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Sound Absorption Properties of Oil Palm Empty Fruit Bunch Cement Boards (EFBCB) Based on Outdoor Exposure

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Abstract: Many researchers have been conducted study to optimize the use of natural fibres as sound insulation materials. Due to the problem of major wastes of oil palm, the use of natural fibers including palm oil corp waste fibres for the purpose of building materials have been introduced. Therefore, this study focuses on the effect of outdoor condition towards sound absorption performance of Empty Fruit Bunch Cement Board (EFBCB). Measurement of sound absorption coefficient is done using impedance tube for low and high frequency according to BS EN ISO 10534. There are two type of sample which are control samples and samples that exposed to outdoor within one month. Based on the result for the treated sample under 1 month outdoor exposure has the 0.888 of sound absorption coefficient while sound absorption coefficient control sample was 0.955. Next, untreated sample for 1 month was 0.768 and the sound absorption coefficient was 0.809 for control sample. This research concluded that outdoor exposure condition effect the absorption capabilities of EFBCB.

Keywords: Natural Fibres, EFB Cement Board, Sound Absorption Coefficient

1. Introduction

Nowadays, OPEFB one of waste from oil palm industries that attracted researcher concern on their application as natural fibres in construction. According to Saba et al. (2015) [1], OPEFB became popular because of their abundant, cheap and easily available. OPEFB are used as sustainable building materials because of their high natural cellulose which have demonstrated their potential to achieve high specific strength, stiffness in polymer matrix and stability, resulting in a good green composites product [2]. It has been proven by Ramlee et al. (2020) [3], the main principal chemical component lignocellulosic biomass is cellulose, hemicellulose and lignin with cellulose accounting for the majority of the biomass (40-50%), hemicellulose accounting 20-30% and lignin accounting for only. Furthermore, a few experiments conducted by researcher using chemical treatment with chlorite

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bleaching, alkali treatment and acid hydrolysis has found the cellulose in the OPEFB fibre was around 58.5% in study by Ching & Ng (2014) [4].

In Malaysia, EFB is now recognised as an agricultural waste resource that can be used for construction materials, solid pellets, chemical products, various fibres, particleboard and paper [5]. Ranachowski & Schabowicz (2018) [6] studied the fibre cement board is a versatile, environmentally friendly and commonly used construction material. Due to the demand of the wood industry, a large number of oil palm trees must be replanted [7]. Various research and development operations, both internationally and in Malaysia, are aimed at finding an alternative source and innovatively raw material from natural fibres and the oil palm empty fruit bunch fibre is a remarkable discovery in Malaysia [8]. According Samsudin et al. (2016) [9] that empty fruit bunch from oil palm processing can be used as a sound absorption material for noise control in buildings. Hence, most of building materials development have introduced the use of natural fiber materials for the purpose of indoor of building materials. Therefore, this research will investigate the potential of empty fruit bunch towards on sound absorption from outdoor exposure.

2. Problem Statement

According to Azni et al. (2015) [10], Malaysia produces around 23.2 million tonnes of EFB waste per year cause the government will have to allocate more hectares of land to disposed when it is not utilized. As a way to solve this problem, the waste has been turned into many applications such as OPEFB became soil conditioners and fibreboard. But the use of OPEFB as a soil conditioner is still unpopular and there is still massive amount of waste to be managed [10]. Hence, EFB fibre has been transformed to composite boards for example cement boards by industries [7]. Next, there are many disadvantages of using the synthetic fibre such as fibre glass for sound absorption material such as tumours, lung infection, skin irritation, eye irritation and air pollutant [11] [12]. Therefore, the natural fibre has being proposed to replace the current material for synthetic fibrous material [13].

The natural fibre also has low density and higher porosity compare to the synthetic fibre Yang & Li (2012) [13]. So, the natural fibre such as EFB fibre being proposed to replace the current material and the sound absorption will be tested. For the purposes, several stages must be completed in order for the EFBCB to comply the criteria for its sound properties which is sound absorption coefficient. Nevertheless, the natural fibre faces several challenges, including poor weather resistance, inconsistency properties and fibre to matrix interface compatibility. According to studies, natural fibres exposed to various environments for an extended period show signs of degradation, change in physical properties and a significant loss in mechanical properties [12] [14] [15] [16] [17] [18]. Therefore, this research intended to explore the potential of sound absorption properties of EFBCB especially when exposed to outdoor.

2. Materials and Methods

This study used 16 EFBCB samples, eight of the sample were not exposed under outdoor condition and others eight were exposed under outdoor condition for one month to see the effect on sound absorption properties.

2.1 Materials

The materials preparation for EFBCB include of a specific ratio of Portland cement, EFB fibre and water. There are three stage of material preparation which are fibre preparation stage, fabrication preparation stage and installation of EFBCB on prototype house model stage. These preparations were crucial in justifying the study’s purpose.

2.1.1 Fibre preparation stage

The raw materials were obtained from the factory and has been sun dried to remove any moisture content that may have existed in the fibre. After that, the EFB fibre were shredded and hammer mill to minimize the fibrous fibre length and being sieved to separate dust that could impair the performance of board. Next, the EFB fibre were immersed in 1% which are the optimal percentage of sodium hydroxide (NaOH) for 24 hours to remove any residual oil and impurities from the fibre [19] [20]. The treated fibre was washed after soaked in NaOH and sun dried again. To ensure that it is completely dry before adding to the concrete mixture, the EFB fibre were oven dried at temperature 105˚C.

2.1.2 Fabrication preparation stage

All the material such as Portland cement, EFB fibre and water has been weighted before mixed using mixer machine. Then, it has been poured into 350 x 350 x 12 milimeters wooden mould and compacted. The sample were held under compression using steel moulds and cured at ambient temperature with relative humidity for 28 days to allow it to cure and increase the strength [21] [22]. After curing process, the sample were cut into circle shape for diameter 28 mm and 100 mm according to the size of tube arrays. Figure 1 shows the fabrication preparation stage.

Figure 1: Fabrication preparation stage

2.1.3 Installation EFBCB on prototype house model stage

The EFBCB has been installed on four side wall of prototype house model for 1 month before test and the climate data at the site provided by Climatology Kit Station.

2.2 Methods

The sound absorption coefficient of EFBCB measurements conducted using an Impedance Tube test according to BS ISO 10534. To cover the entire frequency range, two different diameter tubes were used. The frequency range of 2000 Hz to 6000 Hz was covered by a tube with diameter 28 mm while the frequency range of 150 Hz to 1500 Hz was covered by a tube with diameter of 100 mm. The ratio of the reflect wave to the incident wave was calculated using AFD-1001 Acoustic Tube transfer function method software [9]. Figure 2 shows the Impedance Tube used to measure sound absorption coefficient.

Figure 2: Impedance Tube

3. Results and Discussion

Sound absorption coefficient is observed the loss of sound energy when sound waves come contact with empty fruit bunch cement board (EFBCB). The test was carried out using an Impedance Tube at Acoustic Laboratory, FKAAB UTHM. The testing is based on the BS EN ISO 10534.

3.1 Sound absorption coefficient of EFBCB for control sample

Figure 4.1 and 4.2 shows the result for sound absorption coefficient (SAC) value for treated and untreated samples for control sample. The absorption of treated sample achieved between 40.1% until 95.5 % between range 2000 Hz to 3000 Hz. Compared to untreated sample, the absorption only achieved between 49.3% until 73.7% in the same range at. The treated sample absorb more than untreated sample. This result supported by research from (Nasidi et al, 2018) found that the treated fibre dissipated more energy leading to increase surface friction encountered by the acoustic wave as it hits the fiber's surface. For treated sample, 0.955 for Sample T2 at 2500 Hz was the higher value for sound absorption coefficient. Meanwhile, the higher value of sound absorption coefficient for untreated sample was 0.809 at 3150 Hz. After reaching 1600 Hz, all samples began to show increases in sound absorption coefficient and reached their maximum sound absorption coefficient values in the higher frequency ranged.

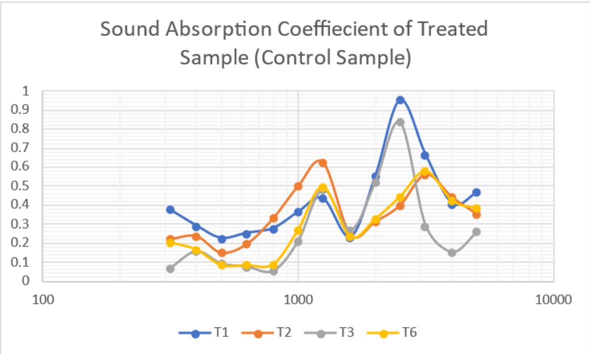


Figure 3: Sound absorption coefficient of treated sample for control sample

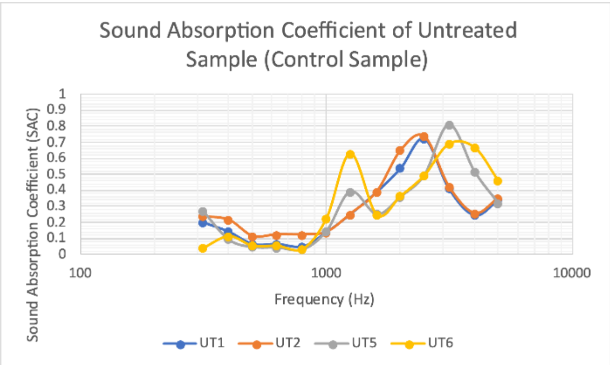


Figure 4: Sound absorption coefficient of untreated sample for control sample

3.2 Sound absorption coefficient of EFBCB for sample under 1 month outdoor exposure

Figure 4.3 and 4.4 shows the result for sound absorption coefficient (SAC) value for treated and untreated samples under 1 month outdoor exposure. In range 2000 Hz until 3000 Hz, the treated sample can absorb between 51.6% until 88.8% contrast with untreated sample they can absorb between 66.1% until 76.8%. The sound absorption coefficient for treated sample was higher at 0.888 for Sample T8 at 2500 Hz. In the meantime, the untreated sample had a higher sound absorption coefficient of 0.768 for Sample UT5 at 2500 Hz. All the samples treated and untreated started to show rises in sound absorption coefficient and achieved their maximum sound absorption coefficient values in the higher frequency range after reaching 1600 Hz.

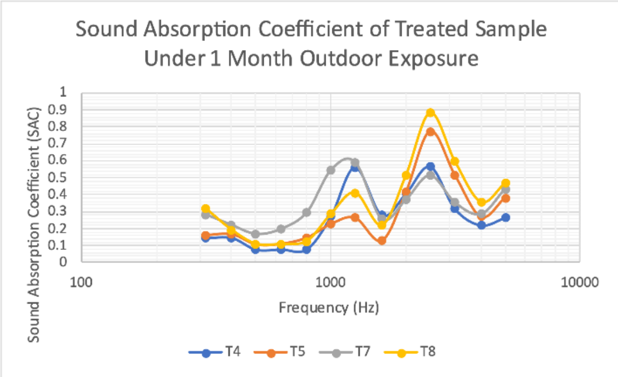


Figure 5: Sound absorption coefficient of treated sample under 1 month outdoor exposure

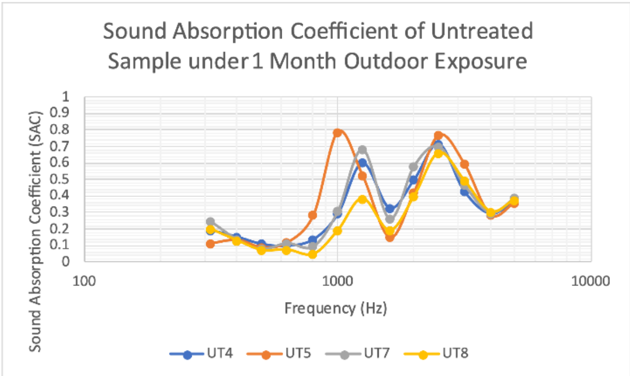


Figure 6: Sound absorption coefficient of untreated sample under 1 month outdoor exposure

3.3 The linear regression for sound absorption properties of EFBCB based on the different parameters

The linear regression for sound absorption properties of EFBCB based on the different parameters of outdoor exposure condition has been construct for treated and untreated sample for control sample and sample under 1 month outdoor exposure. The purpose of the linear regression function is to determine if there is a trend that can be used to make predictions. The outcomes were observed using the linear graph that was created.

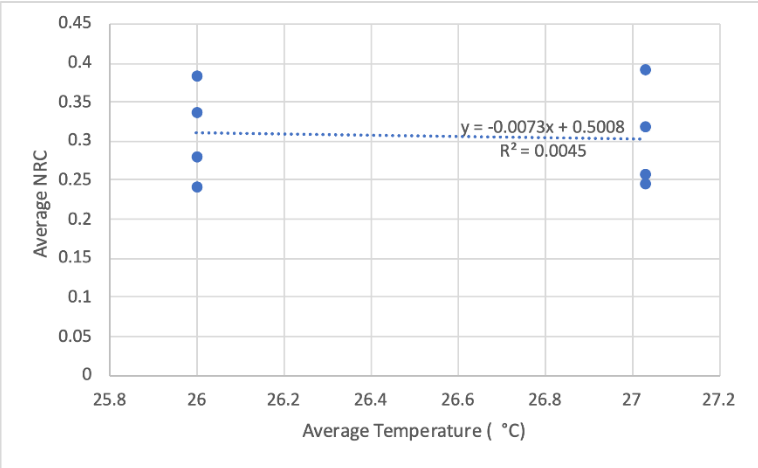
3.2.1 The linear regression for sound absorption properties of EFBCB based on the different parameters

Figure 7 shown the value of coefficient of determination for temperature, relative humidity, rain intensity and solar radiation with sound absorption coefficient. The linear regression for sound absorption properties of EFBCB has been developed by plotted the graph between average temperature, average relative humidity, average rain intensity and average solar radiation versus noise reduction coefficient (NRC). The NRC, which is measured to the closest 0.05 values, is the average arithmetic value of the sound absorption coefficient for frequencies of 250Hz, 500Hz, 1000Hz, and 2000Hz. The

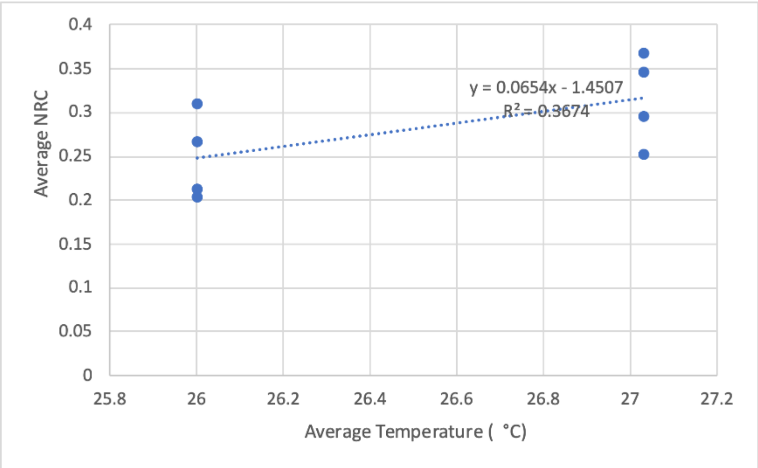
NRC value, which is typically used to describe the degree of sound absorption capabilities of acoustic materials, is crucial in acoustic investigations. Absolute absorption is represented by an NRC rating of 1, whereas 100% reflection is represented by a number of 0. The values of R^2were recorded in Table 1. It was found in this study, the correlation of determinations for all outdoor exposure parameters were poor because less than 0.5.

Table 1: Coefficient of determination at low frequency

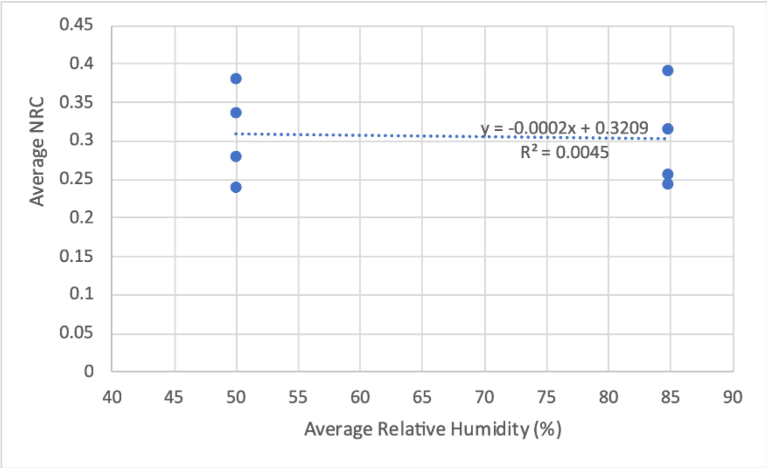
Type of Sample	Outdoor Exposure Parameters	Formula	R^2
Treated	Temperature	y = -0.073x + 0.5008	0.0045
Untreated		y = 0.0654x + 1.4507	0.3674
Treated	Relative Humidity	y = -0.0002x + 0.3209	0.0045
Untreated		y = 0.0019x + 0.1522	0.3674
Treated	Rain Intensity	y = -0.0016x + 0.31	00.0045
Untreated		y = 0.0145x + 0.2468	0.3674
Treated	Solar Radiation	y = -6E-05x + 0.31	0.0045
Untreated		y = 0.0005x + 0.2486	0.3674



(a)

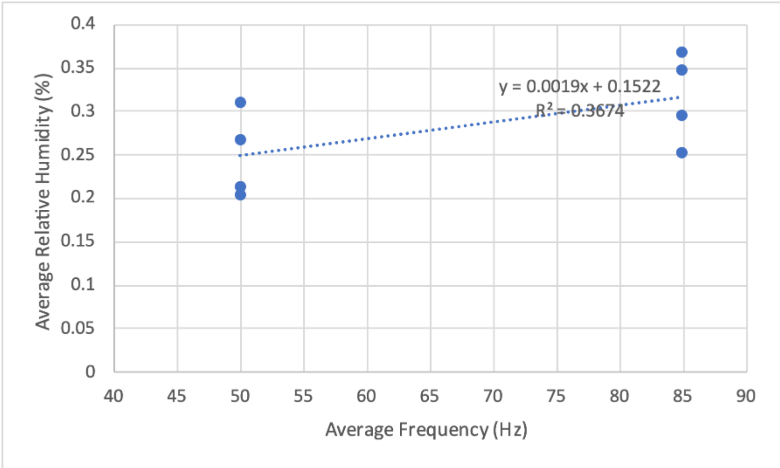


(b)



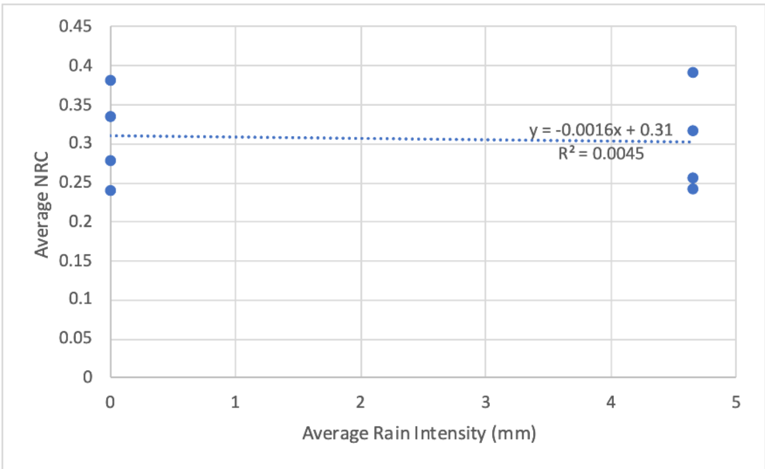
Average NRC
Average Relative Humidity (%)
y = -0.0002x + 0.3209
R² = 0.0045

(c)



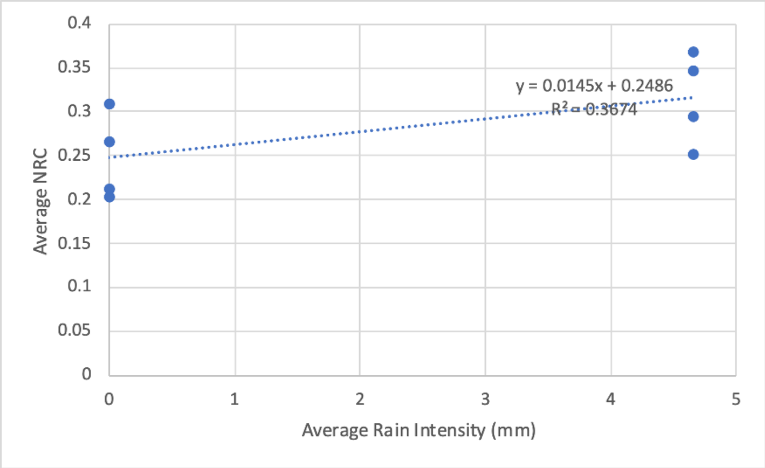
Average Relative Humidity (%)
Average Frequency (Hz)
y = 0.0019x + 0.1522
R² = 0.3674

(d)

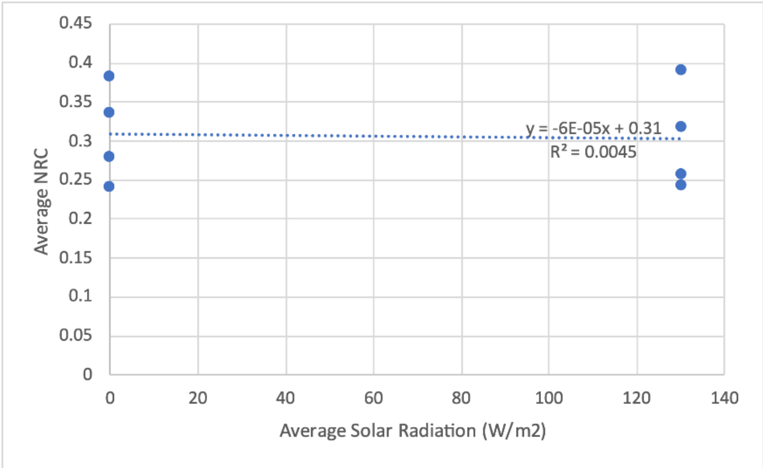


Average NRC
Average Rain Intensity (mm)
y = -0.0016x + 0.31
R² = 0.0045

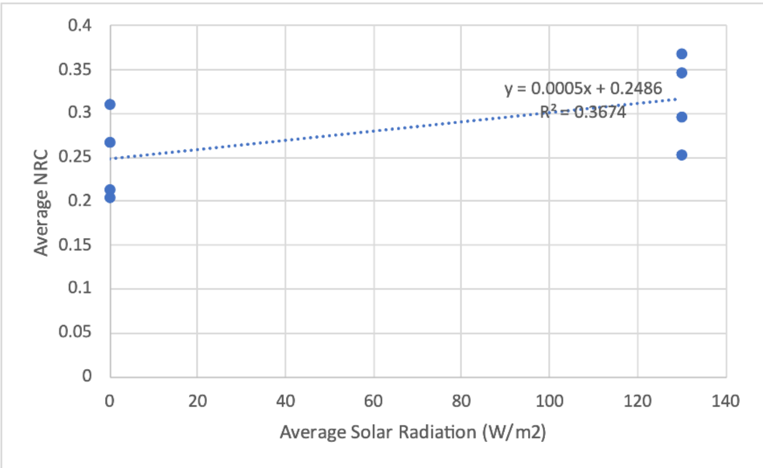
(e)



(f)



(g)



(h)

Figure 7: The linear regression for sound absorption properties of EFBCB based on (a) average temperature for treated sample (b) average temperature for untreated sample (c) relative humidity for treated sample (d) average relative humidity for untreated sample (e)average rain intensity for treated sample (f) average rain intensity for untreated sample (g) average solar radiation for treated sample (h) average solar radiation for untreated sample

4. Conclusion

This study showed that the sound absorption coefficient for all treated and untreated sample has been decreased when exposed to outdoor compared to the control sample. Next, it was found that correlation determination for linear regression model towards average temperature, relative humidity, rain intensity and solar radiation versus noise reduction coefficient of EFBCB for control sample and sample under 1 month exposure has less than 0.5.

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