Research Article

Versatile Rubber Wood-Based Lightweight Cement Brick as Microwave Absorbers

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Abstract: *The explosion of information technology through communication media has made services in telecommunications in high demand, especially in wireless communications. However, this development not only benefit to the people, but also its lead to the exposure of high radio frequency radiation due to the increasing use of telecommunication services. The increasing of radiation exposure may develop other issues which involving human health. This project will create new anti-radio frequency cement brick by combining the common material used in lightweight cement brick with biomass material which has potential in eliminating the radio frequency radiation. Rubber wood sawdust is used in the cement composition of lightweight cement brick because of its potential as absorbing material due to the presence of carbon element inside it. By chance it is also one of biodegradable material that has lighter weight which is suitable in developing lightweight cement brick and also overcome the disposal wood waste issues in which plagues Malaysia as one of the world's largest supplier of rubber. Thus, this project has the potential to contribute a high impact on the development of building technology with anti-radiation features as added value. Our future plan is to develop a model of a house by using this anti-radio frequency radiation building material to obtain comprehensive absorption performance results.*

Keywords: radio frequency radiation; lightweight cement brick; rubber wood.

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1. INTRODUCTION

With the growth of the telecommunications industry, humans are easily exposed to the high radiation conditions in which they will be surrounded with unhealthy and harmful environment. A. Adenkule et. al has estimated that the human body can absorb power radiation at 14.79 dB which is at a distance of two meters from a cell tower and the duration of exposure from the radiation is 86.69 minutes per day (Adekunle et al., 2015). Thus, it requires the absorber that has potential reflectivity level minimum at -15 dB. Electromagnetic wave (EMW) or microwave absorbing material is used to eliminate this unwanted radiation that propagate through it which is involving the transformation of the electromagnetic energy into internal energy of the absorbing material (Baird, 2019).

Microwave absorber are designed to solve a wide variety of problems such as internal cavity resonances, antenna pattern shaping and high-frequency interference (Sharma & Yadav, 2015). Commercial absorbers that currently available have been developed using various types of material which are including magnetic material (i.e. Ferrite) or dielectric material (i.e. Carbon-based) (Hasnain et al., 2007). In the earlier stage of microwave absorber development, carbon has been used as a material in absorbers and many applications due to its characteristics of good electric and thermal conductivities, low density, low thermal expansion and low elasticity (Gupta & Aul, 2016). Elemental carbon can be found in most residue such as wood waste (including rubber wood), POFA (Kharber et al., 2016, 2017; Narudin et al., 2021), fly ash, etc. (Oh & Ching, 2017), it is one of material that is used in the manufacture of absorbing materials (Cheng et al., 2020; Chuayjumnong et al., 2022; Ibrahim et al., 2020; Zou et al., 2011) and building materials (Masadeh, 2015; Munir, 2015).

The commercial cement brick less effective in eliminating electromagnetic wave as it is not integrated with radiation absorbing material. The emergence of lightweight cement brick bring up the potential of this cement brick as microwave absorbing building materials due to the porous nature of lightweight cement brick itself. But microwave absorbing material is still needed as part of cementitious mixture to enhance the absorbency of lightweight cement brick. Rubber wood-based biomass material is integrate in the cement brick to create an environmentally friendly absorbing material and at the same time enhanced the absorption behaviour of the cement brick.

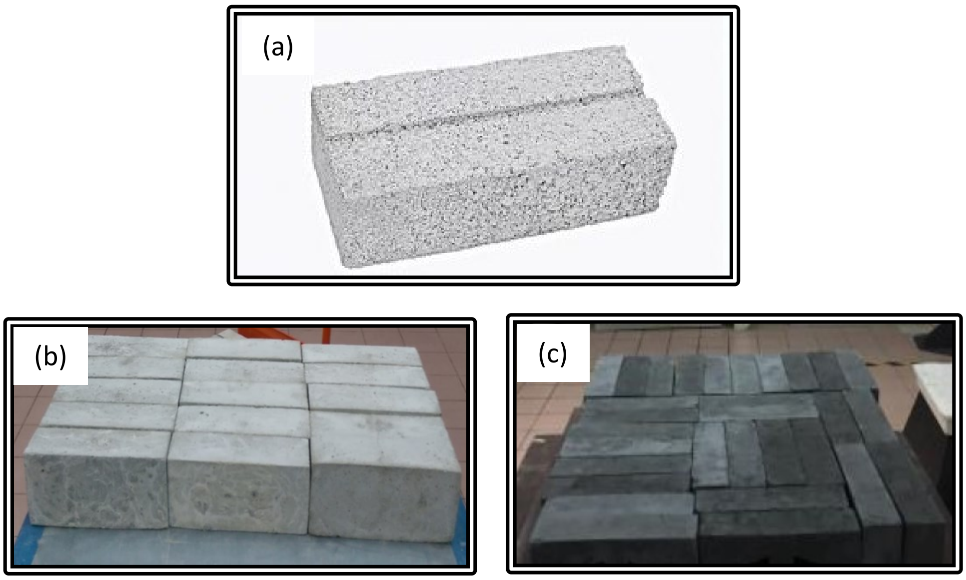
2. METHOD & MATERIAL

The measurements of anti-microwave brick wall were carried out to study the potential of rubber wood as absorbing material in cement brick. The samples involved the cement casting of anti-microwave brick walls which are lightweight cement brick with 20 % of Fine Rubber Wood and lightweight cement brick with 20 % of Carbon Powder Rubber Wood. These rubber wood-based cement bricks were compared with commercial cement brick walls by measuring the relative density or known as specific gravity, dielectric characteristics and absorption performance.

The absorption performance of the material will be measured by using Naval Research Laboratory (NRL) Arch free space method. The free space measurement will be performed in frequency range of 1 GHz to 12 GHz and presented in the graph of reflectivity (dB) versus frequency (GHz). The reflectivity setup measurement is expressed the absorption performance of the anti-microwave rubber wood-based lightweight cement brick.

3. FINDINGS

Figure 1 shows the commercial cement brick, lightweight cement brick with 20 % of Fine Rubber Wood and lightweight cement brick with 20 % of Carbon Powder Rubber Wood.



(a) Commercial Cement Brick. (b) Lightweight cement brick with 20 % Fine Rubber Wood (c) lightweight cement brick with 20 % Carbon Powder Rubber Wood.

Figure 1. Comparison for commercial and anti-microwave brick samples from previous work.

3.1 Physical and Dielectric Properties

The volume and weight of those bricks were measured and tabulated in Table 1. The cement brick, 20 % of Fine Rubber Wood with relative density of 1,072 kg/m^3 and 20 % of Carbon Powder Rubber Wood cement brick with relative density o 1,125 kg/m^3 indicates that they are categorize in lightweight cement brick as compared to commercial cement brick wall which has density of 2,039 kg/m^3 that in the range of dense aggregate cement brick.

Table 1 also shows the result of dielectric and loss tangent of biomass lightweight cement brick with 20 % Fine Rubber Wood and 20% of Carbon Powder Rubber Wood as well as for commercial cement brick wall. From the table, it can be seen that the dielectric constant and loss tangent of 20 % Fine Rubber Wood lightweight cement brick slightly higher compared to those 20 % Carbon Powder Rubber Wood lightweight cement brick and commercial cement brick wall. This proved that dielectric constant and loss tangent giving the important roles to produce the high performance of electromagnetic absorbing material as in overall 20 % Fine Rubber Wood lightweight cement brick shows the highest absorption performance.

Table 1. The dimension, weight, volume, relative density and dimension gravity of for commercial cement brick, lightweight cement brick with 20 % of Fine Rubber Wood and 20% of Carbon Powder Rubber Wood.

Material	Dimension (mm)	Weight (kg)	Volume (m3)	Relative Density (kg/m3)	Dielectric Constant (ε′)	Loss Tangent (Tan(δ))
Commercial	215 x 100 x 65	2.85	0.0014	2,039	3.56	0.0955
20% Fine Rubber Wood	216 x 103 x 65	1.55	0.0015	1,072	1.80	0.3415
20% Carbon Powder Rubber Wood	200 x 100 x 60	1.35	0.0012	1,125	1.78	0.0153

3.2.2 Absorption Performance

Figure 2 is representing the absorption performance of the commercial cement brick as well as the influence of 20 % Fine Rubber Wood and 20 % Carbon Powder Rubber Wood in lightweight cement brick towards the performance of absorption. From the graph in Figure 2, it shows that there is significant improvement for lightweight cement brick with 20 % of Fine Rubber Wood and 20% of Carbon Powder Rubber Wood supported by data shows in Table 2 as well as in bar graph in Figure 3.

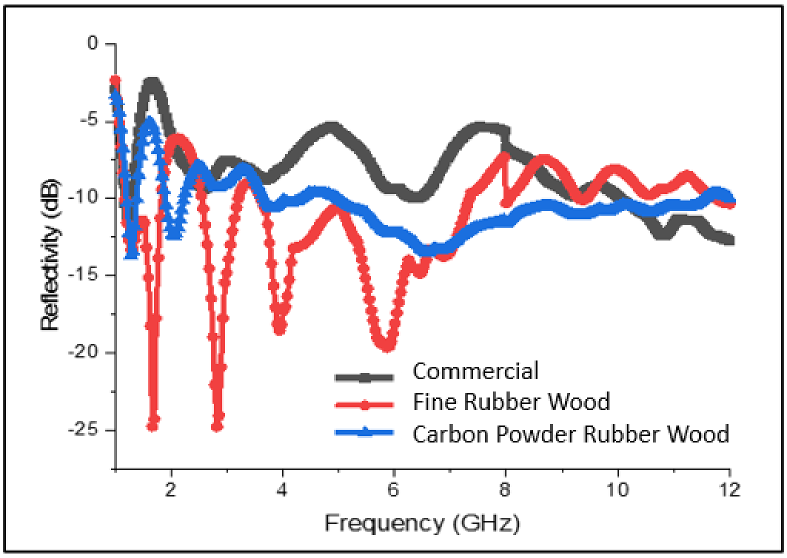


Figure 2. Absorption performance of commercial cement brick, lightweight cement brick with 20 % Fine Rubber Wood and 20 % of Carbon Powder Rubber Wood using NRL Arch Free –Space Method

4. DISCUSSION

At L-band, lightweight brick containing 20 % Fine Rubber Wood giving the best absorption performance of -24.7557 dB at frequency 1.665 GHz. At S-band, lightweight brick containing 20 % Fine Rubber Wood with absorption performance of -24.7738 dB at frequency 2.82 GHz show the best result. Same goes at C-band, lightweight brick containing 20 % Fine Rubber Wood giving the absorption performance of -19.6674 dB at frequency 5.865 GHz. While at X-band, commercial brick slightly shows the best result with absorption performance of -12.7445 dB at frequency 12 GHz. In overall, lightweight brick containing 20 % Fine Rubber Wood offer the best results compared to commercial cement brick and lightweight cement brick with 20 % Carbon Powder Rubber Wood as can be seen in Figure 3.

Table 2. Absorption performance data of commercial cement brick and lightweight cement brick with 20 % of Fine Rubber Wood and 20% of Carbon Powder Rubber Wood in separate frequency band (Maximum).

Frequency	Reflectivity (dB)		
	Commercial Brick	**20 % Fine Rubber Wood**	**20 % Carbon Powder Rubber Wood**
L Band (1 - 2 GHz)	-11.4782	-24.7557	-13.6771
S Band (2 - 4GHz)	-9.3837	-24.7738	-12.4497
C Band (4 - 8GHz)	-9.9688	-19.6674	-13.5018
X Band (8 - 12GHz)	-12.7445	-10.379	-11.6241

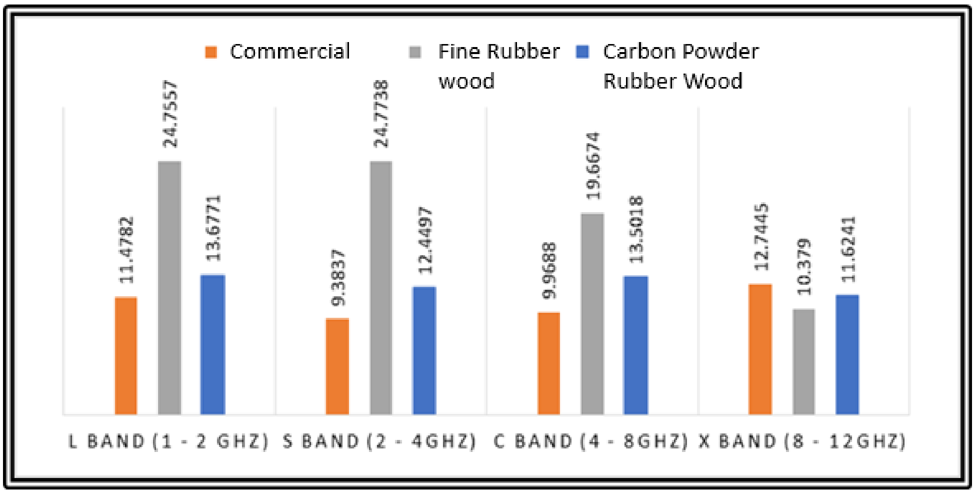


Figure 3.Bar graph of absorption performance data (maximum)

5. CONCLUSION

The free space measurement of Rubber wood-based lightweight cement brick was performed and the results obtained shown that lightweight cement brick with 20 % Fine Rubber Wood has the best performance with the maximum absorption of 24.7738 dB at frequency 2.81 GHz. Results proved that there had a significant effect when rubber wood-based was added in and there is room for improvement by using rubber wood-based as the absorbing material in cementitious mixture for electromagnetic absorber.

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