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BIOCOMPOSITE MATERIAL TO ENHANCE HEAT TRANSFER OF WOOD (*SHOREA FAGUETIANA AND PALAQUIM SP*) FOR GREEN BUILDING IN MALAYSIA

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ABSTRACT

This paper presents a review of material efficiency that became one of major component of green building. Selections of materials from renewable and recycled sources are encouraged since it can help to minimize environmental impact, especially on waste production. The uses of materials that contain recycled content are the third priority for selecting building products. In the construction industry, bio-composite is a new material developed for building materials. It is believe that bio-composites or natural fibre composite can be an economical material for construction. In this study, the performance of bio-composite on wood to enhance heat transfer is investigated. The models of house are building using two types of Malaysian wood, Nyatoh (Shorea Faguetiana) and Meranti (Palaquim Sp.) with addition of bio-composites from saw dust and rice husk. The results of experiment are then compared with simulation result that has done using GAMBIT and FLUENT software.

Keywords: bio-composites, CFD, green building, heat transfer.

INTRODUCTION

Generally, heat is defined as a process of energy transfer from high temperature object to lower temperature object. In tropical climate, Malaysia receives more heat because of the location at Equatorial line. Thus, buildings in Malaysia absorb lot of solar energy and lead to rise of indoor air temperature and goes beyond to a comfortable limit (Azzmi and Jamaludin, 2014).

Over the years, Malaysian construction industries are working towards green and sustainable building. According to United States Environmental Protection Agency (USEPA, 2008), green building is referring to the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle from sitting to design, construction, operation, maintenance, renovation and deconstruction. It should minimize the negative impacts on the building, occupant and environment. One of the criteria of green building is energy efficient. However, recent study shown that, in construction of building in Malaysia, the uses of air conditioning systems are increased, as one of a cooling strategy (Isa, Zhao, and Yoshino, 2010). This is among major contributor towards energy demands and carbon emission.

Other than that, material efficiency also becomes an important component of green building (Joseph and Tretsiakova-McNally, 2010). Selections of materials from renewable and recycled sources are encouraged since it can help to minimize environmental impact, especially on waste production. The uses of materials that contain recycled content are the third priority for selecting building products (Kibert, 2013). In the construction industry, bio-composite is a new material developed for building materials. It is believe that bio-composites or natural fibre composite can be an economical material for construction (Drzal *et al.*, 2004) . Bio-composites are used for exterior construction, window and door, bio-composite panels, and many others (Jamaludin *et al.,* 2011).

In this study, the performance of bio-composite on wood to enhance heat transfer is investigated. The models of house are building using two types of Malaysian wood, nyatoh and meranti with addition of bio-composites from saw dust and rice husk. The results of experiment are then compared with simulation result that has done using GAMBIT and FLUENT software.

Malaysia's climate

Geography

Malaysia is divided into two regions, which are West Malaysia named Peninsular Malaysia and East Malaysia that separated from Peninsular Malaysia by South China Sea, which is known as Borneo. Malaysia located between 2° and 7° north of Equator line with approximately 330 300 km^2 total area. More than half of Peninsula Malaysia is covered with mountains of 150 meters (492 ft) above sea level. Malaysia consists of 878 islands, with the largest island is Labuan, which has an area of 92 km^2 (UNEP, 2011).

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Temperature

As a tropical country, Malaysia experienced a year round tropical climate, with hot and humid weather. Malaysia also has a uniform temperature around 20-30°C while the annual variation is less than 2°C except for East Cost areas due to cold surges from Siberia during Northeast monsoon. Although during the day are usually hot, the night are cooler (UNEP, 2011).

Relative humidity

Malaysia also has a high relative humidity, around 70-90 percent and varies according to place, height and months. The highlands have lower humidity levels, besides cooler and wetter, cause a large temperature variation between low and high land. The minimum daily mean can be as low as 42% during the dry month and during wet months; the maximum relative humidity can reach up to 70% (UNEP, 2011).

Precipitation

Precipitation is high in most part of Malaysia. Due to monsoon seasons, East Malaysia receives high rainfall between November to January, while June and July are the driest month in most region. Other than southeast coastal area, the rest of Peninsular Malaysia undergo two periods of maximum rainfall (October-November and April- May), separated by two periods of minimum rainfall (January- February and June-July). In East Malaysia, it receives 5080mm of rain a year, while West Malaysia receives 2500mm rain a year (Malaysian Meteorological Department, 2013).

Solar radiation

Due to the location at Equator line, Malaysia receives a lot of sunlight and solar radiation. On the average, Malaysia receives sunlight around 6 hours a day. Alor Setar and Kota Bharu receive the longest period of sunlight which is 7 hours per day, while Kuching receives sun light only 5 hours per day on the average. Solar radiation is related to the duration of sunshine (Malaysian Meteorological Department, 2013).

Heat transfer

Heat transfer related to the rate of heat transfer between different medium. The process always involves the transfer of energy as heat, from higher temperature bodies to lower temperature. Heat transfer stop once it reaches equilibrium state. Calculation of the heat loss from building surface to the surrounding can be done by determine the analysis of heat transfer. The comfort of occupants in a room also can be determined by a balance of heat transfer from the person to the surrounding air as well as transfer of heat from interior wall (Mazlan *et al*., 2013).

Modes of heat transfer

There are three modes for heat transfer, which are conduction, convection and radiation. Understanding of the fundamental of heat transfer will help to aware the processes that take place in a building and its influence to the external environment

Conduction

Thermal conduction is the process of heat transfer from one medium (high temperature) to another adjacent medium (lower temperature). The rate of heat conduction is depends on the geometry of the medium, thickness and the material of the medium. In the study by Cengel (2008), they concluded that the rate of heat conduction through a plane layer is proportional to the temperature difference across the layer and the heat transfer area, but is inversely proportional to the thickness of the layer. The process of heat conduction is illustrated in Figure-A1.

Rate of heat conduction is represented as Q. It can be calculated by the equation:

$$Q = kA\frac{T_1 - T_2}{L}$$

where: *k* is thermal conductivity of material
T_2 is outdoor temperature
A is surface area
L is thickness of wall
T_1 is indoor temperature

Convection

Convection is energy transfer between a solid surface the contact with moving liquid or gas. In other word, it involves the combination of conduction and fluid motion. It is believes that the faster the fluid motion, the greater the convection heat transfers (Mazlan *et al*., 2014).

Heat convection can be calculated by the equation:

$$Q_{conv} = hA_s(T_s - T_\infty)$$

Where: *h* is convection heat transfer coefficient
A_s is surface area
T_s is surface temperature
T_∞ is temperature of fluid that contact with medium

Radiation

Radiation is the emission of energy in the form of electromagnetic waves (or photons) such as infrared or visible light, by matter as a result of the changes in the electronic configurations of the atoms or molecules.

Different from conduction and convection, it does not require any medium for transmission (Cengal, 2008).

(Mazlan *et al*., 2014) stated in their studied on heat transfer in using three dimensional numerical analysis of heat and fluid flow in computer. 3D model of microprocessors is built using GAMBIT and simulated using FLUENT software. The study was made for two microprocessors arranged in line under different types of inlet velocities and package (chip) powers.

GREEN BUILDING IN MALAYSIA

Green Building Index (GBI) was launched in Malaysia on 21 May 2009 that acts as a rating tool for green building in Malaysia to assist architects, designer, builders, property owners, government bodies, developers and end users to understand the impact of each design of building toward the environment (Shareena, Ibrahim, and Maimunah, 2013).

In Tenth Malaysian Plan, Malaysia focuses on energy conservation and greenhouse gas reduction. The New Energy Policy has developed and identified five approaches to ensure the effectiveness of the plan, which are:

a) Cost effective for energy supply, by taking into account current economic condition and affordable.
b) The strategic plan of energy efficient including renewable energy.
c) Energy efficiency in all industries.
d) Market pricing of energy with the mitigation the impact on low income group.
e) Integrated approach for New Energy Policy.

In Malaysia, it has been noted that buildings are consumed almost a third of the overall energy consumption and need some attention. Malik and Rodzi (2008) stated that, to reduce the heat build up in the building, use the natural resources before consider to utilise any energy saving mechanical aids. By doing so, it help to reduce energy consumption in Malaysia. About 70 % of energy consumption is contributed for cooling environment. Its agreed by Isa, Zhao, and Yoshino (2010), cooling system consumed more than a fifth of the total energy consumption.

Four strategies for energy efficient

According to Malik and Rodzi (2008), there are four strategies that used by Energy Auditing for exist building or as guidelines for new building. For the architects, this strategies is useful for design and concept of the building, while for electrical and mechanical engineering, they use this for design the system of building (Malik and Rodzi, 2008).

a) First strategy: maximize the merger of passive design into the building design. A good design can minimize the used of energy such as light bulb by use a natural lighting from sunlight (Malik and Rodzi, 2008)
b) Second strategy: utilize the energy efficient appliances. This kind of appliances used less energy. In Malaysia, refrigerators in one of top runner programs by Malaysian Government to introduce energy efficient refrigerator (Malik and Rodzi, 2008).
c) Third strategy: this approach is requiring attitude building, changing the mindsets and monitoring. Its need cooperation and awareness from society.
d) Forth strategy: use of any renewable energy. This approach sometimes costly. For example is installing a photovoltaic system (Malik and Rodzi, 2008).

Building material in Malaysia

In Malaysia, the main building materials used for construction are woods and brick. Traditional Malay house usually used sustainable building materials such as timber or bamboo walls with thatched roof. The design of the house are appropriate with the local climate that use various ventilation and solar control devices and low thermal capacity building materials (J. Y. Lim, 1987; Talib and Sulieman, 2001).

Nowadays, there are numerous traditional and modern hybrid house are built. In addition to hybrid house, terrace house has also dominated the housing industry as the most developed home. The development of terrace house is to meet the current population in Malaysia that increase from day to day. In most modern house, the materials which high thermal capacities are used such as brick, concrete and zinc. These kinds of materials will absorb a lot of heat that will be radiate to the interior of the building and cause thermal discomfort to the occupants (J. Y. Lim, 1987).

Relationship between heat and building material with Malaysia's climate

Due to high solar degree, Malaysia receives continuous supply of sunlight. This situation causes excessive heat in the building (Azzmi and Jamaludin, 2014; Malik and Rodzi, 2008). It is found that the ideal thermal comfort for Malaysian is between 24°C to 28° (Malik and Rodzi, 2008).

In Malaysia, the traditional Malay house is built with minimum mass and optimal hollow, using low thermal cavity and high insulation materials, which are the most ideal for thermal comfort in Malaysia climate. Examples of the materials that have the characteristics are wood, bamboo and attap, that have a good insulating properties and carry less heat into the house (J. Y. Lim, 1987). While Malik and Rodzi (2008) stated that the criteria for the most suitable comfortable thermal environment in Malaysia are to have large space for air movement and a cool surrounding.

In the studied by Malik and Rodzi (2008), they explained on the important of selecting appropriate materials for building. When the sunlight penetrates into the building, the high density floor will heat up. It is because the floor will absorb the heat from sunlight and stored in the floor. If the material of the floor is finished in absorbing the heat, the floor will reradiates the heat to the air and causes rising in temperature of the surrounding air. The thick floor causes the heat traps in the material and will radiate during night due to the low temperature of air. It follows the theory of heat transfer, which it heat transfers from high temperature to low temperature (Azzmi and Jamaludin, 2014; Malik and Rodzi, 2008).

Bio composites

Bio composites are composites materials made from natural fibre and petroleum-derived non-biodegradable polymers like PP, PE and epoxies or biopolymer like PLA and PHAs. While composites materials are derived from biopolymer and synthetic fibres such as glass and carbon also comes from bio composites. Bio composites derived from plant-drive fibre (natural/ biofiber) and crop/bio derived plastic (biopolymer/ bioplastic) are more eco-friendly (Mohanty *et al*., 2005).

Simulation

Among the commercially available avalanche General definition of simulation is imitation of a system. According to Robinson (2004), a simulation is prediction of the performances of an operations system under a specific set of inputs. The purpose doing simulation is to obtaining a better understanding of or identifying improvement to a system (Robinson, 2004).

More investigation can be made by using simulation model over thermal balance for specific thermal zones in the building models in order to seek a better understanding where the thermal insulation could result in higher benefits for thermal performance in hot and humid climate (Westphal, Yamakawa, and Castro, 2011). Computer modeling and simulation are used to assist in exploring the parameter space, thus reducing or eliminating subsequent physical experimentation (Kamke *et al.,* 2005).

FLUENT is a computational fluid dynamics (CFD) software package to simulate fluid problems. It uses the finite-volume method to solve the governing equations for a fluid. It provides the capability to use different physical models such as incompressible or compressible, in viscid or viscous, laminar or turbulent.Geometry and grid generation is done using GAMBIT which is the preprocessor bundled with FLUENT (Mazlan *et al*., 2013).

MATERIALS AND METHODS

Introduction

This experiment involves experimental method and simulation method. This chapter will discuss the raw material used for biocomposites and type of wood. Besides that, preparation of biocomposites also discussed. To find the effect of biocomposites towards heat transfer of wood, we need to take indoor temperature. This is why model of the house need to be made. This chapter also discusses on the simulation method.

Product design

House model

House model were built to determine the inside and outside temperature of the model as mimic to the real situation of the house. Two models were made by using Nyatoh wood and Meranti wood. During data collection, the biocomposites were place inside the box.

Wall

The biocomposites was layered with wood, with biocomposites at the inside while wood at the outside. The thickness of wood and biocomposites is 1.0cm. The area of wall also same for all types of wood and biocomposite with 15cm x 15cm.

Bio-composite materials

Four main material for biocomposites were selected, which are rice husk, clay, cocnut fiber and saw dust. This four material were used to make three types biocomposite boards.

Types of biocomposites are:

a) Rice husk (Bc 1): rice husk is the outer part of of rice grain and obtained during milling process as a waste. According to Johnson and Yunus (2009), the properties of rice husk like low bulk density, availibility, thoughness, resistance to weathering are the reason of rice husk used in construction industry. The existane of silica in rice husk as shown in the Table-A1 give pozzolanic effect to the rice husk that give strengh.
b) Mud brick with coconut fiber (Bc 2): in Thailand, adobe brick containing rice husk is widely used. Raw material for mud brick are clay and natural fiber. Clay is felxible when wet but harden when dry. The properties of clay is based on the amount of water in clay. Mud brick walls has ability to slow down the conductivity of heat during the day but emit heat at night to warm the surrounding air (Lertwattanaruk and Choksiriwanna, 2011).
c) Saw dust with coconut fiber (Bc 3): saw dust is not used widely in construction, but is still used in

concrete (Bdeir, 2012). In production of particleboard, the fuction of saw dust is as filler in the particleboard.

Wood

Yellow Meranti

Meranti is a commercial name of four groups from *Shorea* species. Group of Meranti is separated by the basis of heartwood and weight. In this study, yellow Meranti or *Shorea faguetiana* was used. The color of this wood is light yellow. Air dry density of yellow wood ranges from 510 to 875 kgm^{-3}, average density is $670kgm^{-3}$. This wood is less durable and susceptible to powder post beetle attacks in sapwood. This wood is suitable for planking, light construction, paneling, furniture and flooring (Choo, Gan, & Lim, 1998).

Nyatoh

Nyatoh is light and medium softwood. Scientific name of Nyatoh is Palaquium spp with dark brown colour. The density of Nyatoh is ranges from 400 to 1075 kg m^{-3} air dry. Durability of this wood is good. It is suitable for furniture manufacture, indoor finishing, and panelling (Lim *et. al*, 1999).

Preparation of bio-composites board

Preparation of biocomposites is differ based on the usage of resin. For production of Bc 1 and Bc 3, it used resin to glue the biomass together, while Bc 2 not requires resin. Thus, preparation process is dividing into two. It involves several stages to complete the biocomposite boards.

Bc 1 and Bc 3

Preparation of raw material

Raw materials, which are rice husk and coconut fiber, were ground to the size of 5mm. Then, all the materials including saw dust was heated in the oven for 12 hours at 90°C.

Preparation of board

The materials were weighted before blended manually due to the limitation of equipment. The materials were stirred manually in rotation and added latex resin to mix the material together. The glued material were pressed using manual compressor and leave it for 2 hours. The ration of raw material to binder is based on try and error. The appropriate ratio for both type of raw material to binder for saw dust to ration is 1:1, while ration of saw dust to coconut husk to binder is 2:1:1.5. After that, heat the biocomposites in the oven for 24 hour at 100°C to dry it.

Bc 2

Clay was obtained from Sungai Jeli. Then, the clay was needed, while adding coconut fiber until the mixture attained a uniform consistency. The ratio used for this mud brick is based on try and error. The appropriate ratio for clay to coconut fiber is 3:2. Then, the clay was put in the mold and dries it into the oven for 24 hour at 100°C.

Simulation

This research is an experimental study with a significant amount of trial and error. The scope of this research work is to study a sandwich panel fully made of natural raw materials (agricultural waste) and urea-formaldehyde as a resin. The main purpose of this thesis work is to investigate the potential for the bio-based materials as an alternative for conventional panel, through evaluating it by mechanical properties of temperature which is thermal insulation.

In this research the simulation of heat transfer and the temperature curve in the bio-composites materials combining with the solid wood panel will be compute out using gambit and fluent software. Comparison of temperature profiles of the material in the combined panel with the traditional solid wood panel using constant temperature heat source and linearly varying temperature of the heat source for unsteady state will be done.The geometry used is very simple, similar to muffle furnace.

The problem will be solved by using the software package FLUENT - GAMBIT and the result from the simulation will be compare with the experimental result ,as simulation method will be not influence by any external factors while the experimental method will be influence by some external factors. Thus by comparing results from these two methods we can get the most accurate result.

Simulation analysis

The simulation model was design with the complete geometry and dimension using GAMBIT software. The mesh of the model was meshing using suitable meshing type. The boundary conditions of simulation model were stated. Then, the data of the model like material properties and so on were key in. The simulation model were run using FLUENT software.

RESULT AND DISCUSSIONS

Introduction

This research was aim to study the ability of biocomposites to enhance heat transfer of wood.

Model of houses was built to measure the difference between indoor and outdoor temperature to find heat transfer of biocomposites. Data discussed by day for a month and hours in the form of graph and

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charts.

A second objective is to compare the simulation and experimental analysis of the heat transfer of biocomposites. The purpose to compare the simulation and experimental analysis is to validate the experimental result and to configure the performances of the systems (Barberousse, Franceschelli, and Imbert, 2009; Maria, 1997) .

Physical properties of biocomposites

In this study, types of materials for biocomposites play an important role in reduction of indoor temperature. Based on observation on the finish biocomposites board, every board has different structure and characteristic.

As we can see from Figure-1, the ground rice husk shows a good surface texture of biocomposites. Rice husk produces light biocomposites due to lot of cavity inside it. This biocomposites was labeled as Bc 1.

Figure-2 is a biocomposites from the mixture of clay and coconut fiber. The texture of the biocomposites is rough and heavy. There are some samples were crack. It may be because of wrong composition of clay and coconut fiber. However, by addition of coconut fiber prevent the mud brick from rupture because it improve the cohesion among mud particle and hold the particle together (Dutta *et al*, 2012; Sreekumar and Nair, 2013).

Figure-3 show biocomposite from coconut fiber and saw dust. The appearance of this biocomposite is similar to the commercial particle board and medium in weight.

Figure-1. Biocomposite from rice husk (Bc 1).

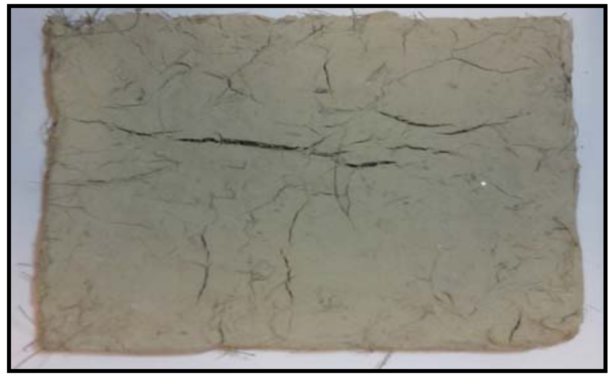

Figure-2. Biocomposite from combination of clay and coconut fiber (Bc 2).

Figure-3. Biocomposite from mixture of coconut fiber and saw dust (Bc3).

Experimental result

The data of indoor and outdoor temperature of the model were collected from 1 November to 30 November manually using thermometer due to limitation of equipment. The temperature was measured every day at 12.00pm at open spaces. The data were demonstrated in shows the comparison of indoor temperature of different types of biocomposite materials and wood, with outdoor temperature to show the changes of temperature with and without biocomposites. Outdoor temperature is referring to surrounding temperature.

In general, outdoor temperature is lower than indoor temperature for any types of wall material as we can see from Figure-4. It cause by sun radiation that absorbed by the model and increase indoor gains energy that brings warm into the building, thus create indoor temperature higher than outdoor (Azzmi and Jamaludin, 2014; Karyono, 2010).

The lowest outdoor temperature recorded is 32°C at 8, 13, 16, 18 and 29 November 2014, while for indoor temperature is 32.8°C by M+Bc2 on 11 November 2014. It may be due to the weather of that day. Usually, rainy day records low temperature for outdoor and indoor

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due to high humidity. The highest outdoor temperature recorded is 36.8°C on 4 November, while 39°C is the highest indoor temperature by Nyatoh wood on 21 November.

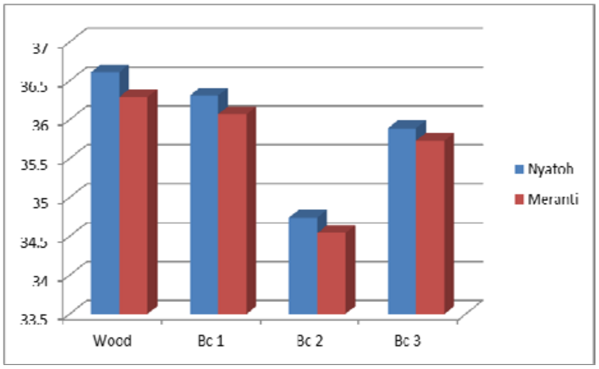

Figure-4. Comparison of average indoor temperature for different types of materials.

From Figures 1 to 3, the averages of indoor temperature were determined. The model made from Nyatoh wood without biocomposites records the highest indoor temperature every day with the average of 36.61°C. From the Figure-4, we assumed that Nyatoh has a low ability to transfer heat from indoor to outdoor by heat conduction. However, it's can't be proven because lack of data to determine thermal conductivity of each material. The figure above shows that on the overall Meranti has ability to reduce indoor temperature.

From Figure-4, heat reduction between biocomposites also been compared. Biocomposites Bc 2 shows a significant decline in indoor temperature for both type of wood, which are 34.74°C for Nyatoh and 34.54°C for Meranti. Clay has ability to absorb heat during hot day and keeping the house cool. It is because of its thermal properties, which is high specific heat capacity that lessen the thermal gradient of the house (Revuelta-Acosta *et al*, 2010).

Heat convection

From Figure-4, heat reduction between biocomposites also been compared. Biocomposites Bc 2 shows a significant decline in indoor temperature for both type of wood, which are 34.74°C for Nyatoh and 34.54°C for Meranti. Clay has ability to absorb heat during hot day and keeping the house cool. It is because of its thermal properties, which is high specific heat capacity that lessen the thermal gradient of the house (Revuelta-Acosta *et al*, 2010).

One of modes of heat transfer is heat convection. Heat convection involves transfer of energy between a solid surface with adjacent gas or liquid in motion. This process occurs at the surfaces of walls, floor and roof. Temperature different between fluid and the contact surface, lead to variation of density in the fluid and resulting in buoyancy. This phenomenon cause heat exchange between solid surface and fluid.

Heat convection of the house model from Nyatoh and Meranti is calculated based on the value from Figure-4 and shown in Table-1.

Table-1. Heat convection of different types of material.

Materials	Q_{conv} (w)
Nyatoh	1.075
N+ Bc1	0.993
N+ BC2	0.570
N+BC 3	0.879
Meranti	0.987
M + Bc1	0.930
M +Bc 2	0.516
M+ Bc 3	0.836

From Table-1, between Nyatoh and Meranti, process of convection heat transfer occurs highly in model of Nyatoh wood compare to Meranti. This is explaining the reason of high indoor temperature in Nyatoh model.

When comparing heat convection between both type of wood with and without biocomposites, it's found that biocomposite reduce heat convection of wood, especially Bc 2 biocomposites with 0.570W for Nyatoh and 0.516W for Meranti. It is because of the difference of thickness between control model (without biocomposites) and with biocomposites. According to (Glicksman, 2010), as the board is thicker, heat transfer will penetrate a further distance from the board surface. The thermal boundary layer thickness will increase and the heat transfer coefficient will be smaller.

Simulation result

Simulation analyses show the contour of indoor temperature of different materials. The analysis of simulations used same parameters as experimental methods, which are thickness, area, density, thermal conductivity, heat transfer and weight. The simulation is design follows the design of the box used in experimental.

The results from simulation show the contour of indoor temperature of different type of materials. Referring to Tables 2 and 3, at centre of the images in green or blue color indicate the lowest temperature in the box, while the red colors show the highest temperature. To read the temperature, refer the temperature indicator in the time column.

Generally, the images shown in Table-2 and

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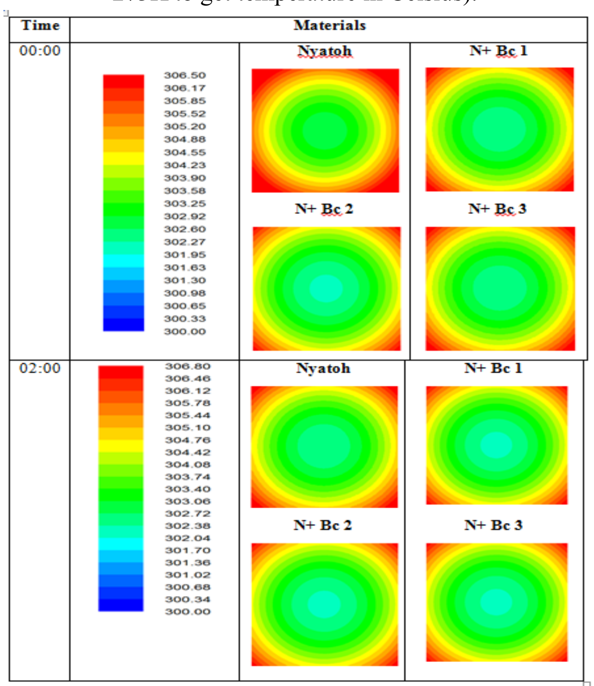
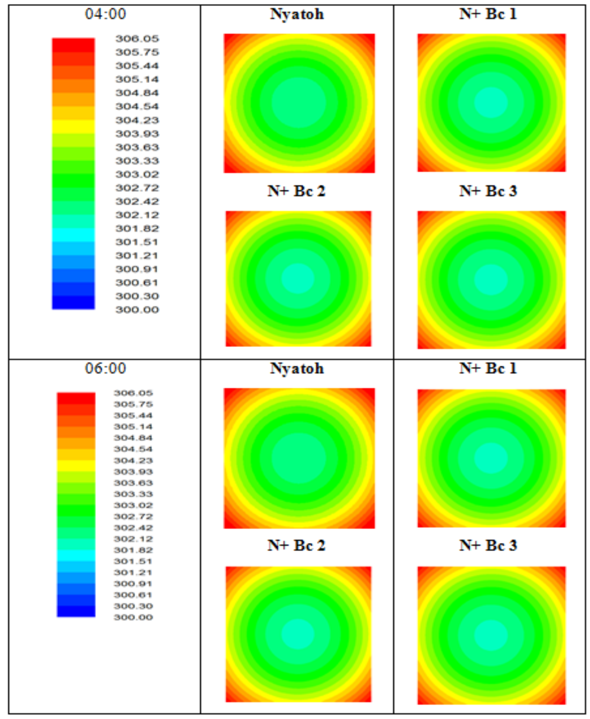
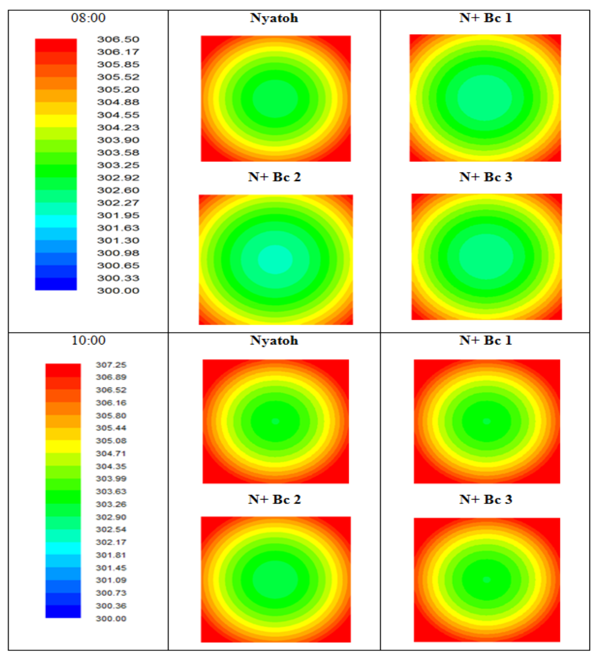
Table-3 indicate the temperature inside the box at different times. Most of the images demonstrate the colder temperature at centre and hotter at the side of the box. It is because the heat is conducted to the wall, which is in low temperature that the air temperature inside the box. This phenomenon leads to the reducing of the indoor temperature and increasing wall temperature. Then, the wall, which is warmer than outdoor temperature will enhance convection of heat of the surrounding temperature due to the different of temperature.

At 12.00 am to 8.00 am, most of the indoor temperature is low. It is strongly influenced by the relative humidity of the atmosphere that high during midnight to morning. Then, from 10.00am to 20.00 pm, the temperature relatively high about 30 to 36.5°C. However, at 22.00 pm, Meranti and Nyatoh shows a significant different, where we can see that Meranti is colder than Nyatoh.

Table-2. Simulation result for Nyatoh in Kelvin (subtract 273K to get temperature in Celsius).







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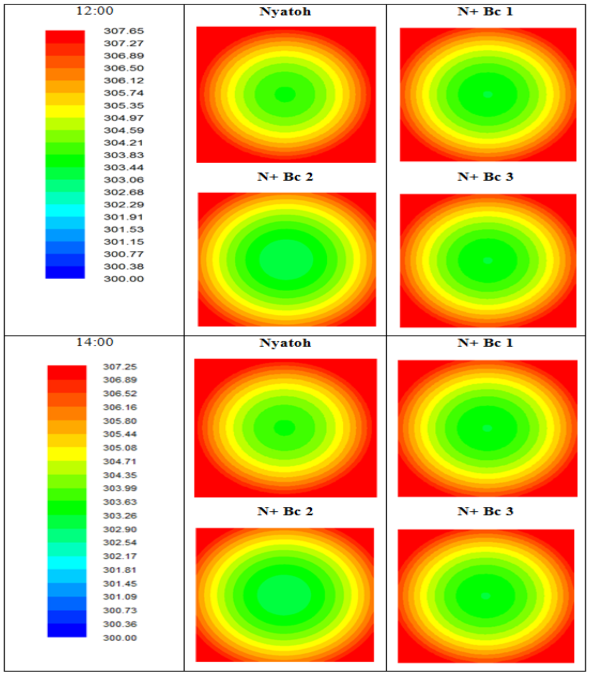
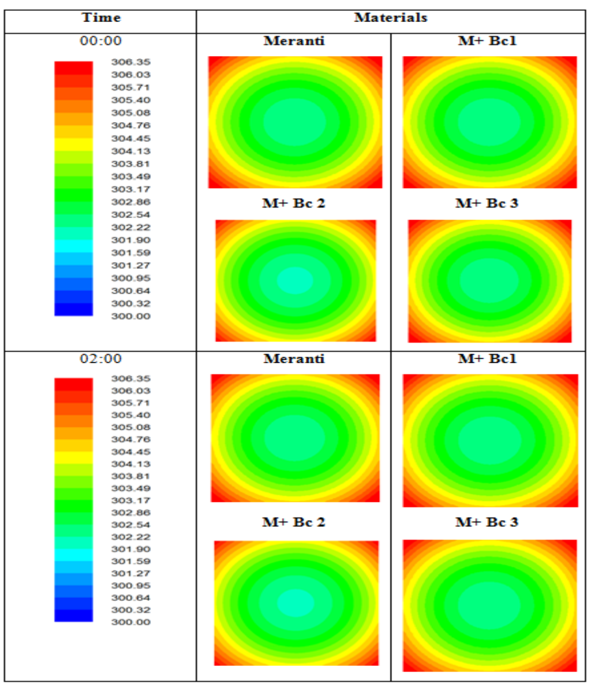
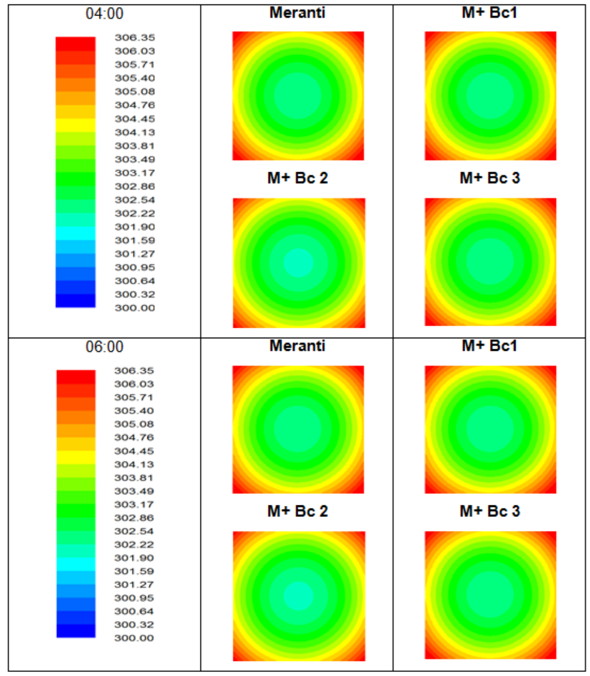
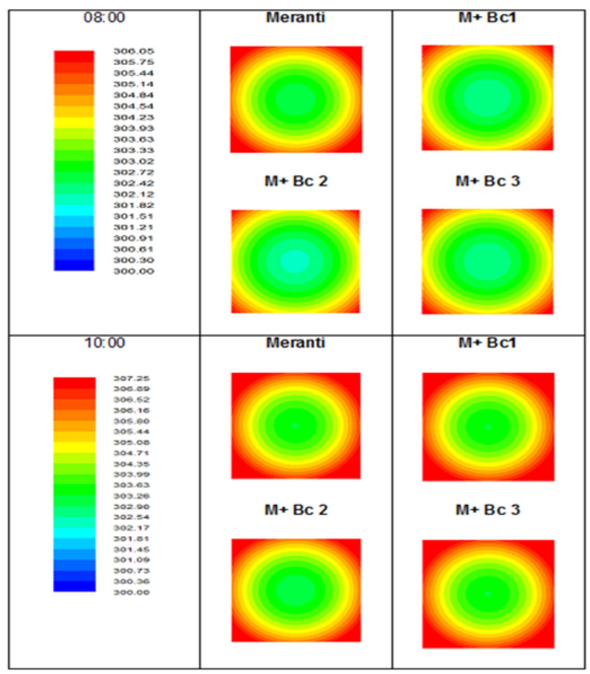


Table-3. Simulation result for Meranti (subtract 273K to get temperature in Celcius).







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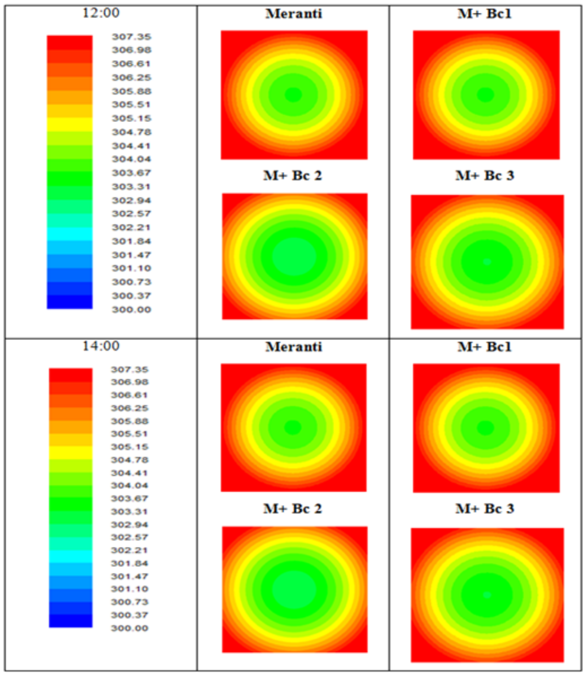

PERCENTAGE OF DIFFERENCE

Comparison between experimental and simulation

Table-4. percentage of differences between experimental and simulation.

	% differences	
	Nyatoh	**Meranti**
Reference model	0.382	0.358
Bc 1	0.083	0.5
Bc 2	1.567	0.843
Bc 3	0.363	1.35

Percentage of differences between simulation and experimental were calculated from Figure-4. From table above, overall percentage of differences between simulation and experimental is small, which is around 0.3-1.6%. For Nyatoh, the maximum difference between result of simulation and experimental was shown by Bc 2 with 1.567 percent difference. While reference model, Bc 1 and Bc 3 are 0.382%, 0.083% and).363% respectively. However, the highest percentage of difference between simulation and experimental result from model made by Meranti is from Bc 3 with 1.35 percent. Then, it follows by Bc 2 with only 0.843 percent. While difference between experiment and simulation of Bc 1 and reference model are 0.5 and 0.358 percent each.

After comparing the result between simulation and experimental, we found that the difference between this two method is very small and below 5%. It does prove that the simulation result by using CFD software is an excellent tool to predict thermal contour and distribution.

Comparison between biocomposites

Table-5. Percentage of difference when using biocomposites.

	Nyatoh	Meranti
Bc 1	0.82%	0.44%
Bc 2	5.24%	4.78%
Bc 3	1.99%	1.39%

The differences between indoor temperatures of Nyatoh with biocomposites was calculated and shown in Table-5. When using biocomposite Bc 2, the percent of indoor temperature is reduced by 5.42 percent from indoor temperature of solid Nyatoh. Biocomposites Bc 3 also show a difference in reduction of indoor temperature by 1.99 percent from indoor temperature of solid Nyatoh. However, biocomposites Bc 1 show a slight lessening of temperature of 0.82 percent.

Heat reduction improvement to 4.78 percent over the reference model has been observed for Meranti stabilized with Bc 2 biocomposites. It's follow by biocomposite Bc 3 and 1 with 1.39 percent and 0.44 percent respectively.

CONCLUSIONS

In a conclusion, different raw material for biocomposites has different thermal properties. These differences make certain biocomposites preferable in different application.

In this study, three types of biocomposites were prepared by different types of raw material. Types of raw material used are rice husk, mixture of saw dust and coconut fiber and mixture of clay and coconut fiber. Then, the biocomposites were installed in the house models that made from Nyatoh and Meranti. The data of indoor and outdoor were taken at the open spaces at 12.00 pm every day. While on 25 November, the data were recorded every 2 hours for 24 hours.

From the heat convection calculated for each biocomposites, it shows that the biocomposites reduce heat convection of indoor temperature of wood building. However, previous researches explain that it is because heat conductivity of material is high. Besides that, simulation results also show positive finding. The images generated from simulation shows the contours of temperature inside the model. Intensity of heat were demonstrated clearly, biocomposites transfer warm heat to the wall and leave inside temperature cool.

From the reading of indoor temperature, we found that biocomposites from clay has a highest cooling effect in indoor temperature. Both reading of clay biocomposites from Nyatoh and Meranti wood shows the lowest value. It follows by biocomposites from saw dust and rice husk.

After comparing the result of simulation and experimental by percentage of difference, it is proven that the simulation by CFD is an effective tool to predict the thermal contour and distribution of tested materials.

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REFERENCES

Abdou A. A. and Budaiwi I. M. 2005. Comparison of Thermal Conductivity Measurements of Building Insulation Materials under Various Operating Temperatures. Journal of Building Physics. 29(2): 171-184.

Agarwal P. 2009. Simulation of Heat Transfer Phenomenon in Furnace Using Fluent-Gambit of. The Department of Mechanical Engineering National Institute of Technology Rourkela.

Azzmi N. M. and Jamaludin N. 2014. A Review of Heat Transfer in Terraced Houses of Tropical Climate 2 Heat and Building Design Interaction in Tropical Climate of Malaysia. In Emerging Technology for Sustainable Development Congress (pp. 10-15). Bangi: EDP Sciences.

Cengel Y. A. 2008. Heat Transfer. In Introduction to Thermodynamics and Heat Transfer (2nd Edition. pp. 371-403). Nevada: Mc Graw Hill Higher Education.

Chitra N. J. and Vasanthakumari R. 2012. STUDIES ON POLYPROPYLENE BIO COMPOSITE WITH CORN HUSK WASTE. 3(7): 1-3.

Choo K. T., Gan K. S. and Lim S. C. 1998. Timber Notes - Light Hardwoods I (p. 8). Kepong.

Drzal L. T., Mohanty A. K., Burgueño R. and Misra M. 2004. Biobased Structural Composite Materials for Housing and Infrastructure Applications : Opportunities and Challenges. In Proceeding of the NSF Housing Research Agenda Workshop (pp. 129-140).

Dutta R. K., Khatri V. N. and Gayathri V. 2012. Effect of Addition of Treated Coir Fibres on the Compression Behaviour of Clay. Jordan Journal of Civil Engineering. 6(4): 476-488.

Glicksman L. R. 2010. Heat Transfer. In Fundamental of Energy in Buildings. MIT.

Greeff A. 2005. It’s rubbish !’ A study of recycled materials to use as interior partitioning in social housing Housing in South Africa. In World Congress on Housing Transforming Housing Environment through Design (p. 9). Pretoria.

Howe J. C. 2010. Overview of Green Buildings. In M. B. Gerrard (Ed.), The Law of Green Buildings: Regulatory and Legal Issues in Design, Construction, Operations, and Financing. (pp. 3-14). United States: American bar Assocoiation.

Isa M. H. M., Zhao X. and Yoshino H. 2010. Preliminary Study of Passive Cooling Strategy Using a Combination of PCM and Copper Foam to Increase Thermal Heat Storage in Building Facade. Sustainability. 2(8): 2365-2381.

Jamaludin mohamad yatim, Hafizah abd khalid nur and Reza M. 2011. BIOCOMPOSITES FOR THE CONSTRUCTION MATERIALS AND STRUCTURE. 2011 (pp. 1-29). Johor.

Joseph P. and Tretsiakova-McNally S. 2010. Sustainable Non-Metallic Building Materials. Sustainability. 2(2): 400-427.

Kamke F. A., Watson L. T., Lee J. N. and Shu J. 2005. A problem solving environment for the wood-based composites industry.

Katipamula S., Turner W. D., O’neal D. and Murphy W. E. 1987. Experimental study of heat transfer in attics with small scale simulator. In ASHRAE Conference (Winter Conference) (pp. 122-133). New York: ASHRAE Trans.

Kibert C.J. 2013. Sustainable Construction: Green Building Design and Delivery. Third Edition. New Jersey: John Wiley and Son, Inc.

Lertwattanaruk P. AND Choksiriwanna J. 2011. The Physical and Thermal Properties of Adobe Brick Containing Bagasse for Earth Construction. Built. 1(1): 53-62.

Lim J. Y. 1987. The traditional Malay house. In The Malay House: Rediscovering Malaysia's Indigenous Shelter System. (pp. 73-97). Institut Masyarakat.

Lim S., Choo K. and Gan K. 1999. Timber Notes - Light Hardwoods V. Timber Technologt Buletin (p. 8). Kepong.

M. Mazlan, A. Rahim, M. A. Iqbal, A. M. Mustafa Al Bakri, W. Razak and M. R. Mohd Sukhairi. 2013. The Comparison between Four PLCC Packages and Eight PLCC Packages in Personal Computer (PC) Using Computational Fluid Dynamic (CFD), FLUENT SoftwareTM Using Epoxy Moulding Compound Material (EMC). Advanced Materials Research. 795: 174-181. doi:10.4028/www.scientific.net/AMR.795.174.

M. Mazlan, A. Rahim, M. A. Iqbal, A. M. Mustafa Al Bakri, W. Razak, and H. M. Nor Hakim. 2013. Numerical Investigation of Heat Transfer of Twelve Plastic Leaded Chip Carrier (PLCC) by Using Computational Fluid Dynamic, FLUENTTM Software. Advanced Materials Research. 795: 603-610. doi:10.4028/www.scientific.net/AMR.795.603.

M. Mazlan, A. Kalam, N. R. Abdullah, H.-S. Loo, A. M. M. Al Bakri, M. S. A. Aziz, C. Y. Khor, M. A. A. and M. Mohd Sukhairi. 2013. Development of Nano-Material (Nano-Silver) in Electronic Components Application. Advances in Environmental Biology. (7): 3850-3856.

M. Mazlan, A. Kalam, N. R. Abdullah, H.-S. Loo, A. M. M. Al Bakri, M. S. A. Aziz, C. Y. Khor, M. A. A. and M. Mohd Sukhairi. 2013. The Effect of Gap between Plastic Leaded Chip Carrier (PLCC) Using Computational. Advances in Environmental Biology. (7): 3843-3849.

M. Mazlan, A.M. Mustafa Al Bakri, Razak Wahab, Zulhisyam A.K, Mohd Sukhairi, M.R, M. H. M. Amini, Mohammad Amizi A. 2014. Comparison between Thermal Interface Materials Made of Nano Carbon Tube (NCT) with Gad Pad 2500 in term of Junction Temperature by using CFD Software, FluentTM. Materials Science Forum. (803): 243-249. doi:10.4028/www.scientific.net/MSF.803.243.

M. Mazlan, A.M. Mustafa Al Bakri, Razak Wahab, Zulhisyam A.K, A. M. Iqbal, M. H. M. Amini, Mohammad Amizi A. 2014. Simulation of Nano Carbon Tube (NCT) in Thermal Interface Material for Electronic Packaging Application by using CFD Software. Materials Science Forum. (803): 337-342. doi:10.4028/www.scientific.net/MSF.803.337

Malik A. R. A. and Rodzi I. M. 2008. Future design in an energy efficient building as an identity of a Malaysian tropical architecture with emphasis on photovoltaic technology and passive solar building design elements (pp. 440-449). Minden, Penang: University Sains Malaysia Publisher.

Mohanty. A.K, Misra, M., Drzal LT. 2005. Natural Fibers, Biopolymers and Biocomposites. (pp. 4-5), Boca Baton: CRC Press Taylor and Francis Group.

Revuelta-Acosta, J., Garcia-Diaz, A., Soto-Zarazua G. and Rico-Garcia E. 2010. Mud brick high thermal conductvt.pdf. Journal of Applied Sciences. 10(19): 2211-1116.

Rowell RM and Stout HP. 1998. Jute and kenaf. In: Lewin M and Pearce EM (eds.) Handbook of Fiber Chemistry. 2nd edn. (pp. 465-504). New York, NY: Marcel Dekker.

Robinson S. 2004. Simulation: The Practice of Model Development and Use. Wiley.

Shareena A. A. S., Ibrahim S. and Maimunah S. 2013. The Potential of Implementing Property Tax Incentives on Green Building in Malaysia. American Jurnal of Economics. 3(2): 63-67.

Sreekumar M. G. and Nair D. G. 2013. STABILIZED LATERITIC BLOCKS REINFORCED WITH FIBROUS COIR WASTES. International Journal of Sustainable Construction Engineering and Technology. 4(2): 23-32.

Talib R. B. and Sulieman M. Z. 2001. Classification of factors contributing to sustainable issues on selected Traditional Malay Houses and Bio-climatic buildings. International Journal of Research in Engineering and Technology. 1(1).

United Nations Environment Programme. 2011. Sustainable Building Policies on Energy Efficiency: Malaysia (p. 50). Malaysia: UNEP and BCA.

Westphal F. S., Yamakawa M. A. and Castro L. T. de. 2011. Thermal Insulation of Building Envelope Toward Zero Energy Design in Hot-Humid Climate. In Proceedings of Building Simulation (pp. 2378-2384). Sydney.