ISSN 2617-6297
Vol.2, No.1

Using Natural Rubber Mixed with Coconut Coir for Casting Indoor Acoustic and Thermal Insulation Board

Pramot Weeranukul[a*], Orawan Jantasuto[b], Kittipong Suweero[c] and Lawan Kankaset[d]
[a] Faculty of Industrial Education, Rajamangala University of Technology Phra Nakhon, Bangkok, Thailand
[b] Faculty of Engineering and Architecture, Rajamangala University of Technology Suvarnabhumi, Suphan Buri, Thailand
[c] Faculty of Engineering, Rajamangala University of Technology Thanyaburi, Pathum Thani, Thailand
[d] Faculty of Engineering and Architecture, Rajamangala University of Technology Suvarnabhumi, Suphan Buri, Thailand
*Corresponding Author: pramot.w@rmutp.ac.th

ABSTRACT

This research aims to develop the indoor acoustic and thermal insulation boards from coconut coir (coconut coir dust and coconut fiber) and natural latex. The 5 ratios of coconut coir dust: coconut fiber: natural rubber (solid part) were equal to 0.1: 0.9: 0.1, 0.1: 0.9: 0.15, 0.1: 0.9: 0.2, 0.1: 0.9: 0.25, and 0.1: 0.9: 0.3 by weight. The indoor acoustic and thermal insulation boards were produced by knitting the coconut coir, spraying the natural latex, and heat compressing. The properties testing of indoor acoustic and thermal insulation boards included the density test, water absorption test, tensile strength test, thermal conductivity test, and sound insulation efficiency test. From the results, 0.1: 0.9: 0.15 ratio is the most suitable ratio of coconut coir and fiber indoor acoustic and thermal insulation board mixed with natural latex. The natural latex which putted in these indoor acoustic and thermal insulation boards can reduce the water absorption, and increase tensile strength and sound insulation efficiency.

Keywords: Indoor Acoustic and Thermal Insulation Board, Coconut Coir Dust, Coconut Fiber, Natural Latex.

1. Introduction

Coconut is an agricultural commodity that Thailand has the potential to produce and it has the trend for more exportation. In Thailand, the coconut planting area is around 2,080 square kilometers where distribute in central, east, and southern part of Thailand (Department of Agriculture Extension, 2016). These coconuts are used in the many industrials such as food, beverage, substance sweetness, medicine, and cosmetics. The important waste from coconut farm is the coconut coir (coconut coir dust and coconut fiber) (Asasutjarit et al., 2007; FAO, 2011). From previous study, the coconut coir is the cellulose fiber which made with ethers or esters. The cellulose fiber is composed by microfibrils in a matrix of hemicellulose and lignin. This type of structure and the chemical composition of them is responsible for the mechanical properties that can be observed. Because the cellulose fiber makes hydrogen bonds between the long chains, they have the necessary stiffness and strength. Moreover, the cellulose fiber can use in wall and roof cavities to insulate, draught proof and reduce free noise (James Cowan, 2000). The natural latex also is an agricultural commodity in Thailand as same as the coconut which have around 37,280 square kilometers of planting area (Rubber Authority of Thailand, 2019). Due to the low price problem of natural latex, the Thai government has been promoting the use of natural latex in industries to improve the

stability of natural latex price. Thus, the objective of this research aims to develop the indoor acoustic and thermal insulation board from the coconut coir and natural latex.

2. Methods

2.1 Materials and equipment

The materials and equipment were used in this research including:
1) 60 % pre-vulcanized latex (see Table 1 and Figure 1).

Table 1 Admixtures of 60 % pre-vulcanized latex by weight.

Admixtures	Weight (Grams)
60% Latex	167.0
10% Potassium hydroxide	2.0
10% Teric 16 A	0.2
50% Sulfur	1.6
50% ZEDC	0.8
50% ZMBT	0.8
50% Wingstay L	2.0
50% TiO_2	2.0
50% Zinc oxide	2.0
Water	170.5

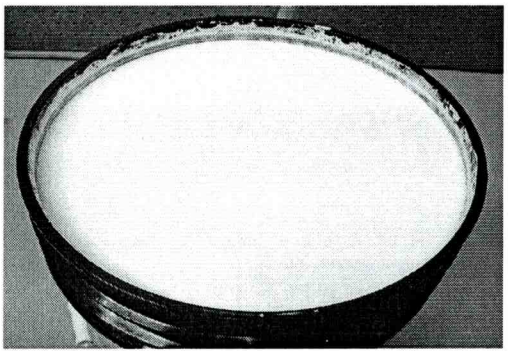

Figure 1 60 % pre-vulcanized latex

2) Coconut coir (coconut coir dust and coconut fiber) (see Figure 2).

Figure 2 Coconut coir

3) Chemical admixtures included rhombic sulfur, zinc oxide (ZnO), stearic acid, mercapto benzthiazole (MBT), and diphenyl guanidine (DPG).
4) Coconut coir separator (see Figure 3).

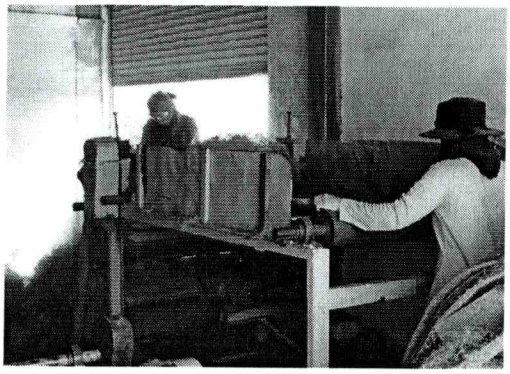

Figure 3 Coconut coir separator

5) Coconut fiber weaving machine (see Figure 4).

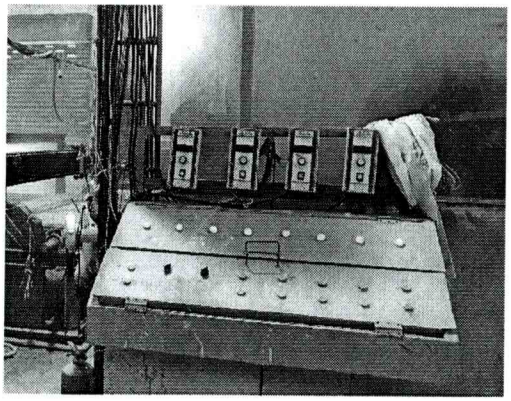

Figure 4 Coconut fiber weaving machine

6) Natural latex sprayer (see Figure 5).

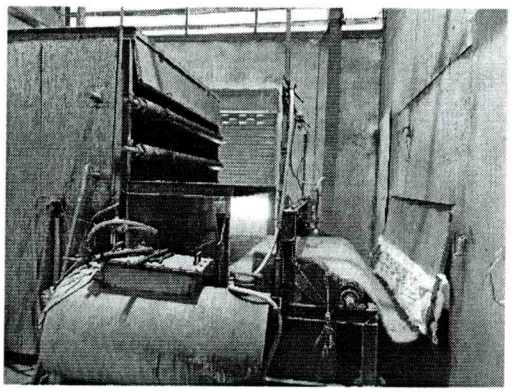

Figure 5 Natural latex sprayer

7) Coconut coir sheet cutter (see Figure 6).

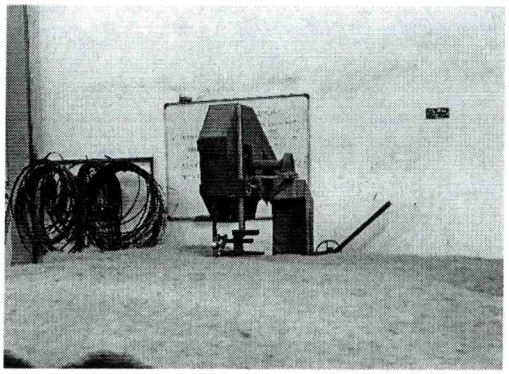

Figure 6 Coconut coir sheet cutter

8) Hot press molding machine with temperature 150 degree of Celsius and pressure 150 bars (see Figure 7).

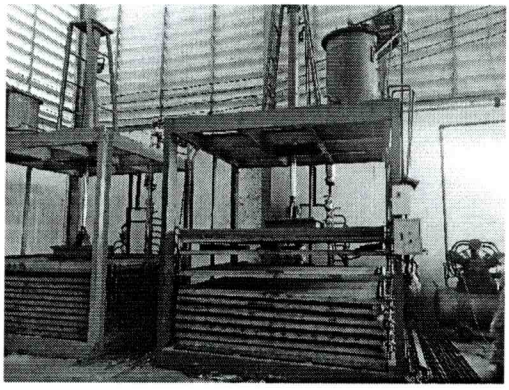

Figure 7 Hot press molding machine

9) Digital weight scale.
10) Universal testing machine (UTM).
11) Density testing apparatus.
12) Water absorption testing apparatus.
13) Thermal conductivity testing apparatus.
14) Sound insulation testing apparatus including:

14.1) Sound Generator with frequency 125, 250, 500, 1,000, 2,000, and 4,000 Hz.

14.2) Speaker 3 watts with frequency range 125 – 20,000 Hz.

14.3) Sound level meter (brand UNI-T model UT351 error less than 1.5 dB (see Figure 8).

14.4) Soundproof chamber for installing the sound insulation board which sized 3 0 x30x30 centimeter, made from galvanized steel plates, and was filled with foam surrounding the chamber (Abdullah et al., 2014) (see Figure 9).

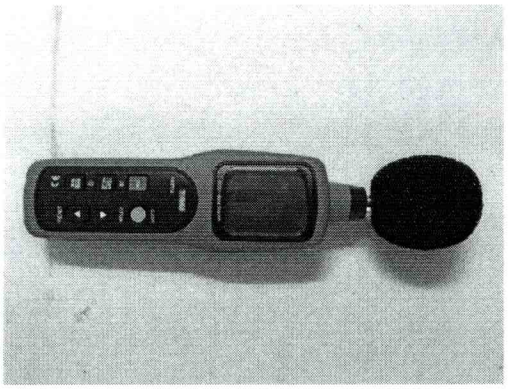

Figure 8 Sound level meter

Figure 9 Soundproof chamber

2.2 Mix Design

Design the 5 mix ratios of indoor acoustic and thermal insulation board from coconut coir and natural latex which included 60 % pre-vulcanized latex and coconut coir as showed in Table 2.

Table 2 The 5 mix ratios of indoor acoustic and thermal insulation board from coconut coir and natural latex by weight.

Ratios	Coconut Coir Dust	Coconut Fiber	Natural Rubber (solid part)
R0.1	0.1	0.9	0.1
R0.15	0.1	0.9	0.15
R0.2	0.1	0.9	0.2
R0.25	0.1	0.9	0.25
R0.3	0.1	0.9	0.3

Remark The amount of natural rubber (solid part) was 60% of natural latex.

2.3 Casting the Samples

1) Weight and separate the coconut coir (see Figure 10).
2) Adjust the ratios of natural latex as showed in Table 2.
3) Weave the coconut coir by using the weaving machine (see Figure 11).
4) Spray the natural latex into the weaved coconut coir sheets (see Figure 12).
5) Cut the weaved and sprayed coconut coir sheets as showed in Figure 13.

6) Overlay the cutted coconut coir sheets (thick 5.7 centimeters) and put them into the hot press molding machine with temperature 150 degree of Celsius and pressure 150 bars around 1 minute as showed in Figure 14 and 15.

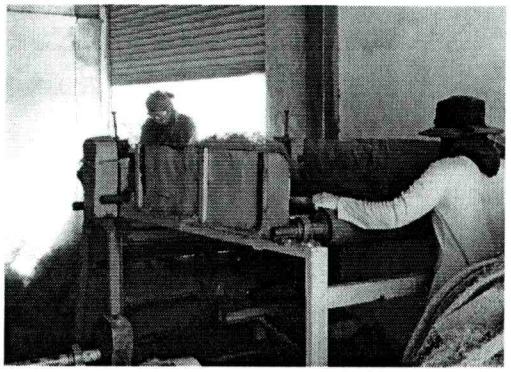

Figure 10 Weight and separate the coconut coir

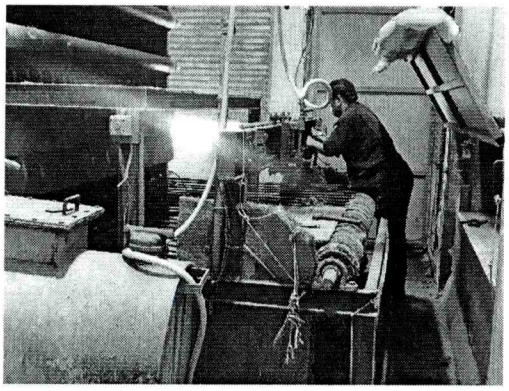

Figure 11 Weave the coconut coir

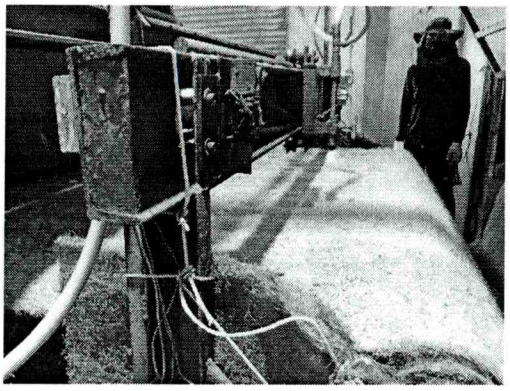

Figure 12 Spray the natural latex into the weaved coconut coir sheet

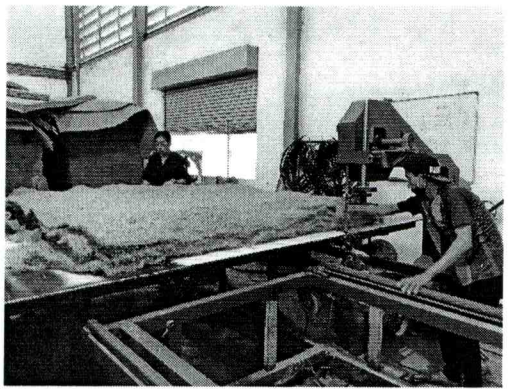

Figure 13 Cut the weaved and sprayed coconut coir sheet

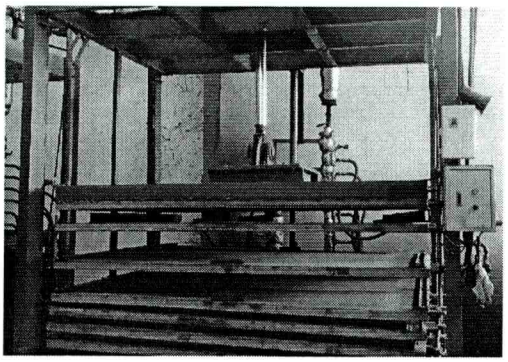

Figure 14 Cast the indoor acoustic and thermal insulation board

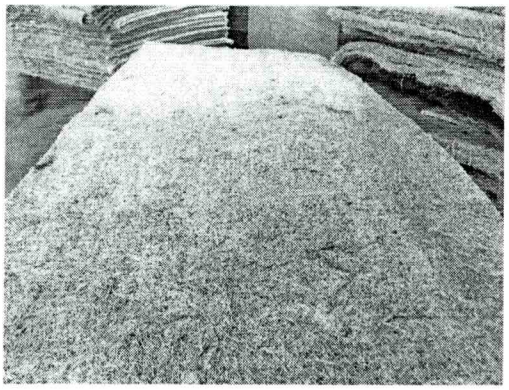

Figure 15 The surface of indoor acoustic and thermal insulation board

2.4 Property Test

Test the properties of physical, mechanical, thermal conductivity, and sound insulation of indoor acoustic and thermal insulation boards from coconut coir and natural latex (5 samples per test per ratio) including: general characteristic test, density (see Figure 16), water absorption, tensile strength (see Figure 17), thermal conductivity, and sound insulation (see Figure 18 to 19).

Figure 16 Density test of the indoor acoustic and thermal insulation board

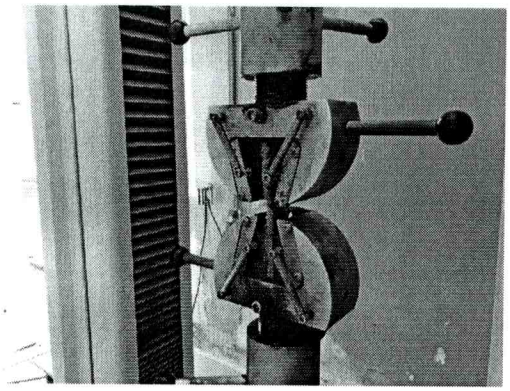

Figure 17 Tensile strength test of the indoor acoustic and thermal insulation board

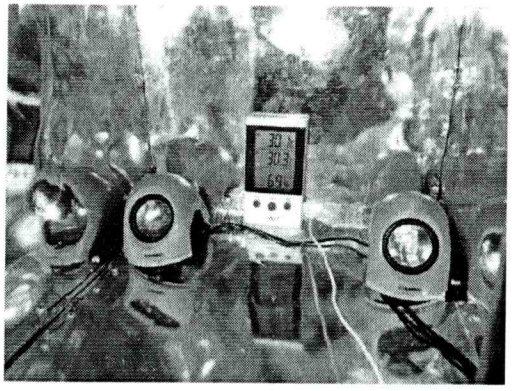

Figure 18 Sound generator in soundproof chamber

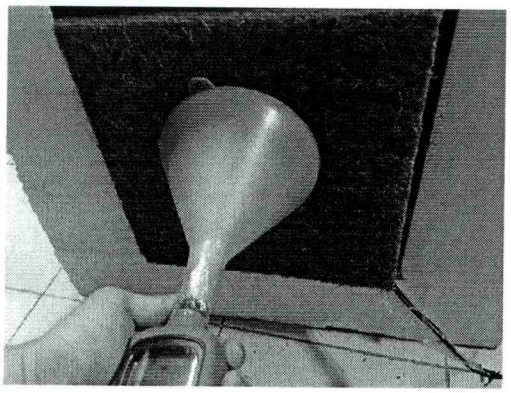

Figure 19 Sound insulation test of the indoor acoustic and thermal insulation board

3. Results and Discussions

The results of physical, mechanical, thermal conductivity, and sound insulation tests of indoor acoustic and thermal insulation boards from coconut coir and natural latex were showed as following:

3.1 General Characteristic

The general characteristics of 5 ratios of indoor acoustic and thermal insulation boards from coconut coir and natural latex were showed in Figure 20 and 21.

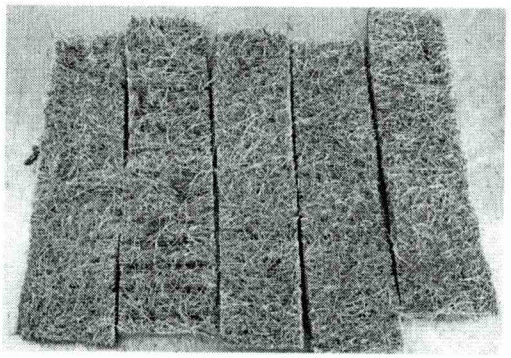

Figure 20 The general characteristics of 5 ratios of indoor acoustic and thermal insulation boards (ratio R0.1 (leftmost) R0.15 (left) R0.2 (middle) R0.25 (right) and R0.3 (rightmost))

Figure 21 The insertion of natural latex in indoor acoustic and thermal insulation board

From Figure 20 and 21, the indoor acoustic and thermal insulation boards from coconut coir and natural latex that the high amount of natural latex will have a more tightly arranged fibers than the low amount of natural latex.

3.2 Density

From the density test, the results of 5 ratios of indoor acoustic and thermal insulation boards from coconut coir and natural latex were showed in Figure 22.

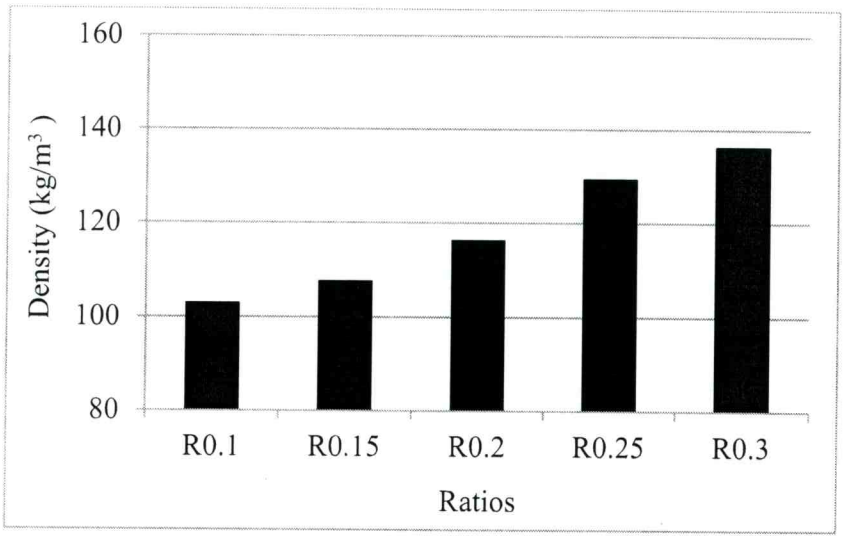

Figure 22 The densities of 5 ratios of indoor acoustic and thermal insulation boards

Figure 22 shows the effect of the amount of natural latex on the density of indoor acoustic and thermal insulation boards from coconut coir and natural latex. The density of indoor acoustic and thermal insulation boards from coconut coir and natural latex ratio R0.3 had the lowest density, followed by R0.25 R0.2, R0.15 and R0.1. The range of indoor acoustic and thermal insulation boards from coconut coir and natural latex were a value between 920 to 1,200 kilograms per cubic meter which density of coconut coir is only 500 to 600 kilograms per cubic meter (Barlow, 1993; Faherty et al., 1995).

3.3 Water Absorption

The water absorption results of 5 ratios of indoor acoustic and thermal insulation boards from coconut coir and natural latex were showed in Figure 23.

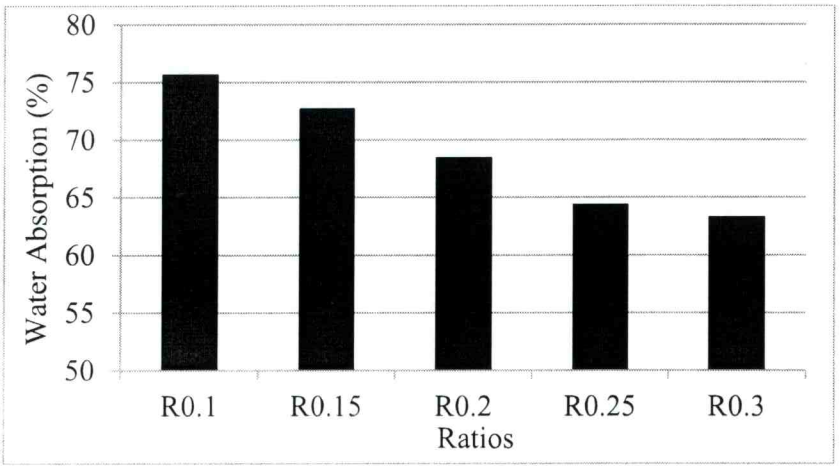

Figure 23 The water absorptions of 5 ratios of indoor acoustic and thermal insulation boards

From the test of water absorption of the indoor acoustic and thermal insulation boards in Figure 23, it is found that the natural latex can reduce the water absorption of indoor acoustic and thermal insulation boards because the natural latex is a waterproof material (Barlow, 1993). These can be seen from the indoor acoustic and thermal insulation board ratio R0.3 that has the lowest water absorption, followed by the R0.25 R0.2 R0.15, and R0.1, respectively.

3.4 Tensile Strength

Figure 24 showed the tensile strength results of 5 ratios of indoor acoustic and thermal insulation boards.

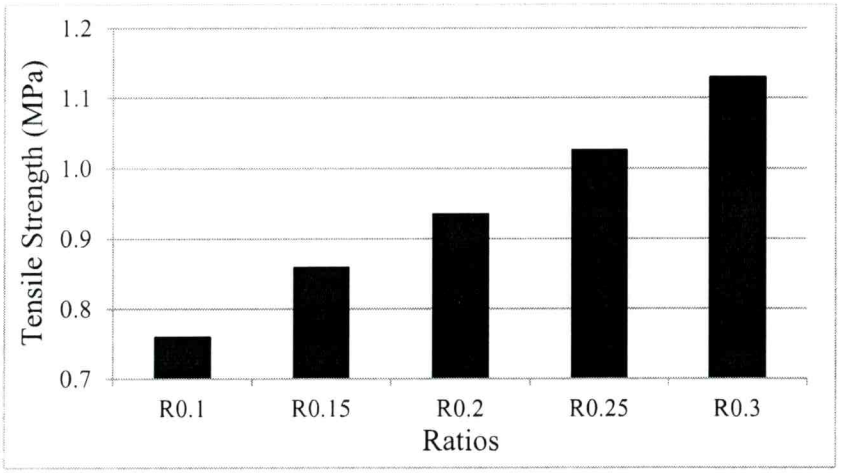

Figure 24 The tensile strengths of 5 ratios of indoor acoustic and thermal insulation boards

According to the test results of the tensile strength of indoor acoustic and thermal insulation boards from coconut coir and natural latex in Figure 24, it is found that natural latex can improve the tensile strength of indoor acoustic and thermal insulation boards. Because of the natural latex is a high tensile strength material (Bledzki and Gassan, 1999) and help the bonding of coconut coir dust and coconut

fiber, so the indoor acoustic and thermal insulation board ratio R0.3 has the highest tensile strength, followed by the R0.25, R0.2, R0.15, and R0.1, respectively.

3.5 Thermal Conductivity

The results of thermal conductivity test of 5 ratios of indoor acoustic and thermal insulation boards were indicated in Figure 25.

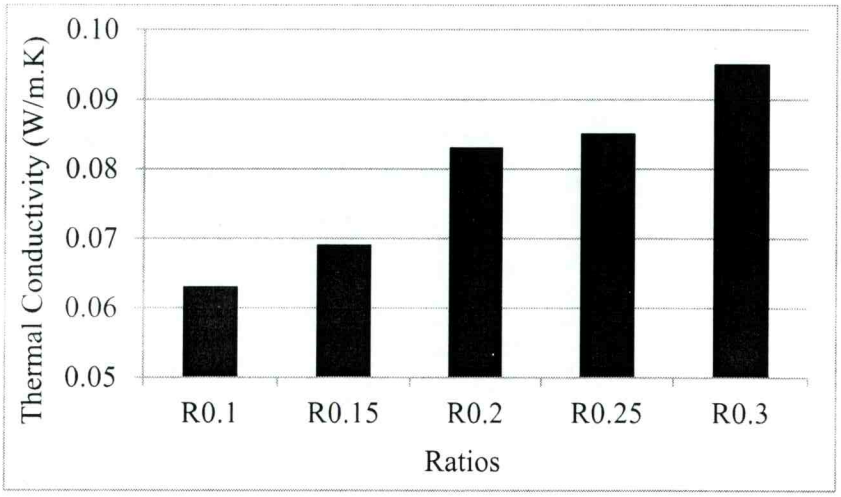

Figure 25 The thermal conductivities of 5 ratios of indoor acoustic and thermal insulation boards

From the Figure 25, the ratio R0.3 was the indoor acoustic and thermal insulation board which has the highest thermal conductivity, followed by R0.25, R0.2, R0.15, and R0.01, respectively. It found that the spraying of natural latex into the indoor acoustic and thermal insulation boards had effect to increase the thermal conductivity. These results were affected from the thermal conductivity coefficient of natural rubber is about 0.15 watts per meter. Kelvin which is higher than the coconut coir dust and coconut fiber with a coefficient of thermal conductivity of about 0.048 watts per meter. Kelvin (Clemens, 2001). The porosity made the coconut coir to have low thermal conductivity coefficient (see Figure 26 and 27).

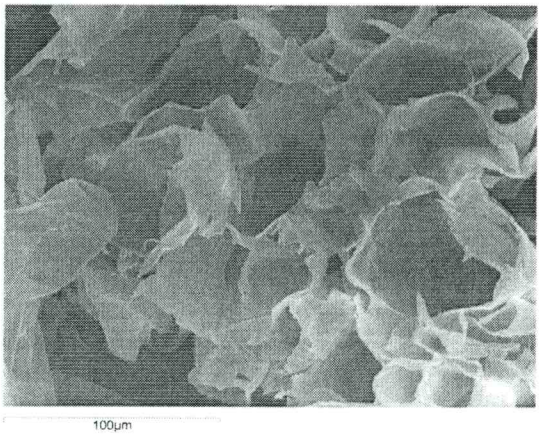

Figure 26 The coconut coir dust from the scanning electron microscope at zoom 500 times

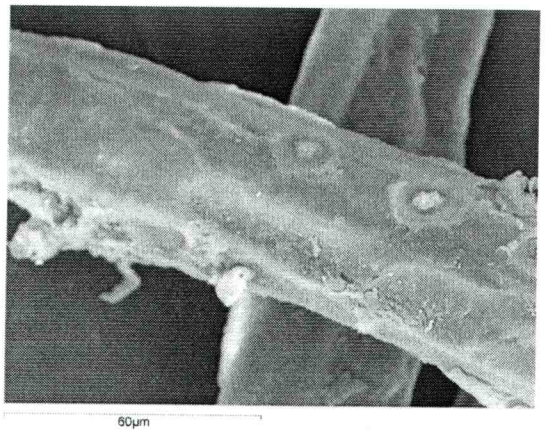

Figure 27 The coconut fiber from the scanning electron microscope at zoom 1,000 times

3.6 Sound Insulation

From the tests of sound insulation or sound insulation efficiency of the indoor acoustic and thermal insulation boards at frequency 125, 250, 500, 1,000, 2,000, and 4,000 Hz, it can show the results in Figure 28 to 29.

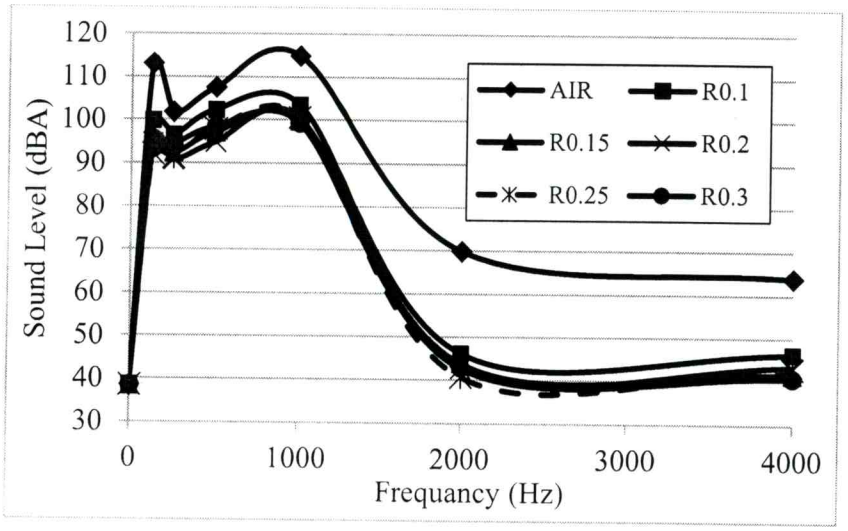

Figure 28 The sound insulations of 5 ratios of indoor acoustic and thermal insulation boards

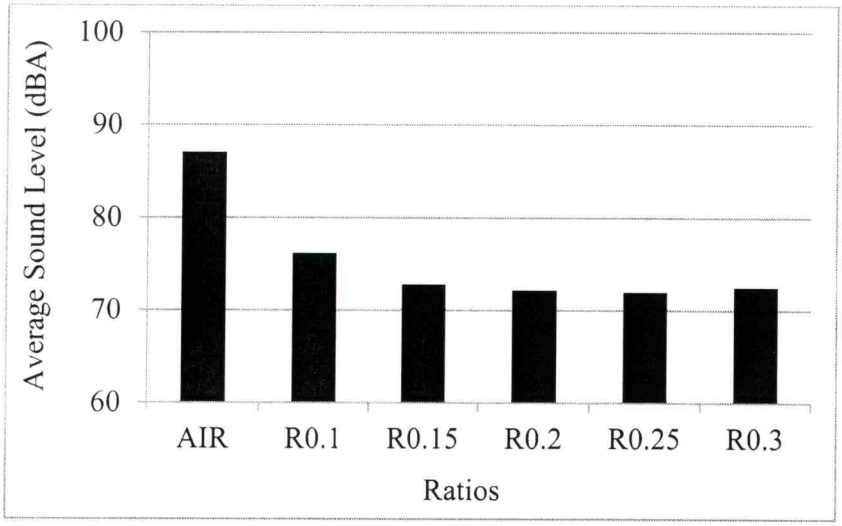

Figure 29 The average sound insulations of 5 ratios of indoor acoustic and thermal insulation boards

From the Figure 28 and 29, it is found that the natural latex can improve the sound insulation of indoor acoustic and thermal insulation boards (David, 1988). The ratio R0.3 is the indoor acoustic and thermal insulation board which has the highest sound insulation, followed by R0.25, R0.2, R0.15, and R0.01, respectively. The improving sound insulation of indoor acoustic and thermal insulation boards were cause by the porous and sound absorbing from coconut coir and natural rubber (Michel, 1933; William and Joseph, 1998).

4. Conclusion

From the development of indoor acoustic and thermal insulation boards from coconut coir and natural latex, it can be summarized as follows:

1) indoor acoustic and thermal insulation boards from coconut coir and natural latex can be casted by using the hot press molding machine with temperature 150 degree of Celsius and pressure 150 bars.

2) The optimum mixing ratio of indoor acoustic and thermal insulation boards from coconut coir and natural latex is ratio R0.15 (coconut coir dust: coconut fiber: natural rubber (solid part) equal to 0.1: 0.9: 0.15 by weight). This ratio used a few of natural latex but has good sound and heat protection properties.

3) The spraying of natural latex into the indoor acoustic and thermal insulation boards from coconut coir that can reduce the water absorption property and increase the tensile strength and sound insulation. However, the high amount of natural latex was affected to increase the density and thermal conductivity coefficient.

4) The developed indoor acoustic and thermal insulation boards from coconut coir and natural latex can be installed in the wall as well as in general insulating panels in the market.

5. Acknowledgement

The authors are grateful to the Rajamangala University of Technology Phra Nakhon for financially supporting this research.

REFERENCES

Abdullah Keyvani, Sasan Somi, and Özgür Eren, 2014. Humidity intrusion effects on the properties of sound acoustic of autoclaved aerated concrete. *International Journal of Research in Engineering and Technology*, 3(2), 6 – 11.

Asasutjarit, C., Hirunlabh, J., Khedari, J., Charoenvai, S., Zeghmati, B., & Shin, U. C., 2007. Development of coconut coir-based lightweight cement board. *Construction and Building Materials*, 21(2), 277–288.

Barlow, Fred W., 1993. *Rubber Compounding: Principles, Materials, and Techniques*. 2nd Edition. London: CRC Press.

Bledzki, A.K. and Gassan, J., 1999. Composites Reinforced with Cellulose based Fibers. *Progress in Polymer Science*, 24, 221-274.

Clemens J. M. Lasance, 2001. *Design, Materials, Compounds, Adhesives, and Substrates* [Online]. Available on: https://www.electronics-cooling.com/2001/11/the-thermal-conductivity-of-rubbers-elastomers/#.

David M. Egan, 1988. *Architectural Acoustics*. New York: McGraw-Hill, Inc.

Department of Agriculture Extension, 2016. *Monthly Report of Plant Production in District Scale*. Bangkok: Information Technology and Communication Center, Department of Agriculture Extension.

Faherty, Keith F. and Williamson, Thomas G., 1995. *Wood Engineering and Construction Handbook*. Second Edition. New York: McGraw-Hill, Inc.

Food and Agriculture Organization of the United Nations (FAO). 2011. Natural Fibers: Coir, *International Year of Natural Fibers 2009*. Retrieved December 1, 2011.

James Cowan, 2000. *Architectural Acoustics Design Guide*. New York, McGraw-Hill.

Michel Barron, 1933. *Auditorium Acoustics and Architectural Design*. London: E&FN Spon, and imprint of Chapman & Hall.

Rubber Authority of Thailand, 2019. *A Summary of year 3/2019 and 4/2019 pricing trends of natural latex in Thailand* [Online]. Available on: http://www.rubber.co.th/ewt_dl_link.php?nid=6499&filename=index.

William J. Cabanaugh and Joseph A. Wikes, 1998. *Architectural Acoustics: Principles and Practice*, New York: John Wiley&Sons.