Research Article

Effectiveness of Natural Fiber/Agricultural Waste Materials as Thermal Insulation

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Abstract: *Sugarcane fiber, coconut fiber and palm oil fiber are the examples of renewable and eco- friendly materials that is usually being implemented as thermal insulation which provides promising alternative compared to artificial options. Previous studies have proven the efficacy of these agricultural by-product in heat insulation for building construction, mechanical system and so on. In those studies, the specimen is in a form of compressed or added with binding agent for further characterization regarding its thermal properties. This study emphasizes on investigation regarding the viability of using coconut peat, sugarcane dregs and palm oil fiber in its dried and uncompressed form as thermal insulation. A temperature difference measurement was conducted to determine the capability of each of the material to retain heat as the result of the material attachment on a surface, without the addition of binding agent. From this study, it was found that each of this material has the capability to retain heat when used as surface insulating element. The sugarcane dregs (dried and uncompressed form) is proven to be most effective in retaining heat, followed closely by palm oil fiber in comparison with the uninsulated control set of experiment.*

Keywords: sugarcane; palm oil; coconut peat; natural fiber, agricultural waste, uncompressed fiber, thermal insulation.

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1. INTRODUCTION

Man-made materials of novel qualities which are fabricated through implementation of advanced technology would often be preferred to be used for thermal insulation. However, the disposal of the man-made materials is a major concern since they do not break down naturally when disposed in landfills. The growing concerns regarding this negative effect on the environment facilitates the necessity to search for possible renewable materials to be use as thermal insulation (Zhou et al. 2005).

Thermal insulation is the process of reduction of heat transfer between objects in thermal contact or in range of radiative influence. Examples of applications of thermal insulations involve clothing, buildings, mechanical systems, refrigeration, spacecraft, automotive etc. Common thermal insulators are wool, fiberglass, rock wool, polystyrene, polyurethane, and goose feather etc. These materials are very poor conductors of heat and are therefore good thermal insulators.

A study conducted by Manohar et al. in 2006 regarding the potential of naturally occurring biodegradable fibers such as coconut fiber and sugarcane fiber to be use as building thermal insulation. It was found that Coconut fiber and sugarcane fiber have acceptable apparent thermal conductivity values for use as building thermal insulation.

The focus of this project would be related to renewable fibrous thermal insulation which includes coconut peat, sugarcane dregs and palm oil fiber because of the ability to regenerate itself and biodegrade easily when disposed. The justification of the materials selection for this project is derived from consideration of certain factors such as cost and availability of resource. In Malaysia, coconut and palm oil plants exist abundantly while the sugarcane dregs which is considered as waste is often being discarded (Rodriguez et al. 2011).

The prospects of agricultural by products such as coconut fiber, sugarcane fiber etc. in building construction material have been studied comprehensively by various researchers, which provide concrete database regarding its heat capacity, thermal conductivity, numerical sensitivity analysis etc. by using meticulous technique and state of the art equipment. Majority of these studies focused on the characterization of the compressed form of the fiber specimen, or the fiber specimen added with artificial binders. However, only a few studies regarding fiber/waste specimen in its uncompressed form were conducted.

In this project, investigation will be carried out to determine which natural fiber/agricultural waste material would be an effective heat insulator in its dried and uncompressed form: coconut peat, sugarcane dregs or palm oil fiber?

2. METHOD & MATERIAL

2.1 SAMPLE PREPARATION

The natural fiber or agricultural waste that were used in this project are coconut peat, sugarcane dregs and palm oil fiber. The coconut peat was obtained from plant nursery in Seri Iskandar, Perak while the sugarcane dregs and palm oil fiber were obtained from Teluk Intan, Perak. All of the samples were placed in open air and exposed to sunlight for three days to remove moisture and odour.

Figure 2.1a Sugarcane dregs

Figure 2.1b Coconut peat

Figure 2.1c Palm oil fiber

2.2 MATERIAL ATTACHMENT

In this project, the insulation material is not attached directly to the box's walls and without the use of any artificial or non-artificial binder. Six sheets of nylon cases with the same dimension as all six sides of the box were designed and sewn. 300 g of coconut peat was inserted into four of the nylon cases while the other two nylon cases was filled with 100 g. The nylon cases were then sewn all over to ensure similar thickness. All of the six filled nylon cases were attached to each side of the corresponding box's wall by using double sided tape to provide insulation lining for one box. Another six nylon cases were prepared for sugarcane dregs to provide insulation lining for the second box and another six nylon cases was prepared for palm oil fibers to provide insulation lining for the third box. Overall, there are three boxes with insulation lining made of dried and uncompressed coconut peats, sugarcane dregs and palm oil fiber respectively and another one additional box without any insulation to serve as control set for the purpose of comparison.

Figure 2.2 Attachment of the insulating materials onto the walls surface

2.3 ASSESSMENT OF THERMAL INSULATING EFFECT THROUGH MEASUREMENT OF TEMPERATURE DIFFERENCE

The insulating effect of coconut peats, sugarcane dregs and palm oil fiber (in dried and uncompressed form) were assessed through the measurement of temperature difference when a beaker of hot water was placed for one hour inside the box. The value of initial and final temperature of the hot water were measured using food thermometer and recorded in a table. Similar action was performed with the control set. Finally, the difference between the initial and final reading was calculated and compared with the control set data. The reading with the least value of temperature difference would imply that the material lining being used provide the best insulating effect among those three materials since it has minimal heat loss which was indicated by the temperature readings.

3. FINDINGS

The efficiency of the insulating elements in terms of minimizing heat transfer were assessed through the measurement of temperature difference for different insulating materials.

Table 1 *Data tabulation for temperature difference for different insulating materials*

Insulating material	Initial temperature (°C)	Final temperature (°C)	Temperature difference (°C)
Coconut peat	87.9	40.6	47.3
Sugarcane dregs	87.9	44.5	43.4
Palm oil fiber	87.9	43.3	44.6
Control set	87.9	39.3	48.6

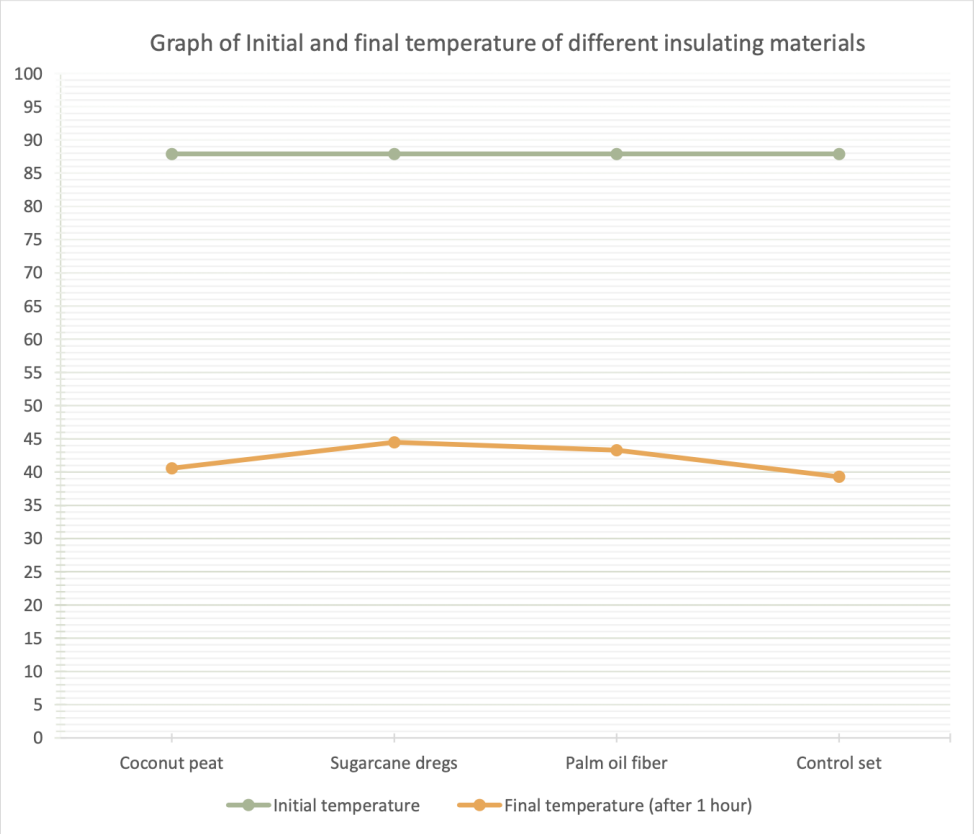

Figure 3 Graph of initial and final temperature of different insulating materials

4. DISCUSSION

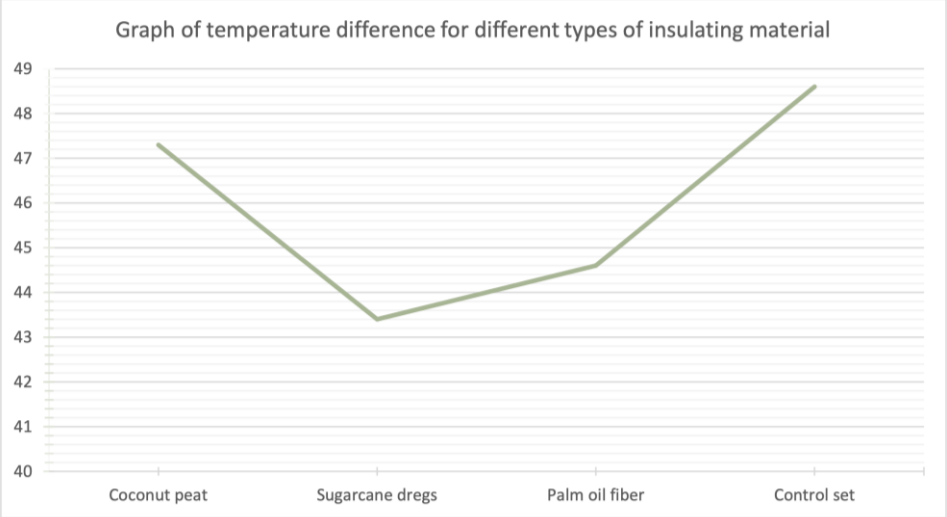

Figure 4 *Graph of temperature difference for different types of insulating materials*

From the graph of temperature difference for different types of insulating materials, sugarcane dregs provide the least temperature difference, followed by palm oil fiber and coconut peat.

Table 2 *Data tabulation for comparison of temperature difference value for different types of insulating materials against the temperature difference value for the control set.*

Type of insulating material	Temperature difference (°C)	Temperature difference value in comparison with the control set (°C)
Coconut peat	47.3	48.6 – 47.3 = 1.3
Sugarcane dregs	43.4	48.6 – 43.4 = 5.2
Palm oil fiber	44.6	48.6 – 44.6 = 4
Control set	48.6	-

Based on the comparison of temperature difference value of different materials against the temperature difference value for the control set, it is apparent that the sugarcane dregs have the highest difference in temperature compared to the uninsulated control set, followed closely by palm oil fiber. This implies that both the sugarcane dregs and palm oil fiber is more effective to retain heat compared to the coconut peat.

5. CONCLUSION

In conclusion, dried and uncompressed form of coconut peat, sugarcane dregs and palm oil fiber are capable to retain heat when it is used as thermal insulating element. This is depicted from the value of temperature difference of the different insulating materials compared to the control set in which the temperature drop is lower than that of the control set. Based on the data, it can be said that the sugarcane dregs and palm oil fiber have fairly significant capability to retain heat when it is used as thermal insulating element. Moreover, it is evident that the sugarcane dregs (in its dried and uncompressed form) is the most capable to provide minimum heat loss when it is used as surface insulation, followed closely by palm oil fiber. Meanwhile, the coconut peat provides relatively low

capability to retain heat compared to the sugarcane dregs and palm oil fiber, which depicted by the value of temperature difference of only 1.3^{o}C in comparison with the control set.

For the purpose of future investigation, other possible natural fiber or agricultural waste such as *Imperata cylindrica sp*. (*lalang* grass), lemongrass fiber etc. can be used to explore their potential in terms of heat insulation.

References

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