>
<td>6-hr</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>24-hr</td>
<td>x</td>
</tr>
<tr>
<td></td>
<td>Boiling</td>
<td>√</td>
</tr>
<tr>
<td></td>
<td>Vacuum-pressure</td>
<td>x</td>
</tr>
</tbody>
</table>

While *Shorea macrophylla* exhibited excellent results in almost all the tests conducted, *Acacia mangium* showed otherwise. The general feeling is that the proposed methodology on delamination appears to be more stringent than the “cold-water-soak method” stipulated in the Japanese Standard for non-structural products. Nevertheless, the mixed results obtained imply that further improvements in material preparation and bonding process may be necessary. One particular area of major concern is its drying quality.
Peeling and slicing

Successful peeling and slicing enable a timber species to be further developed into plywood or other veneer-laminated products.

It must be admitted that in the case of *A. mangium*, a slight deviation from the sampling procedure proposed was applied upon suggestion by the industrial collaborator. As shown in Table 7, some exceptionally round logs were employed and yield exceeding 70% was obtained (Hamdan 2010). Otherwise an average of 60% was attained. In the case of *S. macrophylla*, which follows a “balanced” distribution as stipulated in the sampling procedure (Tan et al. 2010), yield of about 65% was achieved (Table 7) (Lim et al. 2010a). In general, both species could be peeled quite easily with a normal peeling lathe used in furniture mills in the country.

Some furniture chair shells were also manufactured using a commercial set-up. Satisfactory quality was obtained with the moulded veneer product surpassing the relevant technical requirement of up to 100 000 cycles of fatigue loading as spelt out in the relevant EN standard (Hamdan 2010). This shows that such product could be further promoted in the near future, either as it is or overlaid with suitable veneers.

For sliced veneers, Table 8 shows that veneer yields for *A. mangium* were generally better than for *S. macrophylla* for both age groups except in the 13-y-old *S. macrophylla* of 2.5-mm thickness. Furthermore, the surface roughness values for *A. mangium* and *S. macrophylla* were higher in the 2.5-mm than in the 0.6-mm thick veneers.

### Table 7  Quality assessments of peeled veneers

<table>
<thead>
<tr>
<th>Species</th>
<th>Age (y)</th>
<th>Veneer thickness (mm)</th>
<th>Shrinkage (%) Perp. Thickness</th>
<th>Yield (%)</th>
<th>Depth of peeler checks (%)</th>
<th>Surface roughness (µm)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Acacia mangium</em></td>
<td>16</td>
<td>1.2</td>
<td>6.3</td>
<td>1.3</td>
<td>79</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.4</td>
<td>5.2</td>
<td>2.4</td>
<td>67</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.2</td>
<td>4.5</td>
<td>1.2</td>
<td>53</td>
<td>59</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.4</td>
<td>5.1</td>
<td>2.5</td>
<td>74</td>
<td>56</td>
</tr>
<tr>
<td><em>Shorea macrophylla</em></td>
<td>13</td>
<td>1.5</td>
<td>3.5</td>
<td>6.1</td>
<td>63</td>
<td>36</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.5</td>
<td>5.8</td>
<td>5.7</td>
<td>64</td>
<td>46</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1.5</td>
<td>5.4</td>
<td>6.7</td>
<td>65</td>
<td>38</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.5</td>
<td>6.9</td>
<td>5.5</td>
<td>65</td>
<td>47</td>
</tr>
</tbody>
</table>
Table 8  Quality assessments of sliced veneers

<table>
<thead>
<tr>
<th>Species</th>
<th>Age (y)</th>
<th>Veneer thickness (mm)</th>
<th>Yield (%)</th>
<th>Surface roughness (µm)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acacia mangium</td>
<td>16</td>
<td>0.6</td>
<td>33</td>
<td>84</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.5</td>
<td>43</td>
<td>83</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>0.6</td>
<td>34</td>
<td>115</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.7</td>
<td>34</td>
<td>133</td>
</tr>
<tr>
<td>Shorea macrophylla</td>
<td>13</td>
<td>0.6</td>
<td>22</td>
<td>108</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.5</td>
<td>47</td>
<td>152</td>
</tr>
<tr>
<td></td>
<td>22</td>
<td>0.6</td>
<td>26</td>
<td>106</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2.5</td>
<td>32</td>
<td>135</td>
</tr>
</tbody>
</table>

Chemical properties

The total chemical content did not vary very much between A. mangium and S. macrophylla. The amounts of lignin of the two species were also comparable. The tannin content of S. macrophylla bark was quite low (Siti Hanim 2010) as compared with A. mangium (> 15%), Pinus radiata (about 10–11%) and Tsuga canadensis (about 10–12%). Meanwhile, the percentage of sugars of the 22-y-old bark was found to be higher than that of the 13-y-old bark. While the possibility of commercializing tannin derived from S. macrophylla is not likely, commercial exploration of tannin from A. mangium may be commercially viable, particularly at sites where heavy debarking is taking place.

FUTURE PROSPECTS OF UTILIZATION

The recent episode in which an acacia plantation was replaced by other agricultural crops prompted the thought of whether there is any means to improve the value-adding of plantation forests such as those of A. mangium. Currently, most of the acacia is being converted into chips for pulp and paper and panel products manufacture, which is recognised for its voluminous consumption. However, other higher-value-added products should be promoted if not developed to enhance its viability.

As a material, A. mangium is derived from sustainable management; this itself is a unique selling point. Its future availability in this country is also substantial, which warrants due attention from all parties concerned. Its density and other basic properties, especially durability and other working properties, are equally promising.
For a plantation industry to be viable, the log outputs should warrant an attractive income. This is most probable if the end-products produced are of high value and total utilization is achieved.

While flooring boards and furniture are known to be higher value added, the current consumption is limited. At the moment, the bark is not being utilized. The timber as a construction material, which is known to be able to absorb substantial amount of material, is not being explored. The use of such material for energy has also not been considered. In the meantime, once the drying quality is more assured, more high-end laminated products including furniture could then be produced. Together with its current utilization in pulp and paper and panel products, an optimum approach should be striven for in the near future so that the original objectives of plantation industry in the country besides its recognised role as carbon sink could be realized.

The commercial extraction of tannin from the bark of A. mangium deserves a further look.

In general, all plantation species have some plus and minus features associated with them. Shorea macrophylla appears to be quite promising in some basic and working properties. However, it is moderately fast growing, which may have put off some potential investors for whom fast financial return is one of their major concerns. Besides, its site-specific nature also discourages some from considering its commercial planting seriously.

CONCLUSION

The plantation industry is the way to go in many countries. A set of harmonized testing techniques with the potential of comparing the relative performances of plantation-grown timbers has been developed and is presented here. In the case of A. mangium, its future availability alone warrants larger attention from the parties concerned. This is boosted by its generally promising working properties. Nevertheless, to make such plantations more economically viable, efforts should be made to further enhance some of the species’ shortcomings besides further development of higher-value-added products. In the case of S. macrophylla, though satisfactory basic and working properties prevail, the other considerations may put off large-scale planting of this species in the country.

REFERENCES


Drying of *Acacia mangium* using conventional kiln-drying system

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Commercial drying of 30-mm *Acacia mangium* is still problematic with high incidences of drying defects such as collapse, wet pockets/cores and honey-combing. In this study, three drying trials were conducted on 16-y-old 30-mm *A. mangium* obtained from Ulu Sedili, Johor. The drying schedules applied were developed based on the quick-drying test conducted. The first drying trial was conducted on freshly sawn boards using the developed drying schedule. The second trial was conducted also on freshly sawn boards but with a lower initial dry bulb temperature and application of regular high humidity treatments. The third trial was conducted using the same drying schedule as the second trial but the boards were air-dried for about two months prior to kiln drying. There were high incidences of severe wet cores for the first two trials. Lower initial dry bulb temperature and regular high humidity treatments did not reduce the occurrence of wet cores. However, air drying the boards to below fibre saturation point (~30%) prior to kiln drying helped reduce the occurrence of wet cores. It was concluded that air drying of *A. mangium* boards prior to kiln drying proper minimizes the incidence of wet cores.

**INTRODUCTION**

*Acacia mangium* is gaining popularity for use as furniture for its colour and ease of machinability. However, drying of 30-mm *A. mangium* is still problematic with high incidences of drying defects such as collapse, wet pockets/cores and honey-combing. To overcome this, the manufacturers normally saw it into thinner planks of below 25 mm for drying. This affects its recovery and application in some products. The necessity to laminate them to thicker members adds cost to the production. In this study, *A. mangium* boards were dried using almost similar drying schedules but with different treatments applied.

**MATERIALS & METHODS**

In this study, 16-y-old *A. mangium* logs obtained from Ulu Sedili, Johor, were used. The logs were sawn through-and-through into 30-mm boards. Due to
the small diameter of the logs, the width of the boards varied from 120 to 150 mm. The boards were allotted into three batches for the drying trials. The drying schedules applied were developed based on the quick-drying test conducted. The first drying trial was conducted with freshly sawn boards using the developed drying schedule. The second trial was conducted also on freshly sawn boards but with a lower initial dry bulb temperature and application of regular high humidity treatments. The third trial was conducted using the same drying schedule as the second trial but the boards were air-dried for about two months prior to kiln drying.

The drying schedules applied for the drying trials are shown in Tables 1 and 2.

**Table 1** Drying schedule A – for Drying Trial #1

<table>
<thead>
<tr>
<th>WBT</th>
<th>DBT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green</td>
<td>45</td>
</tr>
<tr>
<td>75</td>
<td>44.5</td>
</tr>
<tr>
<td>65</td>
<td>43.4</td>
</tr>
<tr>
<td>55</td>
<td>41.8</td>
</tr>
<tr>
<td>45</td>
<td>39.8</td>
</tr>
<tr>
<td>35</td>
<td>37</td>
</tr>
<tr>
<td>30</td>
<td>37.5</td>
</tr>
<tr>
<td>25</td>
<td>40</td>
</tr>
<tr>
<td>20</td>
<td>47</td>
</tr>
<tr>
<td>15</td>
<td>50</td>
</tr>
</tbody>
</table>

**Table 2** Drying schedule B – for Drying Trials #2 and #3

<table>
<thead>
<tr>
<th>WBT</th>
<th>DBT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green</td>
<td>43</td>
</tr>
<tr>
<td>75</td>
<td>42.5</td>
</tr>
<tr>
<td>65</td>
<td>41.5</td>
</tr>
<tr>
<td>55</td>
<td>40</td>
</tr>
<tr>
<td>45</td>
<td>38</td>
</tr>
<tr>
<td>35</td>
<td>35</td>
</tr>
<tr>
<td>30</td>
<td>35.5</td>
</tr>
<tr>
<td>25</td>
<td>41</td>
</tr>
<tr>
<td>20</td>
<td>47</td>
</tr>
<tr>
<td>15</td>
<td>50</td>
</tr>
</tbody>
</table>
The drying trials were conducted with different treatments as follows:

**Trial #1** Applying the drying schedule without deviation  
**Trial #2** Applying regular high humidity treatments  
**Trial #3** Air drying for about two months before kiln drying using the drying schedule as Trial #2

**RESULTS & DISCUSSION**

The drying curves for the three drying trials are as shown in Figures 1 to 3.

**Figure 1** Drying curve and temperature settings for Trial #1

**Figure 2** Drying curve and temperature settings for Trial #2
The drying time (Trials #1 and #2) for 30-mm green *A. mangium* to about 10 to 12% final moisture content was about 600 hr or 25 days. For air-dried *A. mangium* (Trial #3) to about 30% moisture content, the kiln-drying time was about 300 hr or 12 ½ days to achieve ~10% final moisture content. The variations of initial and final moisture contents for the various drying trials are presented in Figures 4 to 6. The variations of green moisture content of *A. mangium* direct from the sawmill were similar as shown in Figures 4 and 5. After a period of air drying, about two months, the *A. mangium* achieved a moisture content of about 30% (close to the fibre saturation point) and the MC variations were narrower compared with the MC when delivered from the sawmill. The uniformity of final moisture content is important and normally a period of equalization treatment is applied. However, when there is occurrence of wet pockets/cores, the variation could not be narrowed unless with extended drying time. In this case, the spread of final moisture content is indicative of the occurrence and severity of wet cores in a charge.
There were high incidences of severe wet cores for the first two trials. Lower initial dry bulb temperature and regular high humidity treatments did not reduce the occurrence of wet cores. However, air drying the boards to below fibre saturation point (~30%) prior to kiln drying helped to reduce the occurrence of wet cores (Table 1).

Table 1 Percentages of boards with difference between shell and core MC at different levels

<table>
<thead>
<tr>
<th>Difference between shell and core MC (%)</th>
<th>Trial #1</th>
<th>Trial #2</th>
<th>Trial #3</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 3</td>
<td>50.0</td>
<td>30.4</td>
<td>81.3</td>
</tr>
<tr>
<td>3–6</td>
<td>12.5</td>
<td>17.4</td>
<td>8.3</td>
</tr>
<tr>
<td>&gt; 6</td>
<td>37.5</td>
<td>52.2</td>
<td>10.4</td>
</tr>
</tbody>
</table>
CONCLUSION

There were high incidences of wet cores in normal conventional kiln drying of *A. mangium*. Lowering the initial dry bulb temperature and/or regular high humidity treatments did not help to reduce the occurrence of wet cores. Air drying the boards to below fibre saturation point (~30%) prior to kiln drying helped to reduce the occurrence of wet cores. It is concluded that air drying of *A. mangium* boards prior to kiln drying proper minimizes the incidence of wet cores.
THE DEVELOPMENT OF ENERGY SAVING TECHNOLOGY IN WOOD CRUSHING

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The objective of this study was to develop energy saving technology in wood crushing. Sugi (Cryptomeria japonica) lumber was used to examine the effects of heat treatment. The power consumption during chipping of heat-treated (steamed or hot-water-treated) specimens was compared with that during chipping of untreated specimen (green or dried) using a disk chipper. The heat-treated condition was 90 °C for 18 hr. In addition, in order to clarify the energy saving effect of heat treatment with different types of crushing mechanism, untreated or hot-water-treated specimens were crushed using a single-axis shearing type crusher. After crushing, the particle size distribution of obtained chips was measured.

As a result, the power consumptions during chipping of steamed or hot-water-treated specimens were 10% lower than that during the chipping of untreated specimen. This difference between the chipping energy of untreated and treated chips was significant with significance level $p = 0.05$. Using a single-axis shearing type crusher, the power consumption of hot-water treated specimens was 6% lower than that of the untreated specimens. Softening by heat treatment caused reduction of power consumption. In conclusion, heat treatment of lumber using surplus heat is effective to reduce the consumed energy of crushing.

INTRODUCTION

Biomass energy, which is a valuable renewable energy and an alternative to fossil fuels, can help contribute to the prevention of global warming. It is very important to effectively utilize woody biomass because it is not competitive with food resource. When biomass energy is used, we must discuss the energy balance between the produced energy and the consumed energy. Therefore, it is necessary to evaluate the energy consumed in the process to convert woody biomass into energy. As crushing is an indispensable process when woody biomass is burned for fuels, we have investigated the crushing energy of sugi lumber and some wood-based materials so far (Fujimoto et al. 2007). At the next step, the reduction of consumed energy during crushing is required.
In this study, in order to reduce the energy consumed during the crushing process, we investigated the effect of heat treatment (using steam and hot water) of lumber on energy consumed during crushing using a disk chipper. In addition, to clarify the energy saving effect of heat treatment with different types of crushing mechanism, untreated or hot-water-treated specimens were crushed using a single-axis shearing type crusher.

**EXPERIMENT**

**Effect of heat treatment**

Sugi (*Cryptomeria japonica*) lumber of 30-mm thickness, 120-mm width and 900-mm length was used as specimen. Four treating conditions of specimen were used: untreated green, untreated dried, steamed and hot-water treated. In both steamed and hot-water treatments, the specimen was heated at 90 °C for 18 hr. The number of samples was 12 for each condition, and 48 in total. The moisture contents of the untreated green, untreated dried, steamed, and hot-water-treated samples before crushing were 49.8, 15.6, 37.7 and 34.6% respectively. The air-dry density of specimen was 0.40 g cm$^{-3}$.

A disk chipper (CKS Corp, 800DK) was used to crush the specimen into chips. The disk chipper has a disk with four knives. The disk is 76 cm in diameter and 650 rpm in rotational speed. The rated power of the main motor is 22 kW.

In order to evaluate the consumed energy, the power consumption was measured with a power meter during the crushing of the four groups of specimen. After the examination, the average power consumption ($P_{ave}$) during crushing and the maximum power consumption ($P_{max}$) were determined. The specific integrated power consumption ($W$) (Wh/kg) was calculated, using the following equation (1):

$$W = \frac{1}{3600} \int_{T_s}^{T_e} \frac{M}{P(t)} \cdot dt$$

where,
- $P(t)$ is the power consumption (kW),
- $M$ is the weight of the specimens (kg)
- $T_s$ is the crushing start time (sec) and
- $T_e$ is the crushing end time (sec).

The crushing time ($T_e - T_s$) was determined from the variations in the power consumption curve and a video that was recorded simultaneously with the measurement of power consumption.
Particle-size distribution of the chips was measured using an approximately 300-cm³ sample by sieving according to JIS Z 8815 (Anonymous 1994). The sizes of the sieves were: 0.25, 0.5, 1.0, 2.0, 4.0, 8.0 and 16.0 mm. The sieves were then weighed to determine the mass of wood chips on each sieve. The duration of sieving was 10 min, which was previously determined through trial and error to be optimal based on JIS Z 8815.

**Effect of crusher**

Sugi lumber of 53-mm thickness, 114-mm width and 800-mm length was used as specimen. Two treating conditions of specimen were used: untreated green and hot-water treated. Under the hot-water condition, the specimen was heated at 90 °C for 18 hr.

In order to crush the specimen into chips, we used the disk chipper (CKS Corp, 800DK) and a single-axis shearing crusher (UENOTEX Corp, UC-22). The machine crushes raw materials by shear action between square cutter tips that are spirally attached to rotational cylinder in a single row and stators fixed to the crushing chamber. Figure 1 shows the crushing machine and the cutter tips attached to the rotational cylinder. The crusher has 15 cutter tips. The speed of rotational cylinder is 90 rpm. The rated power of its main motor is 22 kW.

![Image of crushing machine and cutter tips](image)

(a) Single-axis shearing crusher  
(b) Cutter tips and stator

**Figure 1** The crusher and cutter tips used in this experiment

The experiment was carried out under the combination of two types of specimen and two crushers. The number of specimens was 24 for each condition, and 96 in total. For the disk chipper, the moisture contents of the untreated green and hot-water-treated samples were 71.9 and 56.6% respectively. For the single-axis shearing crusher, the moisture contents of
the untreated green and hot-water-treated samples were 71.9 and 48.0% respectively. The air-dry density of the specimen was 0.40 g cm\(^{-3}\).

In order to evaluate the consumed energy, the power consumption was measured. After the experiment, particle-size distribution of the chips was measured. The details of measurement were the same as in the above section.

RESULTS AND DISCUSSION

Effect of heat treatment

Table 1 shows the average power consumption (\(P_{\text{ave}}\)), the maximum power consumption (\(P_{\text{max}}\)), the specific integrated power consumption (\(W\)), and crushing time for the four conditions of treatment. \(W\) for both untreated samples was 7.80 Wh kg\(^{-1}\), whereas for the steamed and hot-water-treated samples the values were 7.21 and 7.03 Wh kg\(^{-1}\); \(W\)s for the heat-treated were significantly lower than for the untreated samples (at the 5% level). The decrease of \(W\) for heat treatment was due to the decrease of \(P_{\text{ave}}\) for heat treatment because the crushing time was not influenced by the kind of treatment. The decrease of \(P_{\text{ave}}\) was caused by the heat softening of the material.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Untreated green</th>
<th>Untreated dried</th>
<th>Steamed</th>
<th>Hot water</th>
</tr>
</thead>
<tbody>
<tr>
<td>(P_{\text{ave}}) (kW)</td>
<td>16.61</td>
<td>16.54</td>
<td>16.01</td>
<td>15.03</td>
</tr>
<tr>
<td>(P_{\text{max}}) (kW)</td>
<td>18.99</td>
<td>19.96</td>
<td>19.60</td>
<td>18.23</td>
</tr>
<tr>
<td>(W) (Wh kg(^{-1}))</td>
<td>7.80</td>
<td>7.80</td>
<td>7.21</td>
<td>7.03</td>
</tr>
<tr>
<td>Crushing time (sec)</td>
<td>1.70</td>
<td>1.71</td>
<td>1.63</td>
<td>1.71</td>
</tr>
</tbody>
</table>

Figure 1 shows the particle-size distributions of the chips generated from the disk chipper. The weight of 8-16-mm chips took the highest percentage of the total under all conditions. For particle size of 16 mm or more, the weight percentage of chips was the greatest for the hot-water-treated, followed by the steamed, untreated green, and untreated dried samples. For particle size of 4–8 mm, the weight percentage of chips was the greatest for the untreated dried and the lowest for hot-water-treated samples. These findings show that the particle size of chips generated from the disk chipper was largest for the hot-water-treated, followed by the steamed, untreated green and untreated dried samples.
Figure 1  Particle-size distributions of chips generated from the disk chipper

**Effect of crusher**

Figure 2 shows the $W_s$ for the disk chipper and the single-axis shearing crusher under the two conditions of treatment. For the disk chipper, $W_s$ were 6.76 Wh kg$^{-1}$ for the untreated green and 6.40 Wh kg$^{-1}$ for the hot-water-treated samples, and for the single-axis shearing crusher, $W_s$ were 24.7 Wh kg$^{-1}$ for the untreated green and 23.3 Wh kg$^{-1}$ for the hot-water-treated samples. There was significant difference between the $W_s$ for the hot-water-treated and the untreated samples (at the 5% level). These findings show that heat treatment reduces the power consumption during crushing regardless of the kind of crusher.

Figure 2  Specific integrated power consumptions using two crushers under two conditions of treatment
Figure 3 shows the particle-size distributions of the chips generated from the single-axis shearing crusher. For particle size of 16 mm or more, the weight percentage of chips obtained from the hot-water-treated was greater than that from the untreated green samples. For particle size of 4 mm or less, the weight percentage of chips obtained from the hot-water-treated was lower than that from the untreated green samples. These findings show that, for the single-axis shearing crusher, the particle size of chips from the hot-water-treated was larger than that from the untreated samples.

CONCLUSION

Sugi (*Cryptomeria japonica*) lumber was used to examine the effects of heat treatment. The power consumption during chipping heat-treated (steamed or hot-water-treated) samples was compared with that during chipping untreated samples (green or dried) using a disk chipper. In order to clarify the energy-saving effect of heat treatment with different types of crushing mechanism, untreated specimen or hot-water-treated samples were crushed using a single-axis shearing type crusher. From the experimental findings the following conclusions can be drawn:

- The power consumption during chipping steamed and hot-water-treated samples was 10% lower than that during chipping untreated samples. This difference between the chipping energy of untreated and treated samples was significant at significance level $p = 0.05$.
- Using a single-axis shearing type crusher, the power consumption of the hot-water-treated samples was 6% lower than that of the untreated samples. This difference between the chipping energy of untreated and
treated samples was significant at significance level $p = 0.05$. Therefore, heat treatment of lumber using surplus heat is effective to reduce the consumed energy of the crushing process.

- The particle size of chips generated from the heat treatment was larger than that without treatment.

REFERENCES


CASE-STUDY OF MONITORING TECHNIQUE FOR WOODEN TRUSS BRIDGE USING ULTRASONIC METHOD

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Japan

We used PUNDIT (Portable Ultrasonic Non-destructive Digital Indicating Tester) to monitor deterioration of two wooden truss bridges. Deterioration was evaluated by the method of ultrasonic propagation velocity measuring either direct transmission or semi-direct transmission. We measured ultrasonic propagation velocity every year from 1999 to 2003 to monitor deterioration. The result was that it was effective to monitor deterioration of the two wooden truss bridges using histogram and cumulative probability curve of ultrasonic propagation velocity. And it was found that the two wooden truss bridges showed a different tendency to deterioration even though they were in the adjoining areas.

INTRODUCTION

A wooden truss bridge made of ekki (Lophia alata Banks ex Gaerth.) collapsed in September 1999. This incident occurred 10 years after this bridge was completed. We confirmed from investigation that the reason for the collapse was massive internal decay by some fungi. Ekki is an extremely hard and heavy red-brown timber, which is known as the most durable timber in the west coast. Many of the ekki poles have been reported to remain sound for twenty years. This species has been used locally for bridge-decking, flooring, canoes and many permanent structural works (Chalk et al. 1933). However, we learned from this incident that deterioration can occur in 10 years even with the most durable timber like ekki. We had another example at that time. It was also a similar wooden truss bridge built near the collapsed bridge. We suspected that this bridge might have suffered the same deterioration as the collapsed bridge in which case there was a danger of it collapsing. So, we applied the ultrasonic propagation method to determine the deterioration. And we examined the method of monitoring while the bridge was standing.
BACKGROUND

Methods for detecting deterioration in bridges are divided into two categories: those for exterior deterioration and those for interior deterioration. In both cases, specific methods or tools are appropriate for certain types of damage, and their usefulness varies depending on the type of structure (Ritter 1990).

Exterior deterioration is easy to check. The ease of detection depends on the severity of damage and the method of inspection. Methods for detecting exterior deterioration commonly used in Japan are visual inspection, probing and pin penetration like the Pilodyn.

Interior deterioration is difficult to check because there are few signs of its presence. Many methods and tools have been developed to evaluate internal damage. Methods for detecting interior deterioration commonly used in Japan are sounding the surface with hammer, using stress and ultrasonic waves, and drilling.

The ultrasonic propagation method is one of the ultrasonic techniques. With this method generally, mechanical or ultrasonic impact is used to impart a wave into the member. Transducers are placed at two points on the member and used to detect passing of the wave (Ross et al. 1999).

EXPERIMENTAL

Using PUNDIT (Portable Ultrasonic Non-destructive Digital Indicating Tester), we measured the ultrasonic propagation time across the wood fibres of the two wooden truss bridge members. Table 1 shows the specifications of PUNDIT. Ultrasonic propagation velocity is calculated as follows:

\[ V = \frac{d}{T} \]

where,

\( V \) = ultrasonic propagation velocity
\( d \) = distance between transducers
\( T \) = ultrasonic propagation time

<table>
<thead>
<tr>
<th>Content</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power requirements</td>
<td>Rechargeable battery</td>
</tr>
<tr>
<td>Pulse generator</td>
<td>IKV</td>
</tr>
<tr>
<td>Frequency</td>
<td>54 KHz</td>
</tr>
<tr>
<td>Pulse repeating</td>
<td>8 pulses per second</td>
</tr>
<tr>
<td>Resolution</td>
<td>± lus</td>
</tr>
<tr>
<td>Transducer diameter</td>
<td>50 mm</td>
</tr>
<tr>
<td>Transducer length</td>
<td>42 mm</td>
</tr>
</tbody>
</table>
Figure 1 shows the measurement methods of ultrasonic propagation time. Distance of the direct transmission implies depth of the member. Distance of the semi-direct transmission takes the assumption of the length from minimum distance \( L_1 \) to maximum distance \( L_2 \). In this case, \( L_1 \) was applied to calculate the ultrasonic propagation velocity because the safety side had been obtained.

Figure 2 shows the locational relation between the two wooden truss bridges, hereafter abbreviated as Bridge No. 1 and Bridge No. 2 as indicated in the figure. Figure 3 shows the common profile of Bridge No. 1 and Bridge No. 2.
Figure 3  Common profile of Bridge No. 1 and Bridge No. 2

Figure 4  Cross-section of the measured wooden truss bridge

Figure 5  Measured points of a part of one end of a member and a part of the middle of a member
No. 2 upper chord and lower chord are composed of three members and thirteen panel points each. Figure 4 shows a cross-section of Bridge No.1 and Bridge No. 2. The measured bridges have four chord members at the upper and lower sides of each other. We measured these in this study. Figure 5 shows the measured points of a part of one end of a member and a part of the middle of a member. We set five places at intervals of 100 mm at a part of the end of the member and symmetrical five places at intervals of 100 mm on the centre of the bolt at a part of the middle of the member.

We carried out measurements in October 1999, March 2000, March 2001, March 2002 and March 2003 to examine the changes.

RESULTS

Table 2 shows the measured results of ultrasonic propagation velocity. The ultrasonic propagation velocity, except for the median and minimum values on Bridge No. 1, did not change between October 1999 and March 2000. After March 2000, there was a tendency for the mode, average and maximum values to decrease. As for Bridge No. 2, this tendency was almost the same. When the ultrasonic propagation velocity on Bridge No.1 was compared with that on Bridge No. 2, the value on Bridge No. 2 was overall larger.

<table>
<thead>
<tr>
<th>Measured date</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency (m sec(^{-1}))</td>
<td>730</td>
<td>720</td>
</tr>
<tr>
<td>Median (m sec(^{-1}))</td>
<td>1164</td>
<td>1914</td>
</tr>
<tr>
<td>Mode (m sec(^{-1}))</td>
<td>1849.5</td>
<td>2149.5</td>
</tr>
<tr>
<td>Average (m sec(^{-1}))</td>
<td>1316</td>
<td>1801</td>
</tr>
<tr>
<td>Minimum (m sec(^{-1}))</td>
<td>155</td>
<td>238</td>
</tr>
<tr>
<td>Maximum (m sec(^{-1}))</td>
<td>3077</td>
<td>3030</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>641</td>
<td>515</td>
</tr>
<tr>
<td>Coefficient of value (%)</td>
<td>48.7</td>
<td>28.6</td>
</tr>
</tbody>
</table>

Figure 6 shows the yearly changes in the histogram of relative frequency distribution of ultrasonic propagation velocity on Bridge No. 1. There were two main peaks except for March 2000. Relative frequency of up to 1500 m sec\(^{-1}\) ultrasonic propagation velocity decreased year by year. On the other hand, relative frequency of less than 1000 m sec\(^{-1}\) ultrasonic propagation velocity increased after March 2000.
Figure 7 shows the yearly changes in the histogram of relative frequency distribution of ultrasonic propagation velocity on Bridge No.2. There was one main peak each year and it showed negative skewness. Relative frequency of up to 2000 m sec\(^{-1}\) ultrasonic propagation velocity decreased year by year. On the other hand, relative frequency of less than 1000 m sec\(^{-1}\) ultrasonic propagation velocity increased a little bit after March 2001.

Figure 6  Yearly changes in the histogram of relative frequency distribution of ultrasonic propagation velocity on Bridge No. 1

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Figure 8 shows the cumulative probability curves of ultrasonic propagation velocity on Bridge No. 1. Curves except for March 2000 were almost the same. The cumulative probability values at 1000 m sec\(^{-1}\) of ultrasonic propagation velocity were as follows: 39.6% (October 1999), 23.1% (March 2000), 32.8% (March 2001), 49.8% (March 2002), 39.3% (March 2003).

Figure 7 Yearly changes in the histogram of relative frequency distribution of ultrasonic propagation velocity on Bridge No. 2.
Figure 9 shows the cumulative probability curves of ultrasonic propagation velocity on Bridge No. 2. The curves of October 1999 and March 2000 were almost the same. The curves moved to a slow side after March 2000. The cumulative probability values at 1000 m sec\(^{-1}\) of ultrasonic propagation velocity were as follows: 10.0% (October 1999), 12.2% (March 2000), 19.6% (March 2001), 22.4% (March 2002), 24.5% (March 2003). Consequently, the cumulative probability at 1000 m sec\(^{-1}\) of ultrasonic propagation velocity showed a tendency to increase year by year. According to Kato et al. (2005), the boundary between a sound part and a deteriorated part of ekki was approximately from 1000 m s\(^{-1}\) to 1500 m sec\(^{-1}\) of ultrasonic propagation velocity. We suspected that the deterioration had progressed every year in Bridge No. 2 based on this study.
CONCLUSION

Transverse ultrasonic propagation velocity was measured in order to investigate the possibility of monitoring wooden truss bridge. The measurements were carried out on two wooden truss bridges which were not only of the same design but also adjacent to each other.

The results were:
- Histogram of ultrasonic propagation velocity could indicate the deterioration of wooden truss bridge.
- The time-dependent changes of deterioration of wooden truss bridge could be monitored using the cumulative probability curve of ultrasonic propagation velocity.
- The time-dependent changes of the two bridges tended to be different even though they were of the same design and also adjacent to each other.

REFERENCES


There is a need to establish the effects of various parameters on the basic wood properties from a plantation-grown forest or between different plantations, which, unlike natural forests, are generally homogenous in nature. The parameters referred to include species, generation age, stand density, clone, soil type, silvicultural treatment and so forth. Before such effects can be ascertained, a reliable procedure to extract sample trees which are representative of the population of interest is a necessity. In this paper, the procedure proposed is elaborated and a case study using *Acacia mangium* is presented. Reference is made to the relevant forms used as well as the figures and tables given in the manual *Testing Methods for Plantation Grown Tropical Timbers*.

**INTRODUCTION**

The current ITTO Project entitled “Improving utilization and value adding of plantation timbers from sustainable sources in Malaysia” was first mooted when the Forestry and Forest Products Research Institute (FFPRI), Japan, approached Malaysia to initiate a study on the harmonization of testing techniques for the evaluation of basic properties of plantation-grown species of tropical origin. Prior to that, a group of scientists at FFPRI had prepared a set of testing methods and later initiated relevant studies for plantation-grown timbers in Japan. Realizing that similar studies were yet to be unified among tropical countries, which made comparison of results from different tropical nations less scientifically possible, the intention to extend to the latter nations through a project funded by the International Tropical Timber Organization (ITTO) was then proposed. Being one of the senior recipient countries of the Japan International Cooperation Agency (JICA) technical aid in the field of forest products technology as early as the mid-1980s, Malaysia was identified as the collaborating nation.
Before a complete set of basic studies could be conducted, a good start was necessary so that the original intention either to establish the basic properties of plantation timbers associated with a population, or to compare various effects of treatment associated with a particular set of characteristics such as generation age, stand density, clone, soil type and silvicultural treatment could be achieved. The method to be developed should dictate how trees are to be selected from a population of plantation forest from which further sampling of test pieces for the determination of basic wood properties will be executed. Such information is essential for the production of wood-based products from these resources since sheer comparison of growth rate commonly employed by tree-planting groups is simply inadequate.

The techniques commonly available then for the establishment of basic wood properties were basically meant for timbers derived from natural forests which are generally made up of a greater mix of species, particularly in the tropical regions. The trees from natural forests are relatively more ‘matured’ compared with plantation-grown timbers found in the region. Being younger, the plantation stocks are generally smaller in diameter and made up of juvenile stocks. On the other hand, there is a general lack of technical facilities in some nations in the tropical region. This made some of the techniques used in the advanced nations less directly applicable in some less well-equipped testing centres in some nations. As such, in the methodologies proposed here, some attempts have been made to incorporate the theme of “Objectivity, Practicality and Universality” such that the methods are likely to be applied in most tropical nations.

In this paper, the sampling technique proposed takes into consideration all the factors mentioned. The methodology presented is important since it dictates whether or not the results subsequently derived on the basic wood properties are representative of the population of interest. Upon development of the technique, the methodology was applied in three different regions, namely Peninsular Malaysia, Sabah and Sarawak, in Malaysia. The final proposal has gone through some form of review and is an improvement over what was initially applied.

BACKGROUND

The biggest challenge encountered in preparing the sampling procedure was how to produce something that complies with the theme adopted. Before starting, literature search was carried out with the aim of acquiring an approach already adopted or is likely to be acceptable by the international community. The search revealed that an existing ISO standard (Anonymous 1982) was available for the sampling of sample trees albeit only for physical and mechanical testing. On the other hand, the FFPRI has also included some bucking pattern which allows materials for more than a test to be accommodated (Anonymous
unpublished). Furthermore, for a sampling procedure to be objective, it must serve the purpose well besides being representative of the population selected, at least in terms of diameter, density as well as the overall growth, the few key parameters representing the population. To be practical, it should provide an alternative or make some tests optional when specialized equipment is dictated as most of the tropical countries have limited resources. To be universal, the methods should be applicable in as many nations as possible.

The sampling methodology proposed covers three main scopes, namely:
• selection of test area;
• selection of sample trees in test area;
• allocation of logs for different tests.

SELECTION OF TEST AREA

The test area selected shall be one with the desired characteristics of interest. In our case, the interests were to:
• test and apply the testing methodologies proposed;
• establish wood properties associated with each of the species chosen and their respective age groups. Each region (Peninsular Malaysia, Sabah and Sarawak) was represented by one plantation species of two age groups with the exception of Sabah, where due to manpower constraint, only one age group was chosen;
• fine tune the methodology if necessary.

Similarly, the test area shall be also suitable to be employed for establishing the effect of clonal variations and/or stand density, or the like on the wood properties.

As an illustration, only one age group of Acacia mangium in Peninsular Malaysia is cited.

In this case, it was found that a commercial plantation of one suitable age group was available at Asia Prima Sdn Bhd, located about two (2) hours' drive away from Kuala Lumpur. The age of the plantation was 20 y and was due for harvesting. In order to identify the test area to be used, there was a need to select those trees that were representative of the age group in terms of dimension as well as being good enough in order to allow logs of at least 6-m length to be harvested.

Initially, since the number of logs expected was about 50, and only one log was expected to be cut from each tree, but noting that A. mangium grown in Peninsular Malaysia was known to be associated with incidence of heart rot, a total of 156 trees were then selected for the purpose. As indicated in the methodology, the diameter at breast height should be at least 14 cm. Upon identification of the test area, their information was recorded using Form 1.1*.

*Note:- All forms, figures and tables referred to in this paper are as in Chapter 1 of the manual Testing Methods for Plantation Grown Tropical Timbers (Tan et al. 2010).
Furthermore, the trees in the test area were also inventoried separately by species and age generation according to FRIM's standard practice using Form 1.2. While drawing up the inventory, the diameter and height of the trees as well as description of the defects occurring were recorded in an inventory report using the same form.

**SELECTION OF SAMPLE TREES IN THE TEST AREA**

**Preparation of trees**

A quick check of the area selected revealed that the average diameter of the *A. mangium* age group selected was 37.9 cm, i.e., more than 22 cm, hence the sample trees selected were taken from among trees of not less than 18 cm in diameter. As stated in the methodology, in case the average diameter is less than 22 cm, sample trees of not less than 14 cm diameter shall be chosen instead.

Precaution was taken to make sure that the inventoried trees did not contain any visible defects (with the exception of knots) and did not include any big branches up to a height of at least 6 m from the basal end. Each sample tree was also provided with a card as shown in Form 1.3. It was found that the original forms listed in ISO were too detailed and may be more appropriate for use by plantation scientists. For wood scientists, it suffices to have a simplified version as presented.

In our case, upon identifying the trees within the selected test area, they were all tagged and marked by coloured paint. The concessionaire subsequently made an arrangement to harvest the trees, cut them to 6-m length before dragging them out to an open space. Unfortunately, in so doing, some of the tags were removed or painted marks were obliterated. This warranted the team to remeasure the log diameter in order to re-establish the tree number when logs were delivered. In subsequent exercises, more markings were made to mitigate possible errors.

During chain-sawing to the required length, although there was a provision to reject some of the sample trees if they were found to have some inner defects which prevented them from producing perfect test materials, it was not carried out. This was because their inclusion for sawing, for example, would provide a better indication of their ‘true’ recovery. It was realized that such exclusion is more relevant to billets meant for tests such as mechanical and perhaps drying tests or when the defects are ‘excessive’. Hence the discretion lies on the researchers. In the case of peeling and slicing, it was noticed that while we tried to stick to our game plan, the manufacturers, when such peeling and slicing services were sought, advised us to choose only the premium logs. On second thought, in the case of peeling at least, we should have adhered to the original logs assigned to peeling as they would have given us a true
representativeness of the population at hand. This implies that the test results we are presenting later for the case of peeling are of the superior scenario since only premium logs were indeed utilized.

**Grouping of trees**

The inventoried trees were given an order number after being arranged by diameter in an ascending order in the inventory report (see Form 1.4). These trees were then divided into six groups in our case, each being assigned the respective Diameter Group number. Since our exercise involved only 156 trees, each group was made up of 26 trees. In the manual, it was thought that 120 trees should be selected under normal circumstances and they are to be divided into at least six diameter groups. This is necessary for a full range of tests to be conducted. Should the scope be reduced, the number of trees may be reduced accordingly but the minimum group number shall be retained.

In the manual, the order number was proposed to be arranged in a “vertically zigzag” manner before the batch number is assigned. This will ensure that each batch number subsequently assigned will be made up of identical sum of diameter order numbers, which means that the effect of order number in each batch is eliminated. In other words, the diameter effect on the properties determination has been systematically removed.

**Assigning batch number**

The assignment of batch number is important for the reason stated above. For our exercise on *A. mangium* in which each group was made up of 21 trees, an even-numbered row from the middle band was taken as Batch 1 (in this case, Row 11). In the case of the manual whereby a total number of 120 trees, an even number, is proposed, there are 20 trees in each diameter group. Hence Batch 1 shall be taken from Row 10 as shown in Table 1.2. Subsequent batches were selected in a “down-then-up” sequence as illustrated in Table 1.2. This was to ensure proper matching of sample tree diameters between different batches. The process was repeated until ten (10) batches were allocated. As mentioned in the manual, should there be an odd number of members in each group, then the odd-numbered row from the middle band shall be selected as Batch 1 (say Row 13 for the case of 25 members in each group as illustrated in Table 1.1.).

**Process flow**

A flow chart illustrating the sampling of trees before bucking pattern is carried out is given in Figure 1.1.
It should be noted that a total of ten (10) trees per diameter group starting from the middle band were assigned for testing purposes. The remaining trees, sixteen (16) in this case, or another ten (10) as proposed in the manual, from the same group could be used if excessively defective logs are later found during preparation of specimens for wood property tests. Again, replacements shall only be taken from the remaining logs from the same group with the closest order number to that rejected. This is to make sure that balancing of diameter order number between batches would not have gone far off.

**ALLOCATION OF LOGS FOR DIFFERENT TESTS**

Height is well known to be a factor affecting the property data obtained. As such, in this manual, attempt has been made to neutralize its effect by specifying the distance from which samples for each test shall be taken. Since many tests were to be conducted and each test may require different length and quantity, effort was made to propose a combination which was later reviewed after actual tests were carried out. Some of the original suggestions were changed such as for slicing where it was found that the industry only makes use of billets from the bottom end, hence the reviewed bucking pattern has been suggested likewise.

In our proposal, one log of at least 6 m was proposed to be cut from the basal end of each sample tree from which about 5 m length was made use of. This is necessary to cater for minor defects such as end-checks during billet preparation. The allocation of test materials from each portion of log to different tests is presented in the bucking pattern proposed (Figure 1.2).

In the figure, it should also be noticed that there are cases whereby logs from certain batches are being shared in the sense that the boards derived are reused for another test. An example is Batch 6 whereby the billet was first converted into sawn timber to be used in the sawing study. After the study, the sawn timber was allocated for use in the finger-jointing and gluing studies. Proper marking becomes more essential to prevent any possible mix-ups.

The marking of each log shall include tree, batch and group numbers to facilitate traceability. In our case, it was not carried out but an improvement was suggested. In addition, suitable numbers associated with the test area shall also be included.

To prevent the ends of the logs from biodeterioration and cracking, proper means of protection shall also be used. In our case, prolonged storage worsened the condition. The specification of longer length, however, has mitigated the problem.

**CONCLUSION**

In this exercise, the procedure for sampling of sample trees for the determination of basic wood properties was proposed, tested and reviewed. The sampling
methodology developed could then be used in the selection of sample trees and allocation of logs for the determination of basic properties of wood obtained from tropical forest plantations. It could also be used to compare the effect of plantation practices on the properties of the wood derived. The theme of “Objectivity, Practicality and Universality” was also adhered to such that the methods proposed are likely to be applicable in most tropical nations.

In the identification of the test area, the representativeness of population of the plantation forest of interest selected is of paramount importance. In the selection of sample trees in the test area, only trees that met the selection criteria were selected before each tree was cut to six (6)-m length for subsequent use. Special tree grouping approach was also suggested after which the diameter order number was rearranged in a “vertically zigzag” manner. Together with the method of assignment of batch number, the possible effect of diameter on the wood properties could then be eliminated. The bucking pattern adopted would also help to eliminate the effect of height on the test results when comparisons between populations are being made. All these measures are proposed to ensure that the sampling carried out provides a good representation of the population of interest irrespective of where it is carried out.

REFERENCES

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GUIDELINES ON THE WOOD ANATOMY AND QUALITY STUDIES OF TROPICAL PLANTATION TIMBER

S. C. Lim, M. C. Yang & James Josue

Respectively Forest Research institute Malaysia (FRIM), Timber Research and Technical Training Centre (TRTTC), Sarawak, and Forest Research Centre (FRC), Sabah

Guidelines on the wood anatomy and quality studies of tropical timbers were compiled as a result of literature survey and intensive discussions among researchers from the Forest Research Institute Malaysia (FRIM); Timber Research and Technical Training Centre (TRTTC), Sarawak; Forest Research Centre (FRC), Sabah; and Forestry and Forest Products Research Institute (FFPRI), Japan. The guidelines provide information on the (a) preparation of test material which includes the sampling of trees and samples and (b) test procedures on the sapwood and heartwood determinations, wood anatomical studies, wood quality studies, density variation and fibre morphology study. Examples of the descriptions of the macroscopic and microscopic features of timber, sapwood and heartwood determination, density variation and fibre morphology study using *Acacia mangium* timber are also included.

INTRODUCTION

Guidelines on the wood anatomy and quality studies of tropical plantation timbers were compiled as a result of literature survey and discussions among researchers from the Forest Research Institute Malaysia (FRIM); Timber Research and Technical Training Centre (TRTTC), Sarawak; Forest Research Centre (FRC), Sabah; and Forestry and Forest Products Research Institute (FFPRI), Japan. In the process of compiling this report publications, Anonymous (1957, 2004) and Wheeler *et al.* (1989) were heavily referred to.

Preparation of test materials

*Sampling of trees*

A total of six trees per age group shall be selected based on the method as described earlier. Three sample discs per tree shall be obtained from Batch 1 at the bottom, middle and top ends of the sample log (Figure 1).
Before the discs are cut, a shallow groove along the length of the log shall be made using a chain-saw to ensure that the positions of the samples are consistent throughout the length of the log.

For the sapwood and heartwood determinations, measurements based on the geometric centre shall be taken from the discs (Figure 2) and Form 1 [refer to the manual *Testing Methods for Plantation Grown Tropical Timbers* (Tan et al. 2010)] shall be used for recording.

**Sample preparation**

From each disc, samples $2 \times 2 \times 5$ cm are taken according to Figures 3 or 4.
Figure 3 Cutting of samples from the log with pith at the centre

Figure 4 Cutting of samples from the log with eccentricity

Figure 3 shall be used for discs which are fairly rounded whereas Figure 4 is meant for discs with eccentricity. From each sample, a sample of 1 cm$^3$ is cut for density determination and the remaining portion is used for the anatomical (where applicable) and fibre morphology studies.

For anatomical studies, three samples per disc shall be taken (near pith, between pith and bark, and near bark).

Test procedures

Sapwood and heartwood determinations

By measuring the small radii and the large radii (Figure 2), the percentage of sapwood is obtained as follows:

Percentage of sapwood = \( \frac{R^2 - r^2}{R^2} \times 100 \) where \( R \) is the radius of the disc and \( r \) is the radius of the heartwood.

An illustration of the results is shown in Figure 5.
**Wood anatomical studies**

The anatomical studies of wood shall include the examination of its macroscopic and microscopic features.

**Macroscopic examination**

The examination of the macroscopic features of wood shall be carried out only on air-dry samples. The checklist provided in Form 2 (refer to the manual) shall be used to ensure that important information is not left out. A typical description of the macroscopic features is shown in Appendix 1.

**Microscopic examination**

Microscopic studies require the preparation of microscopic slides that contain transverse, longitudinal and radial sections. Sections of 10–20 µm in thickness for cross-, radial and tangential sections shall be obtained using sledge/sliding microtome. Sections shall be stained using 1% safranin and the procedure of staining is described in the manual on testing. Features to observe shall follow the checklist as shown in Form 3 (refer to the manual). A typical description of the microscopic features of the wood is shown in Appendix 1.

**Wood quality studies**

Plantation timbers harvested from trees at a much younger age are likely to be quite different and less stable compared with the same species obtained from the natural forest. Thus, data on the density and fibre variations are important as they may be used to interpret the quality of the timber obtained. In order to ensure that adequate information is collected, a collection form is devised as shown in Form 1 (refer to the manual).
**Density variation study**

**Sampling**

Strips, 50 mm wide, shall be obtained along the longest and the shortest radii. Specimens shall be obtained at 5 –10-mm intervals along growth layers. Sampling and marking of the disc are according to Figures 3 or 4, depending on the type of disc obtained.

**Density determination**

Density determination is based on the methods as described in BS. 373: 1957 (see Appendix 8.2 of the manual).

The form used to record the data is shown in Form 4 (refer to the manual). An example of the results is shown in Table 1.

**Table 1** Basic densities of 16- and 20-y-old *Acacia mangium* from two different locations

<table>
<thead>
<tr>
<th>Tree No.</th>
<th>20-y-old</th>
<th></th>
<th>Tree No.</th>
<th>16-y-old</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean ± SD</td>
<td>Range</td>
<td>Mean ± SD</td>
<td>Range</td>
</tr>
<tr>
<td></td>
<td>(kg m⁻³)</td>
<td>(kg m⁻³)</td>
<td>(kg m⁻³)</td>
<td>(kg m⁻³)</td>
</tr>
<tr>
<td>1</td>
<td>626 ± 102.4</td>
<td>412–840</td>
<td>7</td>
<td>527 ± 100.2</td>
</tr>
<tr>
<td>2</td>
<td>642 ± 88.3</td>
<td>383–818</td>
<td>8</td>
<td>552 ± 115.8</td>
</tr>
<tr>
<td>3</td>
<td>613 ± 113.3</td>
<td>401–830</td>
<td>9</td>
<td>496 ± 116.8</td>
</tr>
<tr>
<td>4</td>
<td>630 ± 93.3</td>
<td>443–800</td>
<td>10</td>
<td>550 ± 122.6</td>
</tr>
<tr>
<td>5</td>
<td>627 ± 116.1</td>
<td>395–793</td>
<td>11</td>
<td>520 ± 123.9</td>
</tr>
<tr>
<td>6</td>
<td>611 ± 101.8</td>
<td>387–771</td>
<td>12</td>
<td>492 ± 121.0</td>
</tr>
<tr>
<td>Mean</td>
<td>623 ± 102.6</td>
<td>383–840</td>
<td>Mean</td>
<td>522 ± 116.9</td>
</tr>
</tbody>
</table>

Based on the data obtained, the variations in density can be illustrated by the use of graphs as follows (Figure 6):
Figure 6  Variations of density in the (a) radial direction (R1 and L1 are positions near the pith) and (b) along the height of 20-y-old *Acacia mangium*

**Fibre morphology study**

**Sampling**
The samples shall be obtained from the remaining portions of the sample where they have been cut for the density determination.

**Method of maceration**
Matchstick-sized wood splinters shall be obtained from the outermost surface (bark-side surface) of the specimen and immersed in a 10-ml bottle containing a mixture of 30% hydrogen peroxide and 100% acetic acid (1:1 to 2:1 in volume) solution. The bottle is kept in the oven at 60 °C overnight. After confirming the colour change of the stick to white, the sticks are then rinsed several times with distilled water/warm water. A small portion of the macerated fibres is removed using tweezers and placed on the glass slide with gum choral. To separate into individual fibres, stir the fibres on the slide and cover them with cover glass.
However, other standard methods which yield similar results may also be used.

Measurement
Macerated fibres shall be observed with an optical microscope equipped with micrometer eyepieces and condenser lens with a dark field or small optical aperture. Measurements can also be made using projection microscope or any other suitable measuring devices.

A total of 25 fibres shall be randomly selected for measurement using Form 5 (refer to the manual) for recording. Commercial software which is capable of storing the data can also be used.

An example of the results of the fibre morphology study is shown in Table 2.

**Table 2** Summary of fibre morphology of *Acacia mangium*

<table>
<thead>
<tr>
<th>Tree No.</th>
<th>Fibre length (µm)</th>
<th>Diameter (µm)</th>
<th>Lumen (µm)</th>
<th>Fibre-wall thickness (µm)</th>
<th>Tree No.</th>
<th>Fibre length (µm)</th>
<th>Diameter (µm)</th>
<th>Lumen (µm)</th>
<th>Fibre-wall thickness (µm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1138 (625–1150)</td>
<td>19.9</td>
<td>12.2</td>
<td>7.0</td>
<td>7</td>
<td>942 (550–1550)</td>
<td>21.0</td>
<td>11.0</td>
<td>10.0</td>
</tr>
<tr>
<td>2</td>
<td>1134 (750–1575)</td>
<td>19.6</td>
<td>13.5</td>
<td>6.2</td>
<td>8</td>
<td>988 (550–1525)</td>
<td>19.2</td>
<td>9.7</td>
<td>9.8</td>
</tr>
<tr>
<td>3</td>
<td>1130 (675–1600)</td>
<td>20.5</td>
<td>14.4</td>
<td>6.1</td>
<td>9</td>
<td>918 (625–1950)</td>
<td>21.0</td>
<td>12.3</td>
<td>8.6</td>
</tr>
<tr>
<td>4</td>
<td>1066 (525–1525)</td>
<td>21.0</td>
<td>12.5</td>
<td>8.1</td>
<td>10</td>
<td>941 (625–1350)</td>
<td>18.8</td>
<td>9.9</td>
<td>8.9</td>
</tr>
<tr>
<td>5</td>
<td>923 (375–1525)</td>
<td>19.44</td>
<td>9.0</td>
<td>9.7</td>
<td>11</td>
<td>986 (575–1750)</td>
<td>19.8</td>
<td>11.4</td>
<td>8.4</td>
</tr>
<tr>
<td>6</td>
<td>897 (475–1375)</td>
<td>19.7</td>
<td>10.3</td>
<td>9.3</td>
<td>12</td>
<td>951 (550–1450)</td>
<td>21.8</td>
<td>12.6</td>
<td>9.2</td>
</tr>
<tr>
<td>mean</td>
<td>1048 (375–1600)</td>
<td>20</td>
<td>12</td>
<td>8.0</td>
<td>mean</td>
<td>954 (550–1950)</td>
<td>20.3</td>
<td>11.2</td>
<td>9.2</td>
</tr>
</tbody>
</table>

Variations of fibre length in the radial and longitudinal directions are illustrated by the following Figure 7.
Figure 7  (a) Fibre length variations along the height and (b) across the log diameter
Microscopic characters

Microscopic features

Examination of the microscopic features of trees 1 to 6 (20-y-old) provides the following description of *Acacia mangium*.

Growth rings rather indistinct in some, others may be marked by layers of thick-walled fibres or reduced vessel sizes. Vessels diffuse, moderately few to moderately numerous, mainly oval, sometimes round, solitary and in radial multiples of 2–3 (-4), occasionally up to 8, clusters of vessels are common, average tangential diameter of 168 µm (range 100–260 µm), perforation simple; intervessel pits alternate, 7 µm diameter (range 5–10 µm), usually with coalescent apertures and also vested; vessel-ray pits and vessel-parenchyma pits similar and bordered; tyloses absent or sparse; dark brown deposits present. Fibres 1048 µm (375–1600 µm) long, non-septate, thin- to thick-walled, 8 µm thick with few simple pits mainly confined to the radial walls. Parenchyma predominantly paratracheal, scanty to vasicentric, occasionally aliform, strand length of 2 to 4 cells. Rays 7 per mm (range 4–10 per mm), mostly 1–2 cells wide, rarely 3, average 187 µm (range 70–360 µm) high, homocellular. Silica absent. Prismatic crystals present in chambered axial parenchyma cells.

REFERENCES


Appendix 1  Macroscopic features

Growth rings absent or vaguely present. The heartwood is light brown to golden brown, darkening on exposure, sharply differentiated from the sapwood which is white to light yellow and with a width ranging from 0.6 to 2.5 cm. Texture is moderately fine and even. Grain is straight to interlocked. Wood surface fairly lustrous with striped figure on radial surface. Vessels moderately fine and barely visible to the naked eye, solitary and in radial multiples of 2-3, seldom more, tyloses generally absent. Parenchyma mainly as scanty paratracheal to a very thin vasicentric layer. Rays are fine and barely visible to the naked eye. Ripple marks absent.(Figures A1 and A2)

**Figure A1**  Wood structure of *Acacia mangium*

(a) Interlocked grain (rough surface)  
(b) Cross-cut of a log

**Figure A2**  Images and a cross-cut view of *Acacia mangium*
DETERMINATION OF BASIC FLAT-SLICED VENEER PROPERTIES OF ACACIA MANGIUM AND SHOREA MACROPHYLLA

N. P. T. Lim, H. Hamdan, Y. K. Pek & Januarie Kulis

Basic flat-sliced veneer properties such as yield and surface roughness properties were assessed for Acacia mangium and Shorea macrophylla. The mean yield of A. mangium was about 4% higher than that of S. macrophylla. Between the veneer thicknesses of 0.6 mm and 2.5 mm under study, the thicker veneer gave higher yield for both species. Surface roughness measurements of $R_a$, $R_z$ and $R_{max}$ of the two species were generally lower for the 0.6-mm veneers as compared with the 2.5-mm veneers. Also, both age groups of A. mangium usually exhibited lower values than those of S. macrophylla.

INTRODUCTION

The three main methods of producing sliced veneers are flat slicing, quarter slicing and rift slicing.

For flat-sliced veneer, the log is debarked and generally cut in half and mounted on a slicing table which moves into the blade taking progressive slices out of the flitch (Figure 1). This method tends to produce the cathedral pattern in consecutive leaves of veneer which can be grain matched in various ways for a pleasing appearance.

Quarter-sliced veneer gives leaves with straight grain. The log is ripped into four quarters which make up four separate flitches. Each flitch is sliced in the direction as shown in the picture. Quarter slicing also reveals figuring in some woods that contain distinct medullary rays.

Rift-sliced veneer is also produced from quartered flitches. The quarters are turned in a lathe to produce an approximate 15° cut as shown in the picture. This procedure is to minimize the ‘flake’ appearance of certain woods due to the presence of medullary rays.

Figure 1  Methods of producing sliced veneers
Flat slicing is the most common process for the production of sliced veneer. This process produces consecutive leaves of veneer with matching appearance that are suitable for use in wall panels, doors, floors and furniture. The thickness of the veneer produced depends on its application. Face veneer generally is less than 1 mm thick whereas veneer for flooring is greater than 2 mm thick. As sliced veneers are generally used for surfaces, good face quality is important. This explains the relatively lower yield when compared with peeled veneers. The two important attributes of sliced veneer production are veneer yield and surface roughness.

A study was conducted:

- to evaluate the suitability of harmonized test method on slicing of tropical plantation timber;
- to determine the yield and surface roughness of sliced veneer from *Acacia mangium* and *Shorea macrophylla* from two age groups and at two veneer thicknesses.

**MATERIALS AND METHODS**

*Acacia mangium* logs were obtained from Ulu Sedili, Johor, for the 16-y-old group and from Kemasul Forest Reserve in Temerloh, Pahang, for the 20-y-old group. *Shorea macrophylla* logs of 13 y and 22 y ages were taken from Sabal Forest Reserve, Km 100, Kuching / Sri Aman Road. Green logs of about 2.6 m long were sampled and stored in water to prevent splits. Prior to slicing, the dimensions of each log were taken. Each log was trimmed to a block with two parallel sides and soaked in hot water at temperature of about 60–80 °C. Blocks for obtaining 0.5–1.5-mm veneers are usually soaked for 1–2 days whereas those of 2.5–3.0-mm veneers are soaked for 4–5 days. Eight groups of sliced veneers samples were prepared as shown below:

**Table 1  Sources of veneer samples**

<table>
<thead>
<tr>
<th>Species</th>
<th>Age of tree (y)</th>
<th>No. of logs</th>
<th>Veneer thickness (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Acacia mangium</em></td>
<td>16</td>
<td>6</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>6</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>2.5</td>
</tr>
<tr>
<td><em>Shorea macrophylla</em></td>
<td>13</td>
<td>6</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>2.5</td>
</tr>
<tr>
<td></td>
<td>22</td>
<td>6</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6</td>
<td>2.5</td>
</tr>
</tbody>
</table>

101
The *A. mangium* logs were sliced at Lim Ah Soon Sdn Bhd, Semenyih, Selangor, while those of *S. macrophylla* were sliced at Moh Sing Hiong & Sons Sdn Bhd, Kuching. A flitch was prepared from each log and held by mechanical grips with the heartwood away from the knife blade. Cuts were then made with the knife blade almost parallel to the length of the log. Slicing commenced on one side until unacceptable defects such as dead knots, holes and uneven surfaces were detected. Then the block was switched over to the other parallel side. When unacceptable defects in the veneer appeared again, another two parallel sides perpendicular to earlier sides were cut. If the block size permitted, another two parallel sides were cut at 45° to any existing two sides as shown below in Figure 2. The cutting and slicing process was continued until no more acceptable veneers could be obtained. Each sliced veneer was labelled according to the block number.

![Figure 2](image)

**Figure 2** Optimizing sliced veneer recovery by slicing from a third set of parallel sides

The veneers were dried at the respective mills and measurements were taken to determine veneer yield. The yield recovery of veneer from the slicing process was calculated as below:

**Volume of prepared block:** The volume ($V_b$ m$^3$) of the prepared block:

$$V_b = \left[ A_b \times L_b \times 10^{-6} \right]$$

where, $A_b =$ cross-section area (cm$^2$)  
$L_b =$ length of block (cm)

**Volume of sliced veneer:** The volume ($V_s$ m$^3$) of the sliced veneer:

$$V_s = \left[ \sum L_{sv} \times W_{sv} \times T_{sv} \times 10^{-6} \right]$$

where, $L_{sv} =$ length of sliced veneer (cm)  
$W_{sv} =$ width of sliced veneer (cm)  
$T_{sv} =$ thickness of sliced veneer (cm)
**Sliced veneer yield:** The yield of sliced veneer ($Y_s$) as expressed as a percentage is calculated as:

$$Y_s(\%) = \frac{V_s}{V_b} \times 100$$

where, $V_s$ = volume of sliced veneer (m$^3$)  
$V_b$ = volume of prepared block (m$^3$)

Three test sheets from each log were sampled for the determination of surface roughness. Five samples of 100 mm × 100 mm were taken from each test sheet as shown in Figure 3.

![Figure 3](image_url)  
**Figure 3** Sampling of samples for surface roughness determination

A stylus-type profilometer with a stylus tip diameter of 5 µm and a 90° tip angle was used to measure the roughness over a 15-mm tracing length. The set-up is illustrated in Figure 4.

![Figure 4](image_url)  
**Figure 4** Set-up for surface roughness test
Before the test, the profilometer was calibrated against a standard reference plate and subsequently after every 100 measurements. For each test specimen, surface roughness measurements were conducted across the grain orientation on both sides of the veneer. The test data to be collected were $R_a$ (mean arithmetic deviation of profile), $R_z$ (mean peak to valley height) and $R_{\text{max}}$ (maximum roughness). Definitions for these three tests are illustrated in Figures 5, 6 and 7.

![Figure 5](image1.png) **Figure 5** Definition of $R_a$

![Figure 6](image2.png) **Figure 6** Definition of $R_z$

![Figure 7](image3.png) **Figure 7** Definition of $R_{\text{max}}$
RESULTS AND DISCUSSION

Based on the above formulae, the sliced veneer yields of each log of *A. mangium* and *S. macrophylla* were calculated and the mean veneer yields at each veneer thickness for both species are shown in the table below:

<table>
<thead>
<tr>
<th>Veneer thickness (mm)</th>
<th>Mean veneer yield (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><em>Acacia mangium</em></td>
</tr>
<tr>
<td>0.6</td>
<td>16-y-old</td>
</tr>
<tr>
<td>16-y-old</td>
<td>33</td>
</tr>
<tr>
<td>20-y-old</td>
<td>43</td>
</tr>
</tbody>
</table>

It is observed that the mean veneer yields of *A. mangium* were generally higher than those of *S. macrophylla* except for the 13-y-old logs of the latter at 2.5-mm thickness. The 2.5-mm veneers of both species appear to be produced at better yields and also, the younger trees gave comparatively higher yield. However, the 0.6-mm veneer yields of *A. mangium* and *S. macrophylla* were fairly similar for the two age groups.

The surface roughness attributes, $R_a$, $R_z$ and $R_{\text{max}}$, of each test specimen from both species were determined at TRTTC using the Mitutoyo Surftest Model No. SV 3100 and their mean results are given in Table 3.

<table>
<thead>
<tr>
<th>Surface roughness property</th>
<th><em>Acacia mangium</em></th>
<th><em>Shorea macrophylla</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>0.6 mm</td>
<td>16-y-old</td>
<td>20-y-old</td>
</tr>
<tr>
<td>$R_a$</td>
<td>13</td>
<td>19</td>
</tr>
<tr>
<td>$R_{\text{max}}$</td>
<td>84</td>
<td>115</td>
</tr>
<tr>
<td>$R_z$</td>
<td>53</td>
<td>74</td>
</tr>
</tbody>
</table>

Most of the surface roughness properties, $R_a$, $R_z$ and $R_{\text{max}}$, for *A. mangium* were generally lower when compared with *S. macrophylla* at both age groups. For the individual species, there was no considerable difference of these values between the two age groups. Generally, the 0.6-mm veneers gave lower surface roughness values of $R_a$, $R_z$ and $R_{\text{max}}$ than the 2.5-mm veneers for both species. Between the two species, the 16-y-old *A. mangium* veneers had lower surface roughness values than the 13-y-old *S. macrophylla* veneers.
CONCLUSION

In the utilization of *Acacia mangium* and *Shorea macrophylla* for flat-sliced veneers, veneer yield and surface roughness are two properties that can be studied. From the assessment, it can be concluded the harmonized slicing method is suitable for evaluating tropical plantation timbers and also that *A. mangium* tends to offer slightly better yield and surface roughness attributes than *S. macrophylla*. For successful application in products, other subjective properties like aesthetic look and feel also need to be considered.

BIBLIOGRAPHY


A set of four tests, viz air-drying test, drying-rate test, quick-drying test and drying-schedule test, was proposed to assess the drying characteristics of plantation-grown tropical timbers. This set of tests was applied to *Acacia mangium* and *Shorea macrophylla* in the Wood Drying Laboratories at the Forest Research Institute Malaysia and Timber Research & Technical Training Centre respectively. The results of all the tests conducted on *S. macrophylla* were good. However, for difficult/refractory species such as *A. mangium*, the drying-rate test and drying-schedule test did not yield the required results. Reducing the sample thickness for the drying-rate test was necessary because of development of severe wet pockets/cores. The modification as proposed in the drying-schedule test may not work for all timber species as shown in the case of *A. mangium*. Incorporation of pre- or in-kiln treatment may be necessary to develop the appropriate schedule for this timber.

**INTRODUCTION**

Log supply from the natural forest is declining and threatening the timber industry. In the long term plantation timbers are set to be the source that will sustain the timber industry. There is a programme in place to establish large forest plantations for industrial wood in Malaysia. As more timber species are introduced into plantation programmes, there is a need to conduct assessment of their properties and processing characteristics for comparison between species. Drying characteristics of timber are important because of the complex and energy-intensive drying process. This paper reports on the test methods to assess the drying characteristics of plantation-grown tropical timbers.
MATERIALS AND METHODS

*Acacia mangium* and *Shorea macrophylla* were harvested from Kemasul, Pahang, and Sabal Agroforestry Centre, Kuching/Sri Aman Road, respectively. Twenty logs were allotted for this assessment.

Four tests were proposed to assess the drying characteristic of timber, viz air-drying test (ADT), drying-rate test (DRT), quick-drying test (QDT) and drying-schedule test (DST). In Peninsular Malaysia and Sarawak, *A. mangium* and *S. macrophylla* were harvested and tested respectively. All the tests were applied.

Sample preparation

The plantation logs were of small diameter and ideal samples for all the tests were prepared from each log. For logs of more than 300-mm diameter, one can adopt the cutting patterns as proposed in the test method (Figure 1). However, for diameter smaller than 300 mm, modifying the 60-mm flitch may be made. In this case, there will be some reduction to the number of thick samples for the air-drying test. The proposed 150-mm width of the samples, particularly the radial- and diagonal-sawn samples, may be reduced to 120 or even 100 mm. It should be noted that the sapwood may be thick in tropical plantation species and no attempt was proposed to differentiate the sapwood and heartwood for drying assessment.

Figure 1  Sawing patterns for sample preparation
RESULTS AND DISCUSSION

Air-drying test (ADT)

The air-drying specimens were only 600 mm long and it was important that both ends were sealed with silicon grease/bitumen paint before testing to provide good results. The test was conducted on two nominal thicknesses of 30 and 60 mm. The specimens were stacked under shed separated by $25 \times 25$ mm square stickers. The environmental air conditions (DBT & RH) were monitored and recorded by a thermo-hygrometer. The drying curves for *A. mangium* are given in Figure 2. The drying times for 30- and 60-mm *A. mangium* were 150 days (5 months) and 400 days (14 months) respectively. These were slightly longer than the testing period proposed in the test method, ie three to four months for boards 27 mm thick and nine to 12 months for boards 54 mm thick. This may be due to the slightly thicker specimens used.

![Figure 2](image)

**Figure 2** Air drying curves of *Acacia mangium*

For *S. macrophylla* with specimen thicknesses of 27 and 54 mm, the drying times varied from 42 to 70 days and 77 to 161 days respectively. *Shorea macrophylla* is a low density wood that can be dried perfectly well in air-drying.

Drying-rate test (DRT)

The test was conducted in a forced air circulation convective oven with the dry bulb temperature set at 60 °C and wet bulb temperature maintained at 35 °C. The specimens with a thickness of 27 mm were planed so that all surfaces
were smooth. Both ends and the sides shall be coated with silicon/bitumen paint before testing except the top and back surfaces. Measurements of the weight, width and thickness were taken as prescribed in the test method, and the testing period was about four to seven days. Testing was completed when the weight of the specimen had changed by only 1 g in a day.

The DRT method was followed through with *S. macrophylla* without any problem. From the experimental result the coefficient $k$ determined using the given formula: $\frac{du}{dt} = k (u - u_e)$ was $0.32 \text{ hr}^{-1}$.

However, for *A. mangium* the constant condition could not be achieved even after 14 days in the oven. A check on the cross-section of the specimen at the termination of the test revealed severe wet cores in the specimens, particularly the radial-sawn specimen. It was decided then to reduce the specimen thickness to 20 mm and retest. With this, the coefficient $k$ for *A. mangium* was $0.16 \text{ hr}^{-1}$ that was about half the value for *S. macrophylla*. The results indicated that *A. mangium* will dry more slowly compared with *S. macrophylla* and possibly doubling the time required for *S. macrophylla*.

**Quick-drying test (QDT)**

This test method provides a means for the determination of kiln-drying control or temperature settings. The first step is to determine the initial dry bulb temperature (DBT), initial wet bulb depression (WBD) (or difference between dry bulb temperature and wet bulb temperature, WBT) and final dry bulb temperature from the deformation classes based on initial checks, honeycombing and collapse from the oven test. The results of QDT for *A. mangium* and *S. macrophylla* are shown in Table 1. From these initial and final temperature values and the green moisture content of timber, the drying schedule could be drawn up.

<table>
<thead>
<tr>
<th>Initial check</th>
<th>Deformation</th>
<th>Honey-combing</th>
<th>Initial DBT (°C)</th>
<th>Initial WBD (°C)</th>
<th>Final DBT (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Acacia mangium</em></td>
<td>6</td>
<td>7</td>
<td>1</td>
<td>45</td>
<td>2</td>
</tr>
<tr>
<td><em>Shorea macrophylla</em></td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>55</td>
<td>3.6</td>
</tr>
</tbody>
</table>

Following the procedures prescribed in the test method, the initial drying schedules for *A. mangium* and *S. macrophylla* are elaborated in Tables 2 and 3.
### Table 2  Drying schedule for *Acacia mangium* based on QDT

<table>
<thead>
<tr>
<th></th>
<th>M.C (%)</th>
<th>DBT °C</th>
<th>WBT °C</th>
<th>WBD °C</th>
<th>EMC %</th>
<th>RH %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green to 75</td>
<td>45.0</td>
<td>43.0</td>
<td>2.0</td>
<td>18.3</td>
<td>89.0</td>
<td></td>
</tr>
<tr>
<td>75 to 65</td>
<td>45.0</td>
<td>42.6</td>
<td>2.4</td>
<td>19.1</td>
<td>86.0</td>
<td></td>
</tr>
<tr>
<td>65 to 55</td>
<td>45.0</td>
<td>41.6</td>
<td>3.4</td>
<td>15.1</td>
<td>81.0</td>
<td></td>
</tr>
<tr>
<td>55 to 45</td>
<td>45.0</td>
<td>40.2</td>
<td>4.8</td>
<td>13.0</td>
<td>74.0</td>
<td></td>
</tr>
<tr>
<td>45 to 35</td>
<td>45.0</td>
<td>38.1</td>
<td>6.9</td>
<td>10.9</td>
<td>64.0</td>
<td></td>
</tr>
<tr>
<td>35 to 30</td>
<td>45.0</td>
<td>35.0</td>
<td>10.0</td>
<td>8.4</td>
<td>52.0</td>
<td></td>
</tr>
<tr>
<td>30 to 25</td>
<td>48.0</td>
<td>35.4</td>
<td>12.4</td>
<td>7.2</td>
<td>43.0</td>
<td></td>
</tr>
<tr>
<td>25 to 20</td>
<td>56.0</td>
<td>37.0</td>
<td>19.0</td>
<td>6.3</td>
<td>40.0</td>
<td></td>
</tr>
<tr>
<td>20 to 15</td>
<td>65.0</td>
<td>47.0</td>
<td>18.0</td>
<td>5.2</td>
<td>37.0</td>
<td></td>
</tr>
<tr>
<td>15 to final</td>
<td>70.0</td>
<td>50.0</td>
<td>20.0</td>
<td>5.0</td>
<td>35.0</td>
<td></td>
</tr>
<tr>
<td>Equalizing</td>
<td>70.0</td>
<td>60.5</td>
<td>9.5</td>
<td>7.6</td>
<td>64.0</td>
<td></td>
</tr>
<tr>
<td>Conditioning</td>
<td>70.0</td>
<td>64.0</td>
<td>6.0</td>
<td>11.2</td>
<td>76.0</td>
<td></td>
</tr>
</tbody>
</table>

EMC – equilibrium moisture content (%)
RH – relative humidity (%)

### Table 3  Drying schedule for *Shorea macrophylla* based on QDT

<table>
<thead>
<tr>
<th></th>
<th>M.C (%)</th>
<th>DBT °C</th>
<th>WBT °C</th>
<th>WBD °C</th>
<th>EMC %</th>
<th>RH %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Green to 55</td>
<td>55</td>
<td>51.4</td>
<td>3.6</td>
<td>14.6</td>
<td>84</td>
<td></td>
</tr>
<tr>
<td>55 to 50</td>
<td>55</td>
<td>50.8</td>
<td>4.2</td>
<td>13.3</td>
<td>78</td>
<td></td>
</tr>
<tr>
<td>50 to 40</td>
<td>55</td>
<td>49</td>
<td>6</td>
<td>11.7</td>
<td>72</td>
<td></td>
</tr>
<tr>
<td>40 to 30</td>
<td>55</td>
<td>45</td>
<td>10</td>
<td>8.6</td>
<td>57</td>
<td></td>
</tr>
<tr>
<td>30 to 25</td>
<td>60</td>
<td>45</td>
<td>15</td>
<td>6.4</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>25 to 20</td>
<td>68</td>
<td>48</td>
<td>20</td>
<td>5.0</td>
<td>34</td>
<td></td>
</tr>
<tr>
<td>20 to 15</td>
<td>78</td>
<td>52</td>
<td>26</td>
<td>3.9</td>
<td>29</td>
<td></td>
</tr>
<tr>
<td>15 to final</td>
<td>83</td>
<td>53</td>
<td>30</td>
<td>3.0</td>
<td>23</td>
<td></td>
</tr>
</tbody>
</table>

### Drying-schedule test (DST)

The purpose of the drying-schedule test (DST) is to establish a good drying schedule for the species. The initial or basic drying schedule drawn up from the QDT results will be used to run the first experimental drying trial. Assessment
of any drying degrades that may appear will dictate the modification necessary for this initial drying schedule. Normally three drying trials are conducted. If the first test result is good, the initial WBD may be set larger for the drying schedule. However, if the result is poor, the initial WBD will be set smaller.

The schedule test is carried out in an experimental dryer, where the design and capacity might vary but the chamber must be able to be controlled to achieve the drying condition according to the schedule. Figure 3 shows the experimental dryer at the TRTTC.

![Experimental conventional steam-heated kiln](image)

A total of three drying trials were conducted on *S. macrophylla* starting with the basic schedule and modified schedule of increasing severity. From the experimental results, the modified schedule can be utilized for commercial drying of the species except that the period of conditioning for stress relief treatment at the end of drying will be longer.

For *A. mangium*, only one drying trial using the initial drying schedule was conducted. The timber had severe wet cores and even with extended period of drying the timber could not be dried. The recommendation proposed in the test method to modify the drying schedule may not be able to address this. Some other options may be necessary such as regular high humidity treatment or pre-air-drying. As such, the drying schedule test for *A. mangium* was terminated in this study.

**CONCLUSION**

The set of test methods, air-drying test, drying-rate test, quick-drying test and drying-schedule test, proposed to assess the drying characteristics of
plantation-grown tropical timbers was successfully tested on *Acacia mangium* and *Shorea macrophyalla* at two laboratories. The results of all the tests conducted on *S. macrophyalla* were good. However, for difficult/refractory species such as *A. mangium*, the drying-rate test and drying-schedule test did not yield the required results due to occurrence of severe wet cores. Slight modifications of the test methods are necessary for such difficult species and the deviations should be reported with the results.
FINANCIAL ANALYSIS OF PARTICLEBOARD PRODUCTION IN MALAYSIA

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There is a large quantity of sawdust and off-cut wood available at sawmills in Peninsular Malaysia which could be turned into wealth. Most of these are lying around the factories as waste products. The technology is available and ready to be adopted to turn the waste into valuable products such as particleboard. This paper computes the financial analysis required to set up a particleboard factory in Peninsular Malaysia. The financial analysis showed that the particleboard business is highly profitable. For a period of ten years at 10% discount rate, the net present value for the proposed particleboard plant is RM18.4 million with 31.9% internal rate of return and all the investment cost can be paid back within three years. It is worthwhile to venture into this business.

INTRODUCTION

Particleboard is an engineered wood product manufactured from wood particles such as wood chips, sawmill shavings, or even sawdust, bonded with a synthetic resin or other suitable binder, which is pressed and extruded. Particleboard is a composite material (Wikipedia 2010) that is cheaper, denser and more uniform than conventional wood and plywood and is substituted for them when appearance and strength are less important than cost. However, particleboard can be made more attractive by painting or the use of wood veneers glued onto surfaces that are visible. Though it is denser than conventional wood, it is the lightest and weakest type of wood-based panel, except for insulation board. Medium density fibreboard and hardboard, also called high density fibreboard, are stronger and denser than particleboard.

The issue in putting up a particleboard plant in Peninsular Malaysia using wood particles/ sawdust and off-cuts from plantation forest is determining the costs involved and the benefits that can be reaped.

The financial analysis adopts a weighing-scale approach for decision-making. All the positive elements are put on one side of the balance and all the negative elements (the costs and disadvantages) on the other side.
Furthermore, the financial analysis determines, quantifies and adds all positive factors. These are the benefits. Then it identifies, quantifies and subtracts all the negatives, the costs. The difference between the two indicates whether the planned action is advisable. At the same time, the financial analysis is an appropriate tool employed to evaluate projects. It provides the researcher with a set of values that are useful to determine the feasibility of a project. Conceptually simple, its results are easy for decision-makers to comprehend, and therefore enjoys a great deal of favour in project assessments. The end-product of the procedure is a benefit/cost ratio that compares the total expected benefits to the total predicted costs. In practice the financial analysis is quite complex, because it raises a number of assumptions about the scope of the assessment, the time-frame, as well as technical issues involved in measuring the benefits and costs.

The general objective of this paper is to assess the costs and benefits in making particleboard using wood particles/sawdust from the plantation industries, and specifically,

- to calculate the pay-back period for setting up a particleboard factory in Peninsular Malaysia;

- to evaluate the financial analysis of setting up the particleboard factory in Peninsular Malaysia.

The analysis will be beneficial to local stockholders’ to develop their own particleboard factory in Peninsular Malaysia so that the available wood particles / sawdust could be turned into extra income. This optimizes the utilization of the available resources from the plantation forest and it is also good for the environment.

**METHODOLOGY**

**Costs and revenues of particleboard production**

This paper focuses and discusses the details of various aspects of particleboard production. The discussion highlights the production activities and the various costs involved in the establishment as well as the management of particleboard production based on the experiences of established production companies in Malaysia. From the costs and revenues gathered, the financial and sensitivity analyses will be discussed. This paper ends with a section on investment that is needed for the development of particleboard production.
Financial analysis

Net present value (NPV), internal rate of return (IRR) and benefit-cost ratio (B/C ratio) will be used to evaluate the financial feasibility of the project (Gittenger 1982). All costs incurred and revenues gained from the project are discounted to present value for both NPV and IRR. Hence, a discounted rate of 10% is used as the proximity rate of capital loan in Malaysia.

The term net present value is usually computed by finding the difference between the present worth of the benefit stream minus the present worth of the cost stream. It is also the sum of all years’ discounted cash flows. In other words, the net present value is the present value of income generation by the investment (Gittenger 1982). In the evaluation of a single project, the project should be carried out if the net present value is positive. It is not worth to implement if otherwise. In the case where evaluation of more than one project is involved, selection should be made for the highest internal rate of return as well as net present value with high benefit-cost ratio. Besides that, the net present value only tells us how much the expected present profit could be earned from the investment but it does not reveal the proportion of total benefits against the total costs invested. To do this, benefit-cost-ratio analysis is the right financial tool to be employed. The project should be carried out if the benefit-cost ratio is more than one. In a situation where there are more than one project, then the highest benefit-cost ratio is preferable.

Apart from the net present value and benefit-cost-ratio analysis, internal rate of return (IRR) is another financial tool to determine the feasibility of particleboard production. Internal rate of return is measured when the discounted total benefits minus discounted total costs is equal to zero. The investment should only be carried out if the internal rate of return is more than the capital-cost-interest rate (ie bank-loan-interest rate charged).

The formulas used for this study are as follows:

a) Net present value (NPV)
\[ NPV = \sum (B_t - C_t)/(1 + i)^t \]

b) Internal rate of return (IRR)
\[ IRR := \sum \{ (B_t - C_t)/(1 + i)^t \} = 0 \]

c) Benefit-cost ratio (B/C)
\[ B/C = \sum \{ B_t/(1 + i)^t \}/\sum \{ C_t/(1 + i)^t \} \]

d) Pay-back period (PBP)
\[ PBP = \sum \{ \sum (B_t - C_t) \} = 0 \]

where,
NPV = net present value
IRR = internal rate of return

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The study uses secondary data available from the local existing mills in Peninsular Malaysia. The primary data were collected from the Department of Forestry, the Department of Statistics and other relevant central agencies.

This particleboard production requires an area of three acres for factory building construction and storing space for the raw and finished products. All these items have been considered in the analysis.

**COSTS ASSOCIATED WITH THE PRODUCTION**

For the purpose of this discussion, the costs discussed are based on the project which involves individual companies. Costs involved in this analysis are adopted from a few well-established companies with their productions and some are assumption values. The costs discussed here are based on a 10-y project period. The costs for the project can be classified into several categories as shown below:

- capital expenditure
- maintenance costs
- administration and operational cost

The total estimated expenditure for capital and for administration and operational costs for particleboard production is RM106 030 704. Of this, RM65 216 824 is allocated to administration and other operational costs, while the balance falls under the capital expenditure. The costs under capital expenditure include infrastructure and development, transportation and equipment, machinery and equipment and land rental. The total capital expenditure for particleboard production with a 10-y project period is RM40 813 880 (about 14% of the total cost of running the production, which is RM298 317 304). Of the total RM40 813 880, RM2 060 000 is allocated to infrastructure development, RM990 000 to transportation and equipment, RM37 400 000 to machinery and equipment and RM363 880 to land rental. A summary of the costs is given in Table 1. The cost of land is spread out over 10 y at the rate of RM33 080 per year.

In terms of maintenance costs, the most expensive maintenance activity is the consumption of raw material (wood residues), which costs RM154 440 000 over the period of 10 y. The estimated total maintenance cost for particleboard production with a 10-y period, which consists of raw material consumption, maintenance of machinery, spare parts, vehicles, buildings and chemical usage, is RM165 166 845. In terms of revenue it is estimated that the plant machine will produce 49 500 m$^3$ saleable production per year. The total revenue of RM342 642 960 (Table 2) is estimated for the 10-y period for these productions. The net cash flow inflow is RM44 325 656.16.
Table 1  Summary of cash outflows for particleboard production with a 10-y project period

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost (RM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital expenditure</td>
<td>40 813 880.00</td>
</tr>
<tr>
<td>Maintenance cost</td>
<td>165 166 845.00</td>
</tr>
<tr>
<td>Administration and other operational costs</td>
<td>65 216 823.94</td>
</tr>
<tr>
<td>Contingency cost (10%)</td>
<td>27 119 754.89</td>
</tr>
<tr>
<td>Total cash outflow</td>
<td>298 317 303.84</td>
</tr>
</tbody>
</table>

Table 2  Summary of net cash flow for particleboard production with a 10-y project period

<table>
<thead>
<tr>
<th>Item</th>
<th>Total (RM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total costs/outflow</td>
<td>298 317 303.84</td>
</tr>
<tr>
<td>Total revenues</td>
<td>342 642 960.00</td>
</tr>
<tr>
<td>Net cash flow</td>
<td>44 325 656.16</td>
</tr>
</tbody>
</table>

FINANCIAL ASSESSMENT OF THE PROJECT

For this particleboard production project, the calculated values of the NPV and IRR are RM18 460 641.27 and 31.90% respectively (Table 3). The B/C ratio is more than one which is 1.15, indicating that the present worth of benefits for the project is more than the present worth of costs: the company will recover its investment.

Table 3  NPV, IRR and B/C ratio for a particleboard production over a 10-y project period

<table>
<thead>
<tr>
<th>Project period</th>
<th>NPV discounted @ 10% (RM)</th>
<th>IRR (%)</th>
<th>B/C ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Particleboard production with 10-y</td>
<td>18 460 641.27</td>
<td>31.90</td>
<td>&gt; 1 (1.15)</td>
</tr>
</tbody>
</table>

The financial analysis carried out in this study indicates that the production of the particleboard has potential and could provide a consistent return to the individual/company, as the analysis shows a positive NPV, quite high IRR and B/C ratio of more than one.

To test the project’s viability with respect to changes in price and cost, a sensitivity analysis is carried out. In this study, variation of sensitivity is based
on positive increases of 10 and 5% and negative decreases of 10 and 5% for price and cost. For the purpose of this paper we focus only on six extreme effects, ie increase in price by 5 and 10%, increase in cost by 5 and 10%, increase in cost by 10% with increasing price of 5% and increase in price by 10% with increasing cost of 5%. The analysis indicates that the project is still financially viable (at break-even point) even with a 10% increase in cost (Table 4).

Table 4  Sensitivity analysis of a particleboard production over a 10-y project period

<table>
<thead>
<tr>
<th>Item (changes in cost and price)</th>
<th>IRR (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No changes</td>
<td>31.90</td>
</tr>
<tr>
<td>Price increased by 5%</td>
<td>44.91</td>
</tr>
<tr>
<td>Price increased by 10%</td>
<td>59.70</td>
</tr>
<tr>
<td>Cost increased by 5%</td>
<td>20.44</td>
</tr>
<tr>
<td>Cost increased by 10%</td>
<td>10.08</td>
</tr>
<tr>
<td>Cost increased by 10% with increasing price of 5%</td>
<td>20.95</td>
</tr>
<tr>
<td>Price increased by 10% with increasing cost of 5%</td>
<td>44.25</td>
</tr>
</tbody>
</table>

CONCLUSION

The financial analysis carried out in this study indicates that processing wood residues for particleboard production is a profitable venture. The business has positive NPV and IRR values of RM18 460 641.27 and 31.90% respectively with three years of pay-back period.

REFERENCES
