

# PRELIMINARY FINDINGS OF RAW BAMBOO CURTAIN ABSORBER (BCA), CHARRED AND COATED BAMBOO ASH PAINTED CHARACTERISTICS FOR ELECTROMAGNETIC WAVE ABSORPTION

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ARTICLE HISTORY	ABSTRACT
Received 1 March 2017	<i>This paper presents the preliminary findings on the utilization of bamboo, a natural material to act as Electromagnetic Wave (EMW) absorber. Bamboo curtain absorber (BCA) is a curtain or blind made from bamboo and functions to absorb the microwaves. The EMW absorption of three BCA prototypes which are Raw BCA, Charred (burned) BCA and Coated (with bamboo ash paint) BCA has been observed. The utilization of bamboo has shown significant effect in increasing the EMW absorption. The result showed the performance of the raw bamboo as a microwave absorber was very low. However, the introduction of BCA Coated (with bamboo ash paint) showed extraordinary effect to increase the EMW absorption of about 92.8% compared to raw BCA. It can be utilized as an absorbent alternative which is more economical than the existing ones in the market.</i>
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## 1. INTRODUCTION

The rapid developments of technology have helped a lot of human life today even when what is considered impossible before is already a certainty. The same applies to the field of communications. The development of communication technology has created a variety of sophisticated communication equipment and tools such as microwave disc, antenna, mobile phones and etc. These smart inventions help people to communicate with others, seeking quick information, monitoring and doing many more activities based on the application stored in the smart equipment (mobile phone as an example).

Telecommunication tower also known as radio based station (RBS) is required in the communication system in order to enable people to stay connected from one place to another remote area. A place with high density population requires more telecommunication towers installed in that area so that the system is capable to cater to the number of users using the services offered by the service provider. Cell phones communicate with nearby cell towers mainly through radio frequency (RF) waves, a form of energy in the electromagnetic spectrum between FM radio waves and microwaves. While there have been many benefits from the telecommunication technology, significant increase in the number of mobile phone users and installation of telecommunication towers have caused potential health risks to human associated with the use of this device due to the long term exposure to the radio frequency (RF) radiation. Researchers have found that the exposure may cause health deterioration symptoms such as headache, nausea, fatigue, loss of appetite, menstrual disorders, brain activity, loss of concentration and bad effect to pregnant ladies( Rusnani et al, 2008).

Absorber is created to absorb the radiation and to provide non-reflecting environment thus preventing any reflection from the radiation. Absorber also prevents external waves from entering the building. However, most commercial absorber is used for electronic and defense industries. Ibrahim et al. (2011) reported that the most popular commercial absorber is coated by ferrite on the surface of the absorber and made up from carbon and polyurethane (PU) foam as the main material. Industries usually use the commercial absorber in the anechoic chamber in order to avoid reflections that occur on the wall of the chamber. There are many efforts and studies done on the natural materials to replace the current material of absorber which is expensive and non-environmental friendly. The natural material is economic and more environmental friendly since most of the materials under study are from agricultural waste. These studies used many kind of agriculture waste with different designs, shapes and sizes then compared with the commercial absorber in terms of the performance.

A study was done by Nornikman et al. (2010) using rice husk as the main material with different design of wedges absorber. It shows that rice husks can be potentially used as alternative material for absorbers' fabrication. Other alternative materials such as rice straw, banana leaves, dried banana leaves, coconut shell, oil palm ash and sugar cane bagasse (Liyana et al., 2012) with various designs, shapes and sizes are used to investigate the performance of the absorber. The performance of the absorber using these alternative materials provide a similar good result to the commercial one (Farhany et al., 2012).

Apart from the absorber in the chamber room, absorber for private use is also needed, especially to those who live near the radio-based station. In Azhar et al. (2013), an internal vest for pregnant women and a window curtain material are proposed to shield or reduce the effect of RF electromagnetic radiation to humans living near the telecommunication tower or radio based station (RBS). Both RF shieldings are made up from soft and safe fabric with a unique blend of natural materials; 70% bamboo fiber and 30% silver.

The use of bamboo in modern technology has grown by leaps and bounds. This can be evidenced by the presence of lots of bamboo -based products on the market. China, which has the largest population of bamboo, has also recorded an increase of bamboo resources from 1988 to 2007 by 59% (Guan & Fan, 2011).

There are several studies that found the characteristics of the bamboo itself to be highly absorbent material in microwave is poor (Saifuddin et al., 2016) due to the low  $\tan \delta$  value as other biomass material while Jin et al. (2015) state that there is no microwave absorbance for bamboo. However, the use of bamboo as a microwave absorber's performance can be improved through a mixture with other materials such as hybrid bamboo; magnetic  $\gamma\text{-Fe}_2\text{O}_3$ /bamboo composite (Jin et al., 2015), ionic or acid liquid (Saifuddin et al., 2016), and biomorphic charcoal/ $\text{TiO}_2$  composite from moso bamboo (Qian et al., 2016) which has a potential to be used as the microwave absorber material.

The performance of the bamboo as a microwave absorber also can be enhanced through preparation method of the bamboo itself, for example charcoal bamboo (Saifudin et al, 2016; Isa et al, 2016), which the bamboo need to go through the higher degree of burning process. After carbonized, this material can be used as an efficient absorbent. Charcoal bamboo has high electric conductivity, self-lubricity and extremely higher absorption properties (Wu et al, 2008).

Bamboo curtain absorber (BCA) is a curtain or blind which is made from bamboo and functions to absorb the microwave. This idea sparked after issues on high radiation coming from telecommunication towers which is increasingly built around the residence, schools and offices building which is harmful to human's health in the long run. Microwave radiation will be higher in the higher position where those who live or work in high buildings will have a high risk of exposure to microwave radiation (Azhar et al., 2013). Since ordinary curtains installed in the building act just to filter light from entering the building, the bamboo curtain absorber is designed to offer extra features which can absorb and filter out harmful radiation from entering the building, thus reducing the risk to those who live on a higher ground.

The uniqueness of bamboo curtain absorber is the main material used (bamboo plant) in the production of curtain or blind. Ordinary blinds used fabrics, plastics, and material that are only capable of filtering light. With the Bamboo Curtain Absorber (BCA), it is not only capable to filter light but also can filter and absorb the microwave radiation from the surrounding area. The mixture of paint and ingredients from bamboo ash boost the microwave absorption capability. The high carbon material content in the bamboo itself can ensure that these blinds can be used as a microwave radiation absorbing materials.

Creation of Bamboo Curtain Absorber (BCA) is that not only can it be used as decoration curtain but also as microwave absorber particularly to those people living in condominium or tall building near / window facing to telecommunications transmission towers. BCA has high potential for commercialization to such an extent. This is because of the increasing level of health awareness despite living in the world of high technology. With high levels of trust, BCA will become a necessity in the field of building construction and interior decoration. This is because the BCA can be diversified in terms of color, shape and use.

## **2. METHODOLOGY**

### ***2.1 Prototype fabrication***

The idea of this project is to see the impact of raw bamboo materials with EMW absorption. Further burning process is conducted to see the effect of the carbon material. Bamboo Curtain

Absorber (BCA) is made from original bamboo plant where it is cut into pieces of thin bamboo, dried in the sunlight for a day then tied with string. Figure 1 illustrates the woven BCA with dimension 2 feet high x 2 feet wide where the thickness is 1.5 mm.

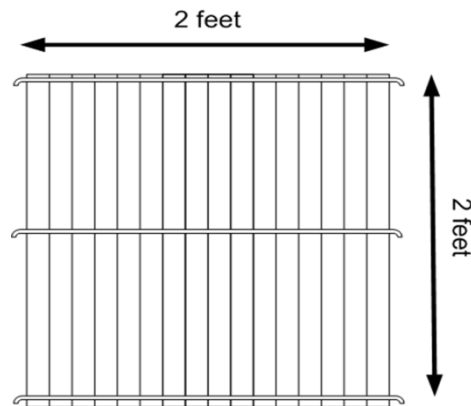


Figure 1: Woven Bamboo Curtain Absorber Prototype

The prototypes were divided into 3 types of curtain depending on the fabrication methods used. The first prototype was made from woven bamboo into raw bamboo blinds as in Figure 3. The second prototype was manufactured using woven bamboo and burned to produce high carbon composition in that bamboo. The burning process was done in a controlled way so as not to cause the bamboo to turn into ashes as shown in Figure 4. Raw bamboo could not be burned like it was on fire, but instead should be cooked slowly, in the presence of oxygen as little as possible to behave like charcoal. The third prototype was made from woven bamboo into bamboo blinds and painted with single layer bamboo ash paint as shown in Figure 5.

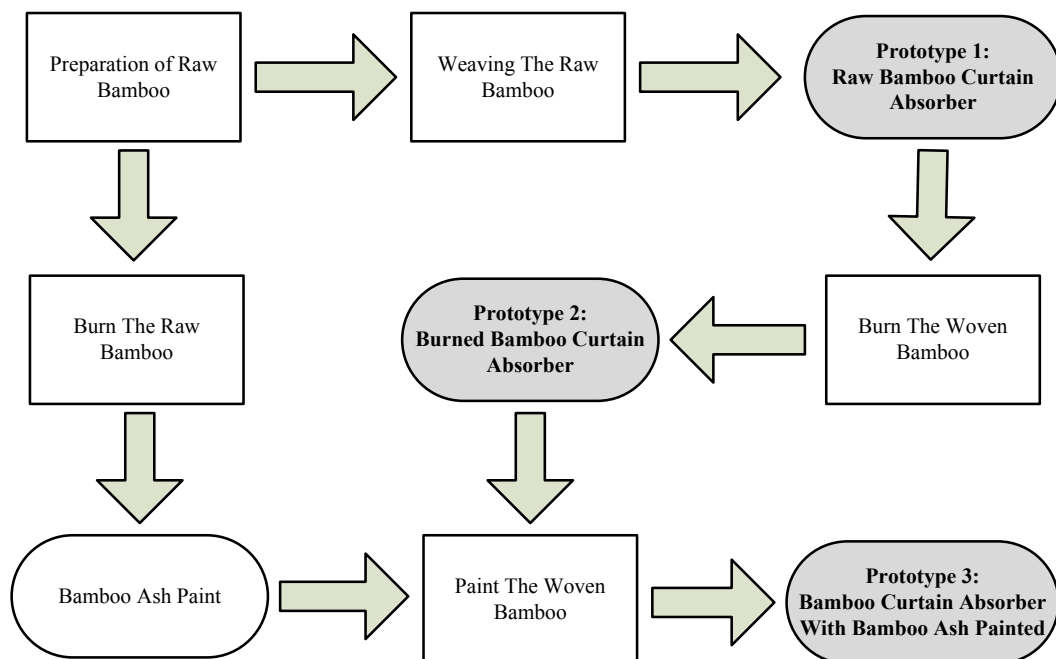


Figure 2: BCA Prototypes Manufacturing Process Flowchart



Figure 3: Raw Bamboo Curtain Absorber

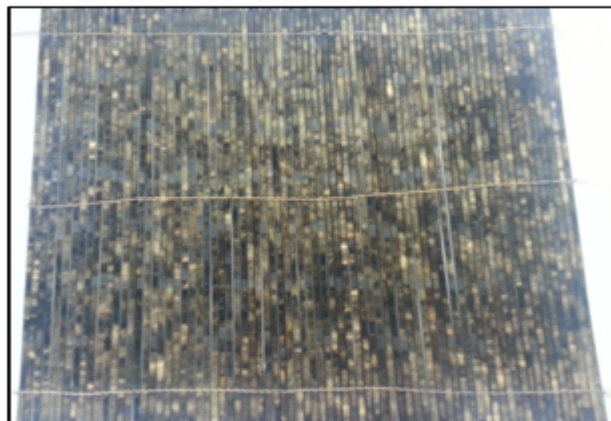


Figure 4: Burned Bamboo Curtain Absorber



Figure 5: Bamboo Curtain Absorber With Bamboo Ash Painted

## ***2.2 Measurement setup***

The free space measurement setup was conducted to measure the absorption of the BCA. The equipment for this measurement is signal generator, a pair of coaxial cable, a pair of horn

antenna, Agilent N5230A 300 kHz – 20 GHz PNA-L network analyzer and a metal plate. Each BCA prototype was located in the same position under a pair of horn antenna. The measurement operated in radio frequency range between 8 GHz to 12 GHz as shown in Figure 6. This X-band range of radio frequency was chosen due to the lab equipment limitation. The direct path was eliminated by replacing metal plate between the horn antennas in order to reduce reflected signal. Since, the maximum frequency for the X-band is 12 GHz, the far-field range antenna measurement is according to Fraunhofer distance,  $d_f = 2D^2/\lambda$  where in this research,  $D = 13$  cm is the largest dimension for each of the physical receiver and the transmitter horn antenna and  $\lambda = 0.025$  is the wavelength of the radio wave. For producing a beam that reaches into the far-field region, the distance between the radiated frequency from the horn antenna to the BCAs surface must be more than 2.18 m.

Resistance test was also employed to the surface of the BCA prototype by using Tektronix TEK DMM870 digital multimeter. The digital multimeter probes were positioned at the both end of the bamboo pieces to measure the resistance value.

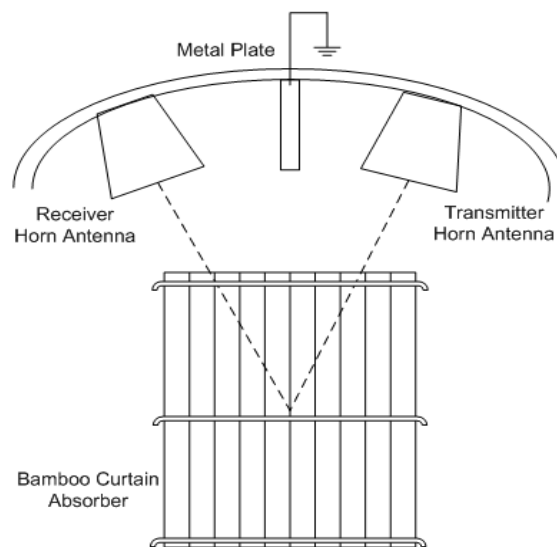


Figure 6: Reflectivity for Raw Bamboo Curtain Absorber

### 3. RESULTS AND DISCUSSION

Figures 7 to 9 represent the reflectivity for three BCA prototypes. Three measurements were taken at 8 GHz to 12 GHz frequency range. A traditional Raw Bamboo Curtain in Figure 7 shows an average of -1.95 dB EM wave absorption. From the measurement, the result shows that the absorption slightly increased from -1.5 dB to -2.6 dB when the frequency increased.



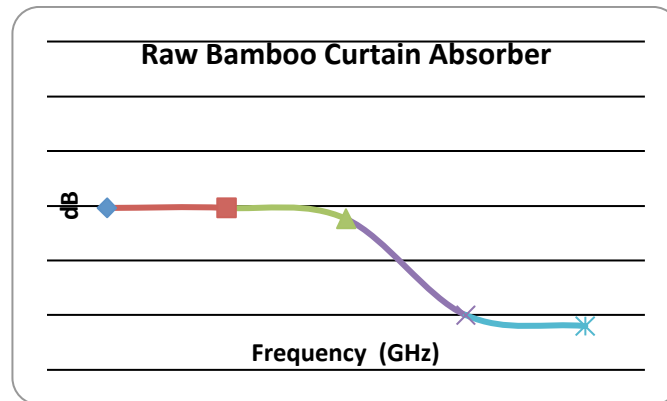


Figure 7: Reflectivity for Raw Bamboo Curtain Absorber

Figure 8 shows the average absorption for burned BCA is -11.72 dB, given about 83.4% increment of EMW absorption from the raw BCA. Figure 8 reveal the BCA with bamboo ash painted gives the highest average absorption among these three prototypes with -27.1 dB which gives an increment of 92.8% absorption from the raw BCA. Similar to the result for raw BCA, the burned BCA and BCA with bamboo ash painted also showed that the absorption increased when the frequency increased.

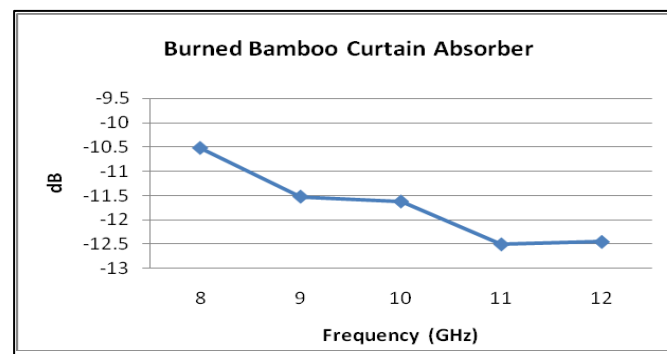


Figure 8: Reflectivity for Burned Bamboo Curtain Absorber

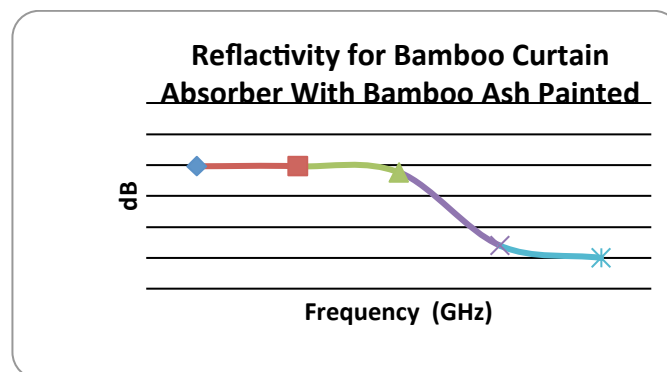


Figure 9: Reflectivity for Bamboo Curtain Absorber With Bamboo Ash Painted

Table 1 shows the absorption rate for burned BCA and BCA with bamboo ash painted as compared to the raw BCA. The process of burning the raw BCA multiplied the absorption

level of this absorber given high dielectric loss material such as carbon to modify the dielectric properties of these bamboo based materials. Carbon is a good semiconductor material that is very suitable for transforming microwave energy because microwaves are impeded as they pass through the carbon. Ashes are the product of complete combustion either of bamboo or later charcoal. Bamboo ash contains a high content of carbon compares to burned bamboo, which is considered to be a lossy conductor material that helps absorb microwave energy. Once the BCA is painted/coated with bamboo ash, it produces an extraordinary absorption at 92.8% compared to raw BCA and 9.4% from burned BCA.

Table 1. Absorption rate for Bamboo Curtain Absorber Prototype

Prototype	Increment of Absorption Rate as Compared to Raw BCA
Burned Bamboo Curtain Absorber	83.4%
Bamboo Curtain Absorber With Bamboo Ash Painted	92.8%

This result is supported by the resistivity test for these three prototypes in Table 2 where the BCA with bamboo ash painted gave the lowest resistivity follow by burned CBA. Bamboo is a non-conductive material and it shows a huge value of resistivity. The burned BCA showed a lower resistivity value since the consequences from the burning of bamboo, carbon would be produced. BCA with bamboo ash painted gave the lowest value of resistivity as the process in producing bamboo ash, more carbon would be produced. In microwave absorbing application, carbon was used as resistive element in transforming incoming microwave into heat. When the microwave were emitted to surface that is painted with carbon, an electric field was generated between the absorber surfaces. Because of this electric field, a voltage on the surface of the absorber drained an electric current. Current thus, transforming the electrical energy into thermal energy and dissipated.

Table 2. Resistivity for Bamboo Curtain Absorber Prototype

Prototype	Resistivity (M $\Omega$ )
Raw Bamboo Curtain Absorber	$\infty$
Burned Bamboo Curtain Absorber	10.86
Bamboo Curtain Absorber With Bamboo Ash Painted	3.265



From this result, the burned BCA and Coated (with bamboo ash paint) BCA were capable of absorbing most of the microwaves emanating from the application of X-band designation such as satellite communications, terrestrial broadband radio communications and radar where humans are exposed to the microwaves every day.

#### 4. CONCLUSION

This paper presents the preliminary study on the utilization of bamboo, a natural material to act as EMW absorber. Three BCA prototypes which are Raw BCA, Charred (burned) BCA and Coated (with bamboo ash paint) BCA were observed and the result shows that the performance of the bamboo as a microwave absorber was very low. However, the introduction of Charred BCA and BCA with bamboo ash painted shows significant effect to increase the EMW absorption as compared to raw BCA; about 83.4% and 92.8% respectively. The carbon material from bamboo burning process enhanced the ability of this biomass in absorbing microwave energy. For future improvement, more experimental work should be done in determining the contributing factors to improve the absorption performance. With this new discovery, it gives a positive impact in terms of good health to the public and with high levels of trust; this product will become a necessity in building construction and home decoration.

#### 5. ACKNOWLEDGMENT

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