Stress Free Lumber For Furniture And Structural Timbers

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Introduction

This study was conducted to determine the causal of growth stresses inherent in the plantation woods, their properties and the potential end-use for the stressed timber trees namely *Acacia mangium, Acacia auricurliformis* and *Hevea brasiliensis*. It is known that these fast growing trees have a major problem due to the present of stressed wood. Stressed wood is refers to the tissue of a living tree that is exposed to stresses during it's maturation period. It is sometime called reaction wood, i.e abnormal wood formed in leaning trees. In hardwood trees, the reaction wood forms on the upper side of the leaning stems or branches and is called tension wood. Tension wood is often dense, shiny and rather flexible due to higher cellulose content. A tension wood experiences abnormal longitudinal shrinkages upon drying, usually about 1~2%, but will increase to 6~7% at extreme. The strength of a tension wood and the normal wood is reported to be the same for the same wood density range. Thus, it is possible to determine and compare the properties of stressed wood (tension wood) to a normal wood. Therefore, the potential uses of stressed wood from these species could be proposed and developed as well. The research project conducted was divided into several sections as follows:

1.Basic characteristic of these stressed wood.
2.Timber processing and stress evaluation
3.Gluing, jointing and finishing

Materials and Methods

Basic characteristic of new wood species

Anatomical Properties

Stressed and non-stressed wood of *Acacia mangium, Acacia auriculiformis* and *Hevea brasiliensis* were studied. The sapwood-heartwood ratio were measured. Tissue proportion and fibre morphological studies were also conducted. In tissue proportion study, wood samples were cut into 2 sections, i.e. sapwood and heartwood. Samples of 10mm x 10mm x 20mm were used for slide preparation through thin sectioning, dehydration, staining and mounting. The slides were then examined under light microscope connected to an image analyser.

Physical and Mechanical Properties

The physical properties evaluation includes the test on Specific Gravity (SG), Moisture Content (MC), Radial Shrinkage (SR) and Tangential Shrinkage (ST). Mechanical properties evaluation includes the Modulus Of Elasticity (MOE), Moduius Of Rupture (MOR), Maximum Shear Strength (Shear) and Maximum Compression Strength (Comp), and were conducted in accordance to British Standard, BS 373:1957 Testing Small Clear Specimens Of Timber.

Kiln Drying and Stress Evaluation

Investigation was carried out on stressed and non-stressed wood of *Acacia auriculiformis* and *Acacia mangium* to determine the suitable kiln-drying schedule conducted through Quick Drying Test (QDT); and to asses the drying defects when dried by low temperature kiln dryer using proposed schedule from QDT. Both methods were accorded to the procedures developed by Terazawa, et. al. (1976).

Gluing, jointing and finishing

The block shear specimens were cut from the each laminated board from these three wood species according to ANSI/ASTM D5751-95 D3110. Twenty- four (24) gluelines were produced from each single species. the shear specimens were subjected to 2 tests condition: dry and vacuum cold water soak. The shear test will be carried out according to the ANSI/ASTM D3110. On the assessment of finishing properties, testing was divided into two categories; gloss test according to ASTM D523-67 and performance test which were the impact resistance (BS 3962: part 6: 1980) and adhesion test (ASTM D3359-76). Each specimen was test for determine the finishing properties

Results and Discussion

Anatomical Properties.

The anatomical properties of wood were divided into fiber morphological study and tissue proportion. For fibre morphological study, stressed wood was found to have longer fiber length, thicker fiber wall and larger vessel diameter compared to non-stressed. However, stressed wood has smaller fiber and lumen diameter. In vessel element length, there was no significant different between growth types. In tissue proportion, the growth rings of stressed wood were found wider than non-stressed. Gelatinous layer was also present in the fibres of stressed woods. Observation on vessel area showed that *H. brasiliensis* has the highest percentage of vessel area compared to *A. mangium* and *A. auriculiformis*. For mean ray height, stressed wood of *A. auriculiformis* and *H. brasiliensis* was found higher than non-stressed wood while *A. mangium* shows reverse result. In ray width, there was no significant difference between stressed and non-stressed woods.

Physical Mechanical Properties.
In physical and mechanical properties tests, *Acacia auriculiformis* exhibited the highest specific gravity value for non-stressed and stressed wood with values of 0.81 g/cm^3 and 0.79 g/cm^3 respectively. Longitudinal shrinkage of stressed wood was about 2-2.5 times higher than normal wood. The bottom part exhibited higher moisture content, specific gravity and shrinkages both at the radial and tangential direction. *Acacia mangium* has the highest value of 9675.24 N/mm^2 in stressed wood but in the non-stressed wood, *Hevea brasiliensis* showed the highest MOE value with a value of 10234.28 N/mm^2. For MOR, *Acacia auriculiformis* gave a value of 97.10 N/mm^2, which was higher than the others for non-stressed timbers. *Hevea brasiliensis* also showed superior shear strength for non-stressed and stressed with values of 16.32 N/mm^2 and 16.53 N/mm^2 respectively. In compression strength, the result indicated that *Acacia auriculiformis* showed highest value for non-stressed and *Acacia mangium* for stressed wood with values of 46.85 N/mm^2 and 45.03 N/mm^2 respectively.

Air drying and Kiln Drying Properties
Air drying of *Acacia auriculiformis* took 91 days and the final moisture content of 21% for normal wood and 20% for stressed wood. However, *Acacia mangium* took 103 days for stressed wood and 93 days for normal wood to achieve 20% of moisture content. Drying defects such as surface checking, bowing, twisting and crooked in normal wood was found to be less in normal wood compared to stressed wood for both species. The colour of dried wood change from light colour to dark. Both drying schedules of *A. auriculiformis* were found similar with schedule E for stressed wood and schedule F for non-stressed wood. *A.*average final moisture content for boards of *A. mangium was* 15% for both wood types; 11% and 17% for *A. auriculiformis* in stressed and non-stressed, respectively. From prong test, casehardening was found higher in stressed *A. auriculiformis* the non-stressed counterpart. Warping (bowing, twisting and springing) was found higher in stressed *A. auriculiformis*. The average shrinkage for both directions (width and thickness of board) in stressed *A. mangium* was found higher than non-stressed. However, reversed observation was found in *A. auriculiformis*. In colour changes due to kiln drying, both growth types in both species showed changes from light to dark.

Wood Machining Properties
In wood machining properties test, the result showed that non-stressed produced better surface quality then stressed wood of each species in planing and sanding test. The stressed wood also produced higher warping defect compared to non-stressed wood for each species. In the boring process, surface quality inside the holes for non-stressed wood was better than the stressed wood of each species. In summary, the quality of work-pieces in machining processes of non-stressed wood were better than stressed wood for each species.

Gluing and Finishing Properties
The study on gluing and jointing properties indicated that the sample in wet condition provide higher shear strength with that of in the dry condition. The effects of cold water soaking was only found in the *Hevea brasiliensis* wood. This indicated that the *Hevea brasiliensis* wood may contain more stressed wood than *Acacia mangium*. Among the four variables studied: species, surface treatment, types of wood and wood sections, surface treatment gives more dominant effect on the finishing properties. Generally Rubber wood preformed better compare to *Acacia mangium* in term of gloss and adhesion. Non-stressed wood generally produced better impact strength than stressed wood. However, the effects of the presence of growth stress in wood are more dominant in surface gloss. Three layers topcoat provides a better adhesion to the wood surface and gives high impact resistance. Meanwhile, filling + topcoat treatment provides better surface gloss. In wood section, sapwood provides good resistance on the impact but has no significant influence on the gloss and adhesion properties.

Conclusions

The growth stresses , sapwood and heartwood ratio, fibre morphology, and tissue proportion of the wood materials has been evaluated and assessed.. The physical and mechanical properties were also being assessed and studied. These woods showed different properties compared to normal woods.
Sawing, machining and seasoning properties of these woods were elucidated. The deviation from normal processing practice is required and improvement on the current processing techniques such as drying technique is proposed.
Results from gluing and finishing studies showed that these stressed wood require special attention. Glue line strength tests reveal that set shear strength was affected by stressed wood. Non-stressed wood generally produced better impact strength than stressed wood. However, the effects of the presence of growth stress in wood are more dominant in surface gloss.

Benefits from the study

The results from this study will help the following sectors:

Forest Plantation: Provide information on the kind of species and its properties.
Wood Processor: Assist and offer alternatives and appropriate technologies associated with timber processing, especially the stressed wood.

Furniture manufacture: Development of new gluing and finishing techniques suitable to manufacture of furniture using stressed wood and juvenile woods.

Patent(s), if applicable:

Not Applicable

Stage of Commercialization, if applicable:

Not Applicable

Project Publications in Refereed Journals

1. Zaidon A., Kamarul Azlan, M., Faizah, A.H. and **Mohd. Hamami Sahri**. 2001. The resistance plantation timber species towards white rot fungus and their durability in service. PERTANIKA Jour. of Agic. Sc.25(1): 69-73.

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Project Publications in Conference Proceedings

1.**Mohd. Hamami Sahri**, Tan Wee Seng and Semsolbahri Bokhari. 2002. Machining properties of stressed and non-stressed *Acacia mangium*, *Acacia auriculiformis* and *Hevea brasiliensis*. Paper presented in The Fourth International Wood Science Symposium. 2-5 September, 2002. Serpong Indonesia.

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3. **Mohd. Hamami Sahri** and Semsolbahri Bokhari. 2003. Physical properties of Acacia wood of various age groups planted in Sabah. Paper presented in International Conference Daejeon. Korea. April, 2003.

4. Wong Ee Ding , **Mohd. Hamami Sahri** and K.H.Puah. 2002. Properties of particleboard manufactured from tension wood of Acacia auriculiformis. Paper presented in The Fourth International Wood Science Symposium. 2-5 September, 2002. Serpong Indonesia

Graduate Research

	Name of Graduate	Research Topic	Field of Expertise	Degree Awarded	Graduation Year
20.	Yoshiyuki Ogata	Seasonality of microscopic structure in some tropical trees.	Wood Anatomy	Ph. D	2002
21.	Paiman Bawon	Growth Stresses in Plantation timbers and Its Influence on Processing	Wood science	Ph. D	2004 (Expected)
22.	Kiyoko Honjo	Variation in fibre length in planted *Acacia mangium*	Wood structure	M.S	2002

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