A Narrowing Analysis on Sound Loss during Transmission on Perforated Natural Fiber Panels

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Abstract

Sound transmission misfortune (STL) is a learn about the sound energy that is kept from communicating through a wall or a parcel, it is fundamental, particularly for clamor protection applications. The principal point of this study is to explore and dissect the STL ability of punctured normal fiber sandwich boards, which went about as sound protection material. The target of this study is to decide the impact of hole width of the punctured board on STL, as well as to decide the ideal hybridization blend sandwich board of punctured board with normal fiber that conveys great STL. In this review, STL estimation was done by utilizing a two-load impedance tube strategy combined with LMS Test Lab programming and LMS SCADAS Mobile DAQ framework. Normal filaments utilized in this study are coconut fiber, oil palm fiber, and pineapple leaf fiber. The normal filaments were ready in round and hollow shapes with three unique thicknesses of 1 cm, 2 cm, and 3 cm to squeeze into the example holder of the impedance tube. Every regular fiber will be tried after it was hybridized with a punctured board of various hole breadth sizes and the STL estimation results are gotten and investigated. The estimation results show all examples had reached their most noteworthy STL at the recurrence range 3000 Hz to 4000 Hz. Furthermore, pineapple leaf fiber hybridized with a punctured board of 3 mm's whole breadth is viewed as the ideal blend where it accomplished the most noteworthy STL of 71.80 dB among all the test tests.

Keywords: Sound loss, Sound transmission misfortune, natural fiber,impedance tube, punctured board

1. Introduction

Sound is a wave that is delivered through the vibration of an item. It is sent as a wave where it could reflect or refract very much like the other type of wave. Sound transmission misfortune (STL) is tremendously connected with the sound decrease where high STL boards will have the more noteworthy capacity to lessen the commotion created from going through the boards. A normal strategy used to gauge the STL of a sound protection material is the two rooms technique, likewise, known as the resonation room strategy [1]. Impedance tube is one more typical technique used to learn about acoustic execution particularly on the STL of a sound spongy material in the past examinations [1]-[4].

In sound controlling applications, punctured boards are generally utilized in controlling the commotion from a sound source. The holes on the boards are ready to lessen the surface volume speed of a vibrating structure and the primary commotion radiation [5]. For a punctured board, the thickness, hole size, and hole porosity will influence the STL. Vincent Phong and DimitriPapamoschou examined the sound reaction of the punctured board when the sound wave is opposite to the board [6]. The punctured board contemplated is either metal or steel with fluctuating hole size, porosity, and thickness. The trial result is matched to the hypothetical assumption and the result showed that hole size influences the STL of the board essentially by contrasting with different boundaries, like thickness or porosity of the board. In this way, it is accepted that punctured boards with various holes breadth sizes and examples will convey assorted results and improvements on the STL.

Normal fiber is a sort of material that performs well on sound ingestion and protection [7]-[9]. They primarily come from plants and creatures while it was arranged by how and where it is being removed. Kenaf fiber, coconut fiber, bamboo fiber, and oil palm fiber are the regular strands that are inexhaustible, low-estimated, eco-accommodating, and decomposable. Simultaneously, normal fiber likewise can be acquired from farming side-effects, for example, rice straw fiber, coconut coir fiber, pineapple leaf fiber, and oil palm mesocarp fiber. A portion of the acoustic exhibition concentrates on normal fiber had been directed and observed that it can give a promising acoustic presentation [10,11]. Other than this, regular fiber can supplant the engineered fiber because of the reality that manufactured fiber produces destructive residue particles, making serious adverse consequences for our well-being like a cellular breakdown in the lungs after an extensive stretch of openness. Consequently, normal fiber is viewed as generally protected and climate agreeable contrasted and engineered fiber [9].

In this review, sound transmission misfortune (STL) of punctured normal fiber sandwich boards is examined and dissected. The sandwich boards are produced using a punctured board combined with normal fiber. Agribusiness side-effects fiber, for example, coconut fiber, oil palm fiber, and pineapple leaf fiber are viewed in this review. Normally, the impact of hole width size on STL is not entirely settled and an ideal blend of punctured regular fiber sandwich board can be gotten. By hybridizing punctured boards with regular fiber, it is accepted that the STL execution will be additionally improved and upgraded.

2. Experimental Material and Methodology

2.1. Material

In this review, normal strands were ready in the free structure. The regular strands were created into 3 distinct thicknesses, which are 1 cm, 2 cm, and 3 cm. It was weighted in 0.5 g, 1 g, and 1.5 g regarding the thickness of 1 cm, 2 cm, and 3 cm test arrangement. There are 3 sorts of regular fiber were utilized, incorporate coconut fiber, oil palm fiber, and pineapple leaf fiber which are displayed in Figure 1, Figure 2, and Figure 3 separately. The example was manufactured utilizing an independent trim instrument. It comprises of a wooden base, 3 cm inward width PVC pipe form, and a little G-cinch. The 3 cm inward distance across the size of PVC pipe form was utilized as its size equivalents to the width of the impedance tube to guarantee the created tests were well-fitted into the impedance tube during the STL test as displayed in Figure 4. For the example readiness, regular fiber was first weighted to guarantee the mass inside the control, trailed by embedding it into the form to shape it as a round and hollow state of test. The state of the test is then gotten by utilizing a holding splash on it.

Figure 1: A sample of fiber found through coconut

Figure 2: A sample of fiber found through palm oil

Figure 3: Sample of pineapple leaffiber

Figure 4: Pineapple leaf fiberembedded in the example holder.

For penetrated board, it is fabricated using the material of aluminum which is easily obtained from any gear vendor watching out. The thickness of the aluminum board is 0.2 mm and it was cut into a square condition of 40 mm x 40 mm before the opening is made. The openings were drilled by power hand drill according to the arranged opening as shown in Figure 5. In this survey, there are 2 opening estimation sizes considered, which are 3 mm and 4.5 mm. The made penetrated sheets are shown in Figure 6(a) and Figure 6(b) independently.

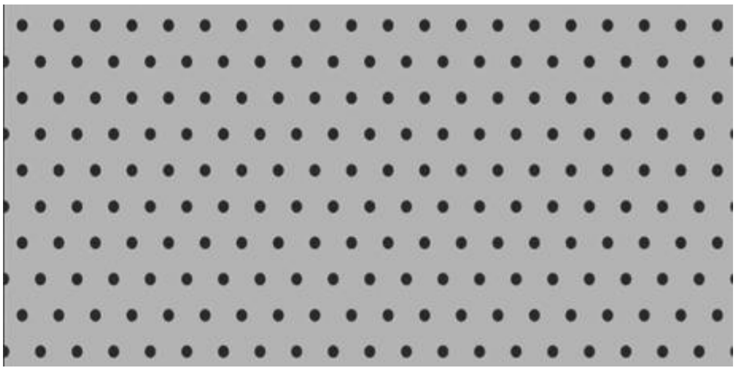
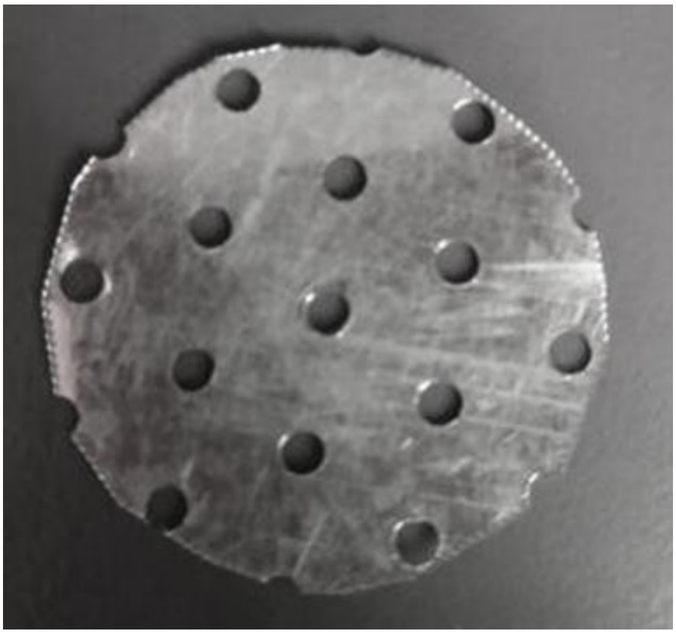
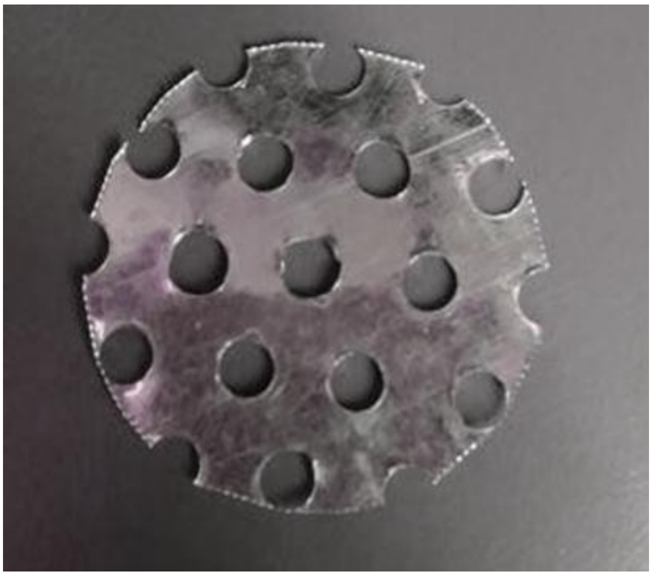


Figure 5: 60-degree staggered hole



(a) 3 mm hole width,



(b) 4.5 mm hole measurement

Figure 6: Perforated board

Load balancing and transfer functions

The strategy used to gauge the sound transmission misfortune (STL) for this study is the two burden move capability technique (TFM) as displayed in Figure 7. It is viewed as a generally basic and simple strategy as STL estimation just includes exchanging the end cap of the impedance tube to get an unbending and anechoic end. The sound tension level of the sound waves inside the impedance tube is estimated by the mounted receivers. From that point forward, DAQ combined with post-handling investigation programming is utilized to decide the STL of estimated tests.

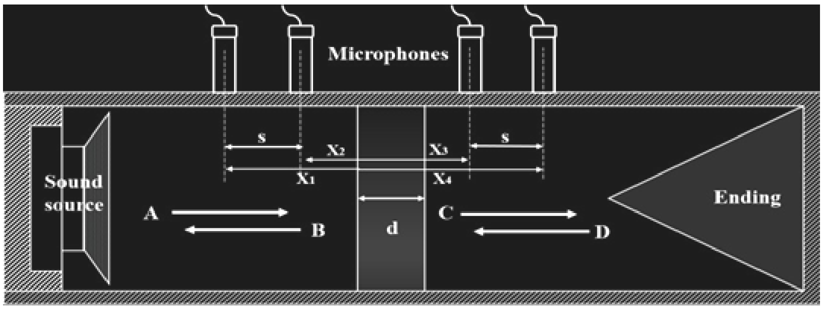


Figure 7: Schematic outline of two burden move capability strategies for impedance tubes [3].

For the two burden move capability strategy, there are 2 wave parts both upstream and downstream of the impedance tube. By alluding to Figure 7, An addresses the episode wave part from the sound source while C is the sent wave part. In the interim, B and D are the reflected wave parts. These four-wave parts are utilized to process the sound tensions in the impedance tube as displayed in Equation (1) - Equation (4).

$$P_1 = Ae^{j(\omega t - kx_1)} + Be^{j(\omega t - kx_1)} \quad (1)$$

$$P_2 = Ae^{j(\omega t - kx_2)} + Be^{j(\omega t - kx_2)} \quad (2)$$

$$P_3 = Ce^{j(\omega t - kx_3)} + De^{j(\omega t - kx_3)} \quad (3)$$

$$P_4 = Ce^{j(\omega t - kx_4)} + De^{j(\omega t - kx_4)} \quad (4)$$

where k is the wave number.

By settling Equation (1) to Equation (4), the accompanying Equation (5) to Equation (8) are gotten.

$$A = \frac{j(P_1 e^{jk\,x_2} - P_2 e^{jk\,x_1})}{2\sin k\,(x_1 - x_2)} \quad (5)$$

$$B = \frac{j(P_2 e^{-jk\,x_1} - P_1 e^{-jk\,x_2})}{2\sin k\,(x_1 - x_2)} \quad (6)$$

$$C = \frac{j(P_3 e^{jk\,x_4} - P_4 e^{jk\,x_3})}{2\sin k\,(x_3 - x_4)} \quad (7)$$

$$D = \frac{j(P_4 e^{-jk\,x_3} - P_3 e^{-jk\,x_4})}{2\sin k\,(x_3 - x_4)} \quad (8)$$

Finally, sound transmission misfortune (STL) can be acquired by utilizing the articulations underneath:

$$\begin{Bmatrix} A \\ B \end{Bmatrix} = \begin{bmatrix} \alpha & \beta \\ \gamma & \delta \end{bmatrix} \begin{Bmatrix} C \\ D \end{Bmatrix} \quad (9)$$

$$STL = -20\log(\|\alpha\|) \quad (10)$$

where α is the sound transmission misfortune coefficient. The sound transmission misfortune (STL) is gotten through the computation will be in the unit of decibels (dB).

Loss of sound during transmission setup

In this review, the impedance tube was worked for two burden move capability strategy sound transmission misfortune (STL) estimation as per ASTM E2611 [12]. As a rule, there are 2 mouthpieces each at the upstream and the downstream of the cylinder. The spine in the tube (test holder) is utilized to hold the test, upstream and downstream of the cylinder. The impedance tube was put on a holder immovably while leading the estimation. Figure 8 shows the impedance tube utilized for estimating STL in this review.

Figure 9 shows the STL estimation arrangement in the lab. Essentially, the STL estimation arrangement comprises LMS SCADAS Mobile DAQ, impedance tube with amplifiers, PC with post-handling programming, and sound source. Before directing the estimation, every one of the receivers was adjusted utilizing a sound level calibrator to guarantee its exactness of estimation. Then, at that point, the test was set into the example holder of the impedance tube as displayed in Figure 4. STL estimation possibly will be begun when all the setting is very much set.

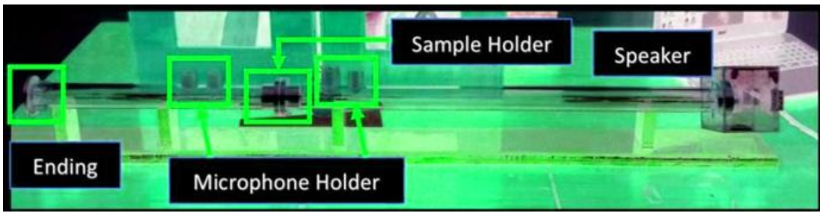


Figure 8: Impedance tube utilized for STL estimation

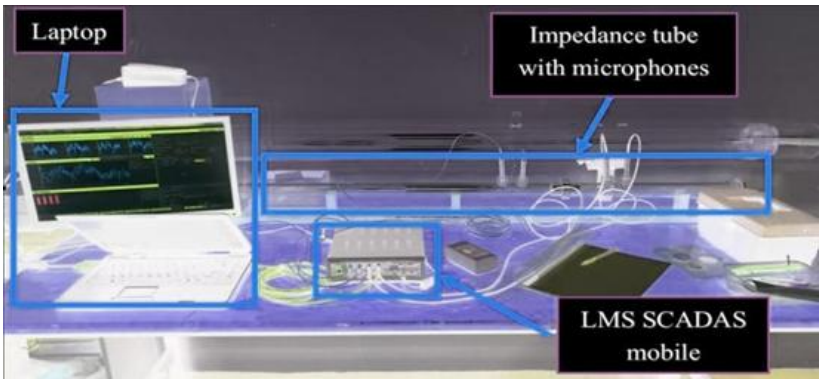


Figure 9: Apparatus set up for the estimation of sound transmission misfortune

Result and Discussion

The gathered information from sound transmission misfortune (STL) estimation is broken down in light of the impact of hole width size and the impact of hybridization of the punctured board with normal fiber. Figure 10 shows the correlation of the STL of the punctured board with various hole widths.

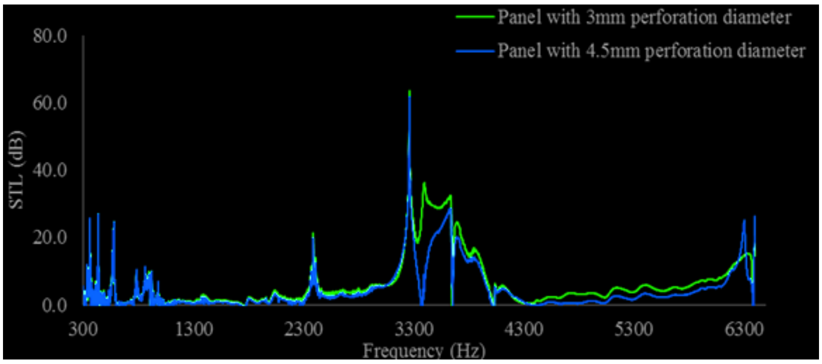


Figure 10: Sound transmission loss of punctured board with various hole breadth sizes.

As indicated in Figure 10, the STL results show the two boards having variances at recurrence under 1000 Hz and afterward go consistently until recurrence 2300 Hz. For the recurrence of 3260 Hz, the two boards have the most noteworthy worth of STL, which are 63.61 dB and 61.66 dB for the boards with hole breadths sizes of 3 mm and 4.5 mm individually. The test is rehashed two times to affirm the outcome stayed indistinguishable and repeatable. Given the estimation, it is seen that the STL of the punctured board is exceptionally dependent on the hole proportion where STL will be diminished as the hole proportion is expanding because the resistive power in the openings is being decreased. In this manner, just 3 mm's hole width size of the punctured board will be considered for hybridization with regular strands in the accompanying outcome and conversation area.

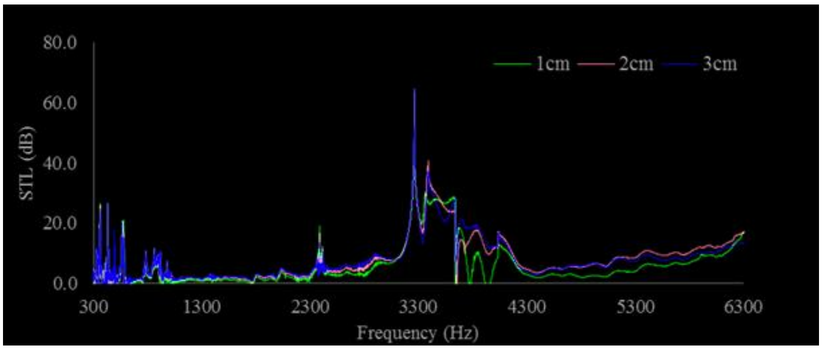


Figure 11: 3 mm's hole width punctured board with various thicknesses of coconut fiber.

Figure 11 shows the STL estimation results for 3 mm's hole breadth punctured board hybridized with various thicknesses of coconut fiber. The outcome shows that the STL of the examples are expanded slowly from 1000 Hz to 3148.44 Hz where a test with 3 cm's thick coconut fiber drives the other two. The pinnacle of STL for all examples is dropped at 3260.94 Hz. For the recurrence range 3300 Hz to 4300 Hz, each example shows STL fluctuating and diminished to 10 dB and lower. Among all, found examples with 3 cm's thickness of coconut fiber give the best STL results, which is 64.71 dB. Thusly, this shows that the example with thicker coconut fiber will convey higher STL.

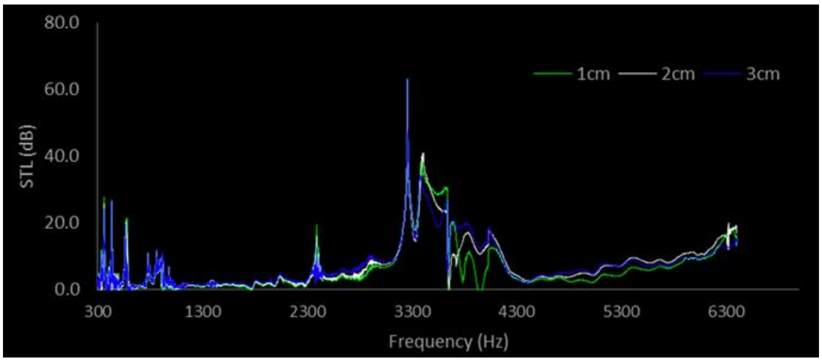


Figure 12: 3 mm's hole measurement punctured board with various thicknesses of oil palm fiber.

The STL estimation results for 3 mm's hole breadth punctured board hybridized with various thicknesses of oil palm fiber are portrayed in Figure 12. The outcome shows that the STL of the examples expanded steadily from 1000 Hz to 3131.25 Hz. The pinnacle of STL is viewed as dropped at 3260.94 Hz for every one of the examples, while the test with 3 cm's thickness of oil palm fiber is recorded as 63.33 dB and it is the most noteworthy STL contrasted and different examples. Each example shows STL is fluctuating and diminished to 10 dB and lower for the recurrence range 3300 Hz to 4300 Hz. Once more, the peculiarity of the test with thicker oil palm fiber will convey higher STL which is comparable to the perception for coconut fiber.

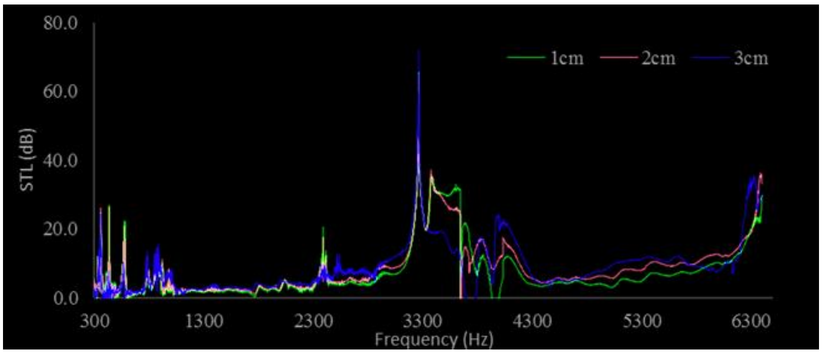


Figure 13: 3 mm's hole distance across the punctured board with various thicknesses of pineapple leaf fiber.

Figure 13 shows the STL estimation of 3 mm's hole measurement punctured board with 1 cm, 2 cm, and 3 cm thickness of pineapple leaf fiber. As per Figure 13, STL for all examples is expanded step by step from 1000 Hz up to the pinnacle STL at 3260 Hz. All examples come to the most noteworthy STL of 65.45 dB, 65.05 dB, and 71.80 dB for the pineapple leaf fiber thickness of 1 cm, 2 cm, and 3 cm individually. For the recurrence range 2300 Hz - 3300 Hz, the example with 1 cm's thick pineapple leaf fiber performs lower top STL, which is recorded as 20.51 dB at 2389.06 Hz, while the example of 2 cm's thick pineapple leaf fiber shows 17.50 dB of STL. Notwithstanding, the STL of the test with 3 cm's thick pineapple leaf fiber dips under 10 dB for the recurrence of 3266 Hz, while the others are as yet having one more top at 3373.44 Hz. By and large, the example with 3 cm's thick pineapple leaf fiber gives generally high STL over the recurrence range 300 Hz to 6300 Hz and its most elevated STL is recorded as 71.80 Hz.

Conclusion

In this research paper, the sound transmission misfortune (STL) of punctured board hybridized with regular fiber has been introduced. Given the estimation and examination, the punctured board with a 3 cm hole measurement size accomplishes the most elevated STL of 63.61 dB for the recurrence of 3260 Hz. Its STL is higher than a punctured board with a 4.5 cm hole distance across the size. This finding demonstrates that the sound energy can go through the board with lesser difficulty as the hole distance across size on the board is getting greater. 3 cm's hole width punctured board hybridized with pineapple leaf fiber is viewed as an ideal punctured normal fiber sandwich board, which gives the best STL of 71.8 dB in this review.

References

[1] ASTM, A. (2009). E2611-09: Standard Test Method for Measurement of Normal Incidence Sound Transmission of Acoustical Materials Based on the Transfer Matrix Method. ASTM International, West Conshohocken, PA, USA.

[2] Barnard, A. R., &Rao, M. D. (2004). Measurement of sound transmission loss using a modified four microphone impedance tube. Proceedings of the ASME Noise Control and Acoustics Division (Noise-Con’04).

[3] Ho, K. M., Yang, Z., Zhang, X. X., & Sheng, P. (2005). Measurements of sound transmission through panels of locally resonant materials between impedance tubes. Applied acoustics, 66(7), 751-765.

[4] Jung, S. S., Kim, Y. T., Lee, Y. B., Cho, S. I., & Lee, J. K. (2008). Measurement of sound transmission loss by using impedance tubes. Journal of the Korean Physical Society, 53(2), 596-600.

[5] Niresh, J., Archana, N., Karthink, T., & Hong, T. W. (2019). Physical, Chemical, Morphological and Thermal Characterization of Natural Fibers for Sound Absorption. Textile and Apparel, 29(3), 219-227.

[6] Nor, M. J. M., Jamaludin, N., &Tamiri, F. M. (2004). A preliminary study of sound absorption using multi-layer coconut coir fibers. Electronic Journal Technical Acoustics, 3, 1-8.

[7] Phong, V., &Papamoschou, D. (2012). Acoustic transmission loss of perforated plates. In 18th AIAA/CEAS Aeroacoustics Conference (33rd AIAA Aeroacoustics Conference) (p. 2071).

[8] Putra, A., & Ismail, A. Y. (2014). Normal incidence of sound transmission loss from perforated plates with micro and macro size holes. Advances in Acoustics and Vibration, 2014.

[9] Tan, W. H., Lim, E. A., Chuah, H. G., Cheng, E. M., & Lam, C. K. (2016). Sound transmission loss of natural fiber panel. International Journal of Mechanical & Mechatronics Engineering, 16(6), 33-42.

[10] Yahya, M. N., & Chin, D. D. V. S. (2017, August). A review on the potential of natural fibre for sound absorption application. In IOP conference series: materials science and engineering (Vol. 226, No. 1, p. 012014). IOP Publishing.

[11] Yousefzadeh, B., Mahjoob, M., Mohammadi, N., &Shahsavari, A. (2008). An experimental study of sound transmission loss (STL) measurement techniques using an impedance tube. Journal of the Acoustical Society of America, 123(5), 3119.

[12] Zunaidi, N. H., Tan, W. H., Majid, M. S. A., & Lim, E. A. (2017, October). Effect of physical properties of natural fibre on the sound absorption coefficient. In Journal of Physics: Conference Series (Vol. 908, No. 1, p. 012023). IOP Publishing.