Coconut Leaf Sheath fibers as a Sound Absorption Board

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Abstract*–Coconut fiber is a better replacement to wood for it is inexpensive, it helps prohibit deforestation, and it can be an extra source of income for agricultural farmers. This paper investigates the effectiveness of coconut leaf sheath fiber as a potential sound absorbing material that incorporates less environmental impacts. Coconut leaf sheath fiber with urea formaldehyde as a binder was fabricated into a sound absorption board. Low and Mid density boards were produced with varying resin content which are 15%, 20%, and 25%. Sound absorption coefficient of each sample shows a satisfying result and among all the samples, M25 exhibits the best sound absorption coefficient of 0.95 at 3092 Hz. Thus, CLSF boards are feasible alternatives for synthetic sound absorption materials

Keywords-- Coconut leaf sheath fiber, Urea Formaldehyde, water absorption, density, thickness swelling, internal bond strength, face screw holding, modulus of rupture, sound absorption coefficient

I. INTRODUCTION

Sound absorption is used in residential, commercial and any structural building as a form of treatment to walls, ceilings and other surfaces and objects. It is more often used in auditorium, studio, theater, karaoke, etc. to absorb the unnecessary noise or to prevent noise heard from the inside of the room. According to Park, Lee, Seo, Kang, & Kang, et. al., (2020), the demand for noise absorbing materials in occupational settings is growing, but the existing noise reducing materials used for the ceilings and walls have been economically unviable and costly.

According to National Geographic Society (2022), noise pollution is an unseen threat that is not visible but exists anywhere. On a daily basis, millions of people are affected by noise pollution. The most prevalent health hazard it produces is Noise Induced Hearing Loss (NIHL). Loud noise could also lead to hypertension, cardiovascular disease, sleep disturbances, and stress. Sujatmika, et. al., (2017), stated that humans consider noise to be an annoyance, and it can be present in the surroundings, creating discomfort. This is also true of the design process, which tends to encourage noise transmission. The usage of materials to absorb sounds has been widely employed as a solution.

Synthetic fibers including mineral wool and fiberglass are commonly employed as sound absorbers in the construction industry, but their harmful environmental consequences have been discovered (Taiwo, et. al., 2019). As stated by Yang, et. al., (2020), synthetic fibers are typically created using high - temperature production processes, and synthetic fibers are frequently derived from petrochemical industries, resulting in a significant amount of emissions footprint. Therefore, one of the effective means of reducing this environmental problem is by using natural fibers for sound absorption boards. According to Girijappa, et. al., (2019), natural fibers are sustainable materials that are abundant in nature. Low- cost, lightweight, renewability, biodegradability, and strong specific characteristics are only a few of the benefits.

Also, due to natural fibers' low impact on the environment and public health, and its mechanical and sound absorbing characteristics, it is becoming an engaging candidate to be used in a variety of applications (Lee, Ng, Rammohan, & Tran, et. al., 2017). Therefore, this study aims to collect data on the physical, mechanical, and acoustic properties of the coconut leaf sheath fiber.

II. DATA AND RESULTS

A. *Physical Properties*

1) Density Test: Density test is necessary to consider when producing sound absorption boards because density has a major impact on the sound absorption coefficient and vice versa. The density of the specimens is shown in the table below.

TABLE I
DENSITY OF CLSF BOARDS

Appearance		
Regular	Low Density Board	Medium Density Board
Mass of board	500 g	606 g
Volume	1080 cm^3	1080cm^3
Density	0.468g/cm^3	0.561^3

Table 1 shows the results of the density of the CLSF sound absorption board. There are two variables for density which are low-density board and medium-density board. The volume of low-density and medium-density boards were both 1080 cm3 since the produced samples have the same length, width, and thickness. Mass of the board differs depending on

the density, for a low-density board, 505 g was obtained with a density value of 0.468 g/cm3 while on the medium-density board was 606 g with a density value of 0.561 g/cm3 . Density affects physical, mechanical and acoustic properties. According to Garcia M., et. al., (2020), density is directly proportional to MOE and MOR while the thickness swelling is indirectly proportional to density. Moreover, large density or medium-density boards creates small voids or spaces between particles in the board which is an advantage given an absorbed high- frequency sound to the board with intensifying flow resistance can lead to a good result to the properties of the board (Yang T., Hu L., Petru M., et. al., 2020) while in a less dense board, SAC improves at low frequency sound (Sakthivel, S., et al., 2021). Furthermore, application and purpose differ depending on what type of density is used

2) Water Absorption Test: The water absorption of the samples was tested in accordance with ASTM D1037 - Standard Test Methods for Evaluating Properties of Wood-Base Fiber and Particle Panel Materials. The samples were submerged in water for 24 hours and the weight of the samples was recorded before and after the submersion.

TABLE 2
WATER ABSORPTION TEST OF LOW-DENSITY BOARD

Samples	Initial Weight (g)	Final Weight (g)	Waier Absorption (%)	Average Waier Absorption (%)
L15	12.81	32.28	151.99	128.08
	11.61	25.07	116.12	
	11.60	25.07	116.12	
L20	12.72	33.04	159.75	166.92
	11.57	33.39	188.59	
	10.51	26.53	152.43	
L25	12.87	33.84	162.94	145.78
	10.66	27.54	158.35	
	11.03	23.83	116.5	

The computed water absorption percentage for low density boards is shown in table 4.2. The water absorption percentage for the L15 board for 3 trials was 151.99%, 116.12%, and 116.12%. For the L20 board, the 3 trials were 159.75%, 188.59%, and 152.43%. Lastly, for the L25 board the 3 trials were 162.94%, 158.35%, and 116.05%.

TABLE 3
WATER ABSORPTION TEST OF MEDIUM-DENSITY BOARD

Samples	Initial Weight (g)	Final Weight (g)	Waier Absorption (%)	Average Waier Absorption (%)
M15	19.07	44.05	130.99	138.57
	16.67	42.82	156.87	
	16.80	38.28	127.86	
M20	19.39	33.04	110.47	114.01
	17.24	40.81	127.78	
	17.24	39.27	103.77	
M25	18.70	38.68	106.84	117.50
	16.78	37.70	124.67	
	16.93	37.41	120.97	

The computed water absorption percentage for low-density boards is shown in table 4.3. The water absorption percentage for the M15 board for 3 trials was 130.99%, 156.87%, and 127.86%. For the M20 board, the 3 trials were 110.47%, 127.78%, and 103.77%. Lastly, for the M25 board the 3 trials were 106.84%, 124.67%, and 120.97%.

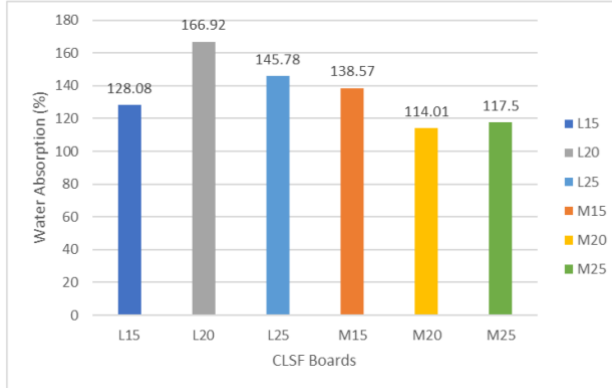

Fig. 1 Average Water Absorption Percentage of Each Samples

Based on figure 1, the average water absorption percentage for each sample was 128.08%, 166.92%, 145.78%, 138.57%, 114.01%, and 117.50% for L15, L20, and L25, M15, M20, and M25, respectively. According to Poddar, et al., (2018), the hydrophilic nature of the fibers affects its water absorption capacity. The CLSF contains about 70% cellulose and 28% lignin, the cellulose structure of the CLSF has a lot of hydroxyl groups (-OH) which is responsible for its strong hydrophilic nature. This material will only be applicable for dry place condition and indoor applications e.g., interior design.

III. CONCLUSIONS

The density of the specimens is shown in the table below. The increase in resin content improves the physical and mechanical properties of the coconut leaf sheath fiber board. The variation in the density of boards affects the SAC values. The results of SAC from mid density boards are better than low density boards. Therefore, as the amount of CLSF increases the better the sound absorbing capacity of the sample. The resin content and internal bond are directly proportional to each other. Moreover, increasing the resin content improves the properties for thickness swelling. As shown in the results, the higher the resin content, the lower thickness swelling obtained. In this case, increasing resin content improves the internal bond and thickness swelling of the board

REFERENCES

[1] Alengaram, U. J. (2022a). Enunciation of lightweight and self-compacting concretes using non-conventional materials. Handbook of Sustainable Concrete and Industrial Waste Management, 45–62

[2] Cayanan, N. D., Gozun, S. C., Tongol, E. R., & Bautista, L. G. (2019). Hibla: Acoustic fiber.

[3] Lee, C. H., Khalina, A., Lee, S. H., & Liu, M. (2020). A comprehensive review on bast fibre retting process for optimal performance in fibre-retting process for optimal performance in fibre-reinforced polymer composites. Advances in Materials Science and Engineering, 2020, 1–27.