ISBN : 978-979-96348-8-7

PROCEEDINGS

THE 2ND INTERNATIONAL SYMPOSIUM OF INDONESIAN WOOD RESEARCH SOCIETY

Developing Wood Science and Technology to Support the Implementation of Climate Change Program

12 – 13 November 2010
Inna Grand Bali Beach Hotel, Sanur,
Bali INDONESIA

Organized by

Indonesian Wood Research Society (IWoRS)

In collaboration with

Ministry of National Education of Indonesia
Ministry of Forestry of Indonesia
Perum Perhutani
PT. Wirakarya Sakti
Department of Forest Products – Bogor Agricultural University
Research Center for Settlement, Ministry of Public Works of Indonesia

Published by

Indonesian Wood Research Society (IWoRS)
2011

PROCEEDINGS

THE 2ND INTERNATIONAL SYMPOSIUM OF INDONESIAN WOOD RESEARCH SOCIETY

Developing Wood Science and Technology to Support the Implementation of Climate Change Program

12 – 13 November 2010
Inna Grand Bali Beach Hotel, Sanur, Bali

INDONESIA

Editors

Nyoman J. Wistara
Muh. Yusram Massijaya
Deded S. Nawawi
Arinana
Istie Sekartining Rahayu
Suhasman
Wayan Darmawan

Organized by

Indonesian Wood Research Society (IWoRS)

In collaboration with

Ministry of National Education of Indonesia
Ministry of Forestry of Indonesia
Perum Perhutani
PT. Wirakarya Sakti
Department of Forest Products – Bogor Agricultural University
Research Center for Settlement, Ministry of Public Works of Indonesia

Published by
Indonesian Wood Research Society (IWoRS)
2011

PREFACE

The 2nd International Symposium of Indonesian Wood Research Society 2010 attracted the interest of over 134 scientists from 7 countries including Japan, Russia, Iran, Thailand, The United Kingdom, Malaysia, and Indonesia. The symposium covered the disciplines of biocomposites, wood properties and quality improvement, wood design and engineering, forest products chemistry, and forestry sciences related to climate change. The technical program consisted of 116 oral presentations under 4 sessions and 17 poster presentations over a period of two days.

This publication is a compilation of presented papers. Every effort has been carried out to retain the original meaning and views of authors during the editing processes. All claims on trade products and processes and views expressed do not necessarily imply endorsement by the editors.

We believe that this publication will be a useful source of information and achieved its primary objective of disseminating new experiences and information to researchers, academics, policy makers and students mainly in the field of wood science and technology. Additional information provided by papers related to climate change is expected to further direct the development of environmentally benign forest products technology.

The organization of this international gathering and compilation of the proceedings could not have been achieved without the combined effort of all members of the organizing committee and the supports of Ministry of National Education of Indonesia, Ministry of Forestry of Indonesia, Perum Perhutani, Research Center for Settlement – Ministry of Public Works of Indonesia, PT. Wirakarya Sakti, and Department of Forest Products – Bogor Agricultural University. The editors hereby wish to acknowledge the contributions of all parties.

Editors

December 2010

CONTENTS

FOREST PRODUCTS CHEMISTRY

FORESTRY SCIENCES

POSTERS

Densified Softwood as an Acoustics Material

James Rilatupa

Department of Architecture, Christian University of Indonesia

Abstract

In building design, architect should consider acoustics condition; besides other conditions like structure, mechanical-electrical etc. The term acoustics can be used to describe the study of sound in general, but the subject of acoustics is concerned with the control of sound within a room. The general aim of acoustics is to provide the best condition for the production and reception of sound such as music or speech. Wood in general has been used for acoustics material, because their ability to absorb a significant amount of incident sound in a room. Wood as an acoustics materials are very flexible applied in a room; like ceiling and walls surface, floor platforms, or other components depending on its performane requirements. Otherwise, in this research is selected softwood (Agathis loranthifolia) which one of fast growing tree. The result of this research showed noise reduction index between 0.10 -0.18; tranmission loss value 18.31 – 36.73 dB; and absorption coefficient of sound 0.12 – 0.22.

Keywords: acoustics, densified softwood, absorption coefficient

Introduction

Acoustics can cover a very wide range and touch almost every aspect in human lives. Such as doctors, psychologists, audiologists, biologists, musicians, composers, musical instrument companies, communication scientists, computer and space, oceanic major, people who works in radio, television and recording industries, city planning architects, machinery electrical, and chemistry engineers will be related to acoustics aspects. It is clear that acoustic is one of the architecture elements for indoor or outdoor environmental studies (Doelle and Prasetio, 1993)

Softwood is a type of wood that is being promoted by the government, because of its fast-growing nature and economically less expensive compared to other type of woods that are available in the market. The uniqueness of this wood is its smooth texture and follows its straight fiber. The color of the *Agathis loranthifolia* wood is yellowish white to golden brown, it also has plain slick and shiny surface. A low quality wood such as *Agathis loranthifolia* wood can be upgraded to fix its natural mechanism through densifying it by compression, therefore it can usage as acoustics panel material become vary.

Methods

Sample Preparation. The object material is being shaped into cubes of densified softwood (*Agathis loranthifolia*) and also they made into 3 (three) different sizes, which are: 36 x 12 x 12 cm^3, 24 x 12 x 12 cm^3, and 12 x 12 x 12 cm^3. Then the shaped softwood is known as the experiment object material and a softwood board with the same measurement is being used as the control from the experiment object material, which are: 36 x 12 x 12 cm^3, 24 x 12 x 12 cm^3, and 12 x 12 x 12 cm_3.

Acoustical Test. The acoustic test to the experiment object material is the sound absorption test using the sound test software. That software is connected to the source of sound unit that has been programmed to a computer/laptop. Then the source of sound unit is connected to a receiver which located inside the test object and will be valued to the highest peak of sound measurement value. The highest measurement of the sound is received through the frequency measurement in order to get noise reduction index and transmission loss.

Frequency measurements in this test are 125 Hz, 250Hz, 500Hz, 1000Hz, 2000Hz, and 4000Hz, as the most important measurement on acoustics (Figure 1). Beside of that there has been conducted a measurement on the time of echo on the respective frequencies to get to get their absorption coefficient. The measurement will be conducted 5 (five) times to each of the object materials. Before the measurement of the sound absorption on the object materials took place the test was performed without the test objects materials first.

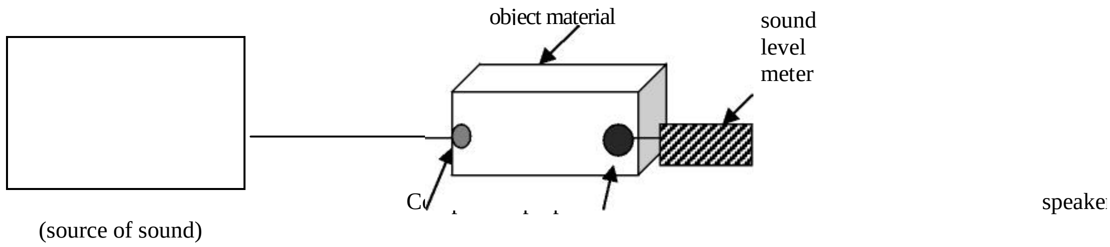


Fig. 1. The test scheme on object material.

The Calculation of the Sound Absorption. Calculation of the sound absorption includes Noise Reduction Index (NRI), Transmission Loss and Absorption Coefficient.

Noise reduction index is a ratio of pressure, the difference in sound pressure level on the single or more sides of wall and the incident sound pressure. In other word, noise reduction index is the reduction of the sound power on the acoustic board which received based on the sound difference (energy of sound source reduced from the energy of reflected sound) with the highest pitch of sound source and can be calculated as:

$$NRI = \{(Ee - Er)/Ee\} \times 100 \qquad (1)$$

where: NRI = noise reduction index
Ee = incident acoustic energy (db)
Er = energy of reflected source (db)

The transmission loss is a power medium to slow down/reduce the sound and it is different on each of its frequencies. On this experiment the transmission loss can be received/reached based on the observation result, but this also can be calculated with the equation:

$$TLf = 18 \log M + 12 \log f - 25 \text{ dB} \qquad (2)$$

where: M = wall mass (kg/m^2) f
= frequency, Hz

Absorption coefficients it's a measurement for power absorption per range unit of a surface absorption in a comparison between non reflected energy and the whole upcoming energy of sound. Meanwhile absorption coefficient is an ability of a material to slow down the upcoming sound, calculated in percentage or decimals. The calculation of coefficient is depending on reverberation time from the tested materials, which are:

$$\alpha = (0{,}16\ V)/(T_R\ S) \qquad (3)$$

where: α = coefficient absorption
V = room volume, m3
S = sound of absorbed energy (db)

Result and Discussion

Noise Reduction Index. The result from the research showed that the reduction of sound power at densified board is higher than non-densified softwood (*Agathis loranthifolia*) board. Noise reduction index on the densified softwood board is valued at 0.10 - 0.18; meanwhile the non-densified softwood board is between 0.04 - 0.09. Therefore, from this study also shows that the bigger of wood box, the higher its noise reduction index. Meanwhile, if it is seen from the data which has been collected, there are differences in noise reduction index on every frequency. It does not influence the noise reduction index on the densified softwood board, compared to non-densified softwood board (Table 1 and Figure 2). The increasing of noise reduction index on the densified softwood board, compared to the non-densified softwood board occurred due to its physical nature and its mechanism on densified softwood board which has already changed.

Table 1. Noise Reduction Index on the densified softwood board and non-densified softwood board

Wood Box	Noise Reduction Index					
(cm^3)	125	250	500	1000	2000	4000
Densified						
12x12x12	0.10	0.11	0.11	0.10	0.12	0.11
21x12x12	0.14	0.14	0.14	0.14	0.14	0.13
36x12x12	0.17	0.16	0.17	0.18	0.16	0.18
Non-densified						
12x12x12	0.05	0.05	0.05	0.05	0.04	0.04
24x12x12	0.07	0.08	0.08	0.07	0.07	0.07
36x12x12	0.08	0.09	0.09	0.08	0.08	0.09

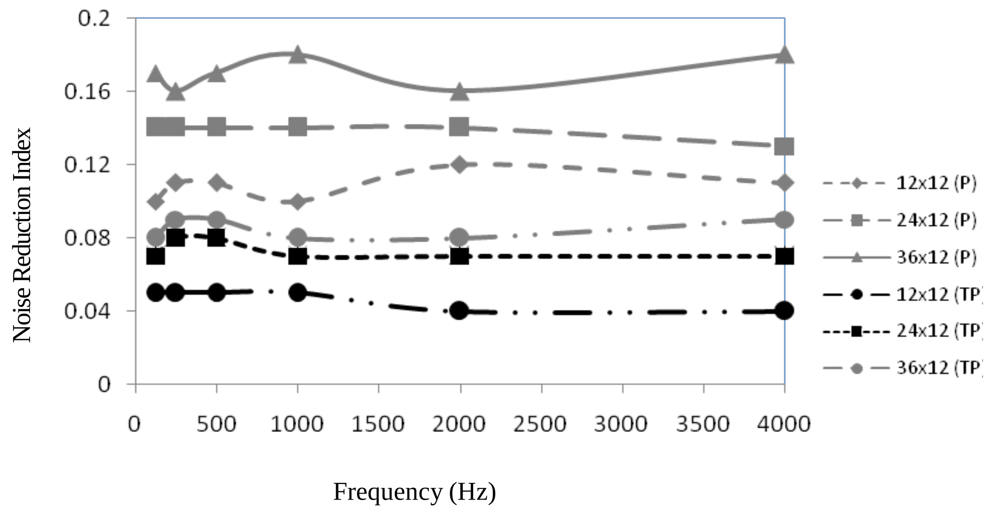


Fig. 2. Noise reduction index on the densified softwood board (P) and non-densified softwood board (TP).

Transmission Loss. The study result showed that the transmission loss on densified softwood board with the size 12 x 12 x 12 cm^3 is between 18.31 - 34.48 dB, the 24 x 12 x 12 cm^3 is between 19.40 - 36.52 dB, and the size of 36 x 12 x 12 cm^3 is between 20.15 - 36.73 dB. Meanwhile the transmission loss on the non-densified softwood board with the size of 12 x 12 x 12 cm^3 is between 21.19 - 38.38 dB, the 24 x 12 x 12 cm^3 is between 20.87 - 39.89 dB, and 36 x 12 x 12 cm^3 is 21.36 - 40.85 (Table 2). Based on these data it is showed that the least transmission loss occurred in frequency of 125 Hz and the highest transmission loss occurred in frequency of 4000 Hz.

In accordance with Mangunwijaya (1981) and Bucur (1995), the transmission loss (contagious) of sound happened by the air molecules inside the pores which caused a friction of a molecule to another, and the energy of sound was turned into the heat energy. The difference transmission loss both of the boxes either on densified softwood board and non-densified softwood board shows that the pores of box made out of densified softwood board have fewer pores if compared than box made out of non-densified softwood board.

Table 2. Transmission loss on densified softwood board dan non-densified softwood board based on study.

Wood box (cm^3)	Transmission Loss (dB) 125	250	500	1000	2000	4000
Densified						
12x12x12	18,31	22,28	26,17	29,87	32,22	34,48
24x12x12	19,40	23,48	27,05	30,11	33,24	36,52
36x12x12	20,15	24,84	27,67	30,87	34,58	36,73
Non-densified						
12x12x12	21,19	24,60	28,53	32,00	34,01	38,38
24x12x12	20,87	24,76	29,33	32,19	36,04	39,89
36x12x12	21,36	25,29	29,18	33,07	36,96	40,85

The transmission loss of the sound in both of the boxes made out of densified softwood board and non-densified softwood board shows it is increasing along with the increase of the noise frequency. This also shows that there is a connection of linear positive between sound frequency and its transmission loss (Figure 3). The similarity of linear that has been received is Y = 11.07 X - 3.31 for the box made out of densified softwood board and Y = 15.41 X – 13.44 for the box made out of non-densified softwood board, where Y is the transmission loss (dB) and X is the logarithm from the frequency (Hz).

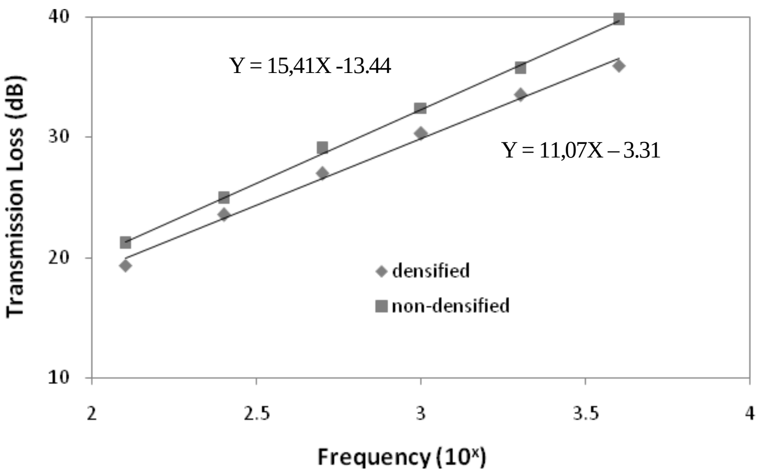


Fig. 3. The graphic of relationship between the frequencies (10^x Hz) and the trans-mission loss for the box made out of densified softwood board and the non-densified ones.

Sound Absorption Coefficient

The result of the experiment shows that the sound absorption coefficient in the box made out of densified softwood board with the sizes of 12 x 12 x 12 cm^3 is between 0.12 – 0.22; the box with the size 24 x 12 x 12 cm^3 is between 0.12 – 0.22; and the box with the size of 36 x 12 x 12 cm^3 value is between 0.12 – 0.21 (Table 3). Meanwhile, the sound absorption coefficient in the box made out of non-densified softwood board with the sizes of 12 x 12 x 12 cm^3 is between 0.16 – 0.41; the box with the size 24 x 12 x 12 cm^3 is between 0.18 – 0.40; and the box with the size of 36 x 12 x 12 cm^3 value is between 0.20 – 0.39 (Table 3). Based on all those data, it is showed that the lowest sound absorption coefficient occurred at frequency 4000 Hz, and the highest occurred at frequency 125 Hz, with the exception of the box with the size of 12 x 12 x 12 cm^3 made out of non-densified softwood board the highest absorption occurred at 250 Hz. In general this result shows that the highest of sound frequency will make its sound absorption coefficient lower. The study result also shows that the size of the box does not give much effect on the sound absorption coefficient. This might occur due to the size of the boxes which is almost similar.

The sound absorption coefficient on densified softwood board which is between 0.12 – 0.22, shows that is qualified to be used as one of acoustic material; even though there are no specific standards for sound absorption coefficient for specific materials. Generally, the specific standard of sound absorption is required to make a room or a building. For example, the acoustics needs for a classroom are different with studio room, or between the worship hall, and an auditorium. The sound absorption coefficient in the box made out of densified softwood board and the non-densified one shows a decrease while the sound frequency increase; this also shows that there is a (relation) negative linear between the sound frequency with its absorption coefficient (Figure 4). The linear similarities that have been occurred are Y=0.345 - 0.06 X for the box made out of densified softwood board, and Y = 0.721- 0.146 X for the box made out of non-densified softwood board where Y is the noise absorption coefficient, and X is the logarithm from the frequency (Hz).

Table 3. Sound absorption coefficient on densified and non-densified softwood board.

Wood box (cm^3)	Frequency (Hz) 125	250	500	1000	2000	4000
Densified						
12x12x12	0.22	0.18	0.17	0.15	0.14	0.12
21x12x12	0.22	0.19	0.18	0.13	0.13	0.12
36x12x12	0.21	0.18	0.17	0.14	0.14	0.12
Non-densified						
12x12x12	0.39	0.41	0.33	0.28	0.26	0.16
24x12x12	0.40	0.39	0.33	0.27	0.26	0.18
36x12x12	0.39	0.39	0.31	0.26	0.25	0.20

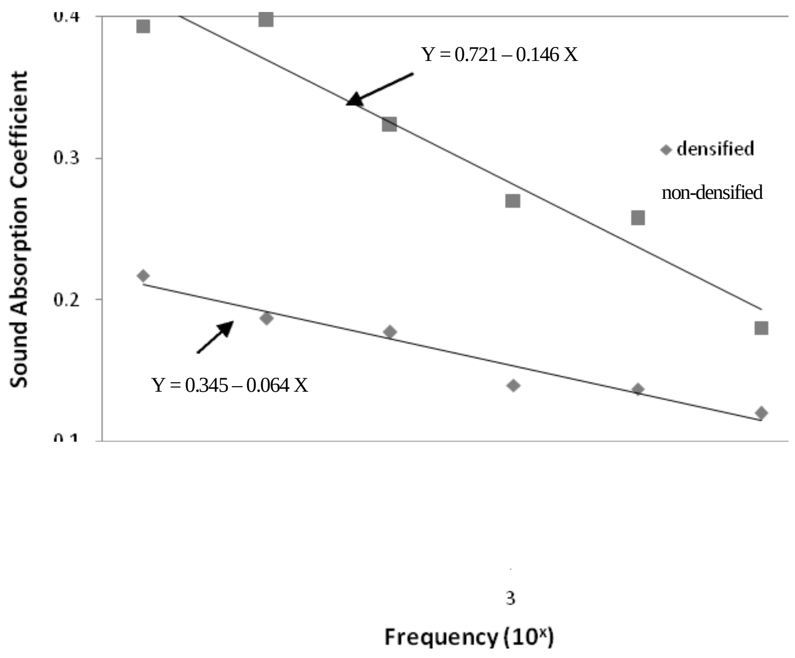


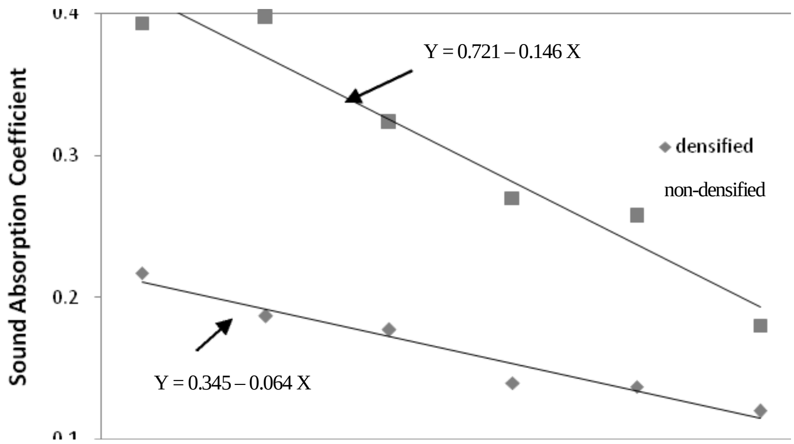
Fig. 4. Graphic of the relation between the frequencies (10x Hz) and the sound absorption coefficient for the box made out of densified softwood board and non-densified ones.

Conclusions

There are no significant changes on the noise reduction index for the difference frequency. It shows that the noise reduction index is relatively the same for all frequencies. Meanwhile, if there have been some improvements on noise reduction index along with the high volume in both of the boxes both of made out of densified softwood board and non-densified ones, therefore, it shows that though the volume is high in

the box the noise can be reduced.

The transmission loss in the box made out of densified softwood board, and the non-densified softwood board will increase with the higher of sound frequency; this also shows that there is positive linear relationship between sound frequency and its transmission loss. Meanwhile it is the opposite occurred in its sound absorption coefficient. The sound absorption coefficient in the box made out of densified softwood board and the non-densified ones, shows a decrease when its sound frequency gets higher, and also it shows there is a linear negative relationship between sound frequency and its absorption coefficient.



References

Bucur, V. 1995. Acoustics of Wood. CRC Press. New York.

Doelle, L.L. and L. Prasetio. 1993. *Akustika Lingkungan* (Enviromental Acoustics). Erlangga. Jakarta.

Martawijaya, A., Kartasujana, K. Kadir and S.A. Prawira. 1981. *Atlas Kayu Indonesia Jilid I* (The Atlas of Indonesiaan Wood Volume I). Balai Penelitian dan Pengembangan Hasil Hutan. Bogor.