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CFD SIMULATION USING WOOD (CENGAL AND MERANTI) TO IMPROVE COOLING EFFECT FOR MALAYSIA GREEN BUILDING

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ABSTRACT

In this study, heat transfer investigation is done in order to improve the cooling effect for green building without damaging the environment. This proposal is provoked by the desire to reduce the temperature for the green building and to sustain the environment and natural resources. The building industry is also a large consumer of non-renewable materials, and this trend has increased dramatically over the past century. To this end, we have been addressing sustainability concerns related to building construction materials through much research approach. It applied to building elements where we can collectively influence design, materials, construction, energy consumption and disposal. Comparison of temperature profiles of the material in the traditional wood house and green building model by using the constant temperature heat source and linearly varying temperature of the heat source for unsteady state is done. Also, the time for temperature to become steady is compared. The problem will be solved by using the software package FLUENT-GAMBIT. The parameters under analysis focused on changing the influence of exterior walls in the energy consumption for cooling the building.

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

INTRODUCTION

The purpose of green building materials is to save energy, minimize its impact on climate change and decrease the rate at which we are consuming natural resources [7]. A green building material has little or no impact on the environment [2]. Widely, it refers to an attempt to consciously create buildings with an eye to how they interact with our planet's ecosystem. In Malaysia, building surfaces such as windows, walls and roofs are exposed to the sun that can absorb heat from solar radiation, leading to an increase in the amount of energy needed for cooling purposes [3], [21].

The energy consumption in the building is affected by three factors that are technology, people and outdoor climate. These three factors determine the total amount of energy usage of a building. Currently, the first factor, i.e. technology, receives the main attention in the construction sector. Minimizing transmission and ventilation heat losses, e.g. by using efficient insulation in the building envelope with high air tightness or by using energy saving equipment such as a heat recovery system, variable air volume ventilation system or a heat pump, which all these results are improving the technical properties of the building [10].

The Malaysian building industry has over the years been developing and working towards a more sustainable and green architecture. The needs for SBRS (Sustainable Building Rating System) become more apparent with the increasing demand from building end-user for green rated building [4]. It reveals that one of the major barriers holding back the development of sustainable building in Southeast Asia is the lack of awareness of sustainability issues in the related to the profession. The survey was conducted also reveals that the Malaysian building industry players have 'little' knowledge on sustainable building assessment, rating and labelling system.

Bio-based composite wall

A sandwich material containing cork, clay and resin as natural materials was manufactured and tested in order to evaluate the thermal conductivity. As previously shown, the use of the eco-sandwich in building application is an innovative solution which suitable for well insulated light-weight structures [8]. Walls are a predominant fraction of a building envelope and are expected to provide thermal and acoustic comfort within a building, without compromising the aesthetics of the building [9].

Conventionally, insulation is placed in one of three different locations: (i) internally towards the building's interior, (ii) externally to the outside of the building shell or (iii) in between the building's outer and inner layer known as cavity insulation. Less commonly, insulation may be located in multiple layers throughout a construction or comprise the entirety of the construction. However, these rarely used solutions will not be discussed here as they do not apply to earth wall construction techniques [6].

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 an equilibrium state [18, 19]. Calculation of the heat loss from building surface to the surrounding can be done by determining 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 the transfer of heat from interior wall [12, 13].

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 depends on the geometry of the medium, thickness and the material of the medium. In the study by [14, 15], 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.

Rate of heat conduction is represented as Q. It can be calculated by the Equation. (1):

$$\mathbf{Q = kA\frac{T_1 - T_2}{L}} \quad (1)$$

where k is thermal conductivity of material, T_2 is outdoor temperature, A is surface area, L is thickness of wall and T_1 is indoor temperature.

Convection

Convection is an 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 believed that the faster the fluid motion, the greater the convection heat transfers [5, 16].

Heat convection can be calculated by the Equation. (2):

$$\mathbf{Q_{conv} = hA_s(T_s - T_\infty)} \quad (2)$$

whereh is convection heat transfer coefficient, A_s is surface area, T_s is surface temperature and T_∞ is temperature of fluid that contact with medium.

MATERIALS AND METHODS

CFD simulation (FLUENT)

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 [20]. It provides the capability to use different physical models such as incompressible or compressible, in viscid or viscous, laminar or turbulent, etc. Geometry and grid generation is done by using GAMBIT which is the preprocessor bundled with FLUENT [22].

Mesh generation FLUENT solver (GAMBIT)

GAMBIT is a software package designed to generate structured as well as unstructured mesh required for CFD analysis. GAMBIT software has been used to generate the structured grid for FLUENT simulations for all the benchmark problems [11].Fast geometry modeling and high quality meshing are crucial to the successful use of CFD, where GAMBIT gives us both GAMBIT has a single interface for geometry creation and meshing that brings together all of FLUENT's preprocessing technologies in one environment. Advanced tools for journaling which lead to use it, and conveniently replay model building sessions for parametric studies such as temperature [1].

RESULTS AND DISCUSSIONS

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

Table-1. Bio-composites indicator.

Types of bio-composites combine with wood panel	Indicator
Sawdust + Coconut husk	Bc1
Cob (Clay + Bagasse)	Bc2

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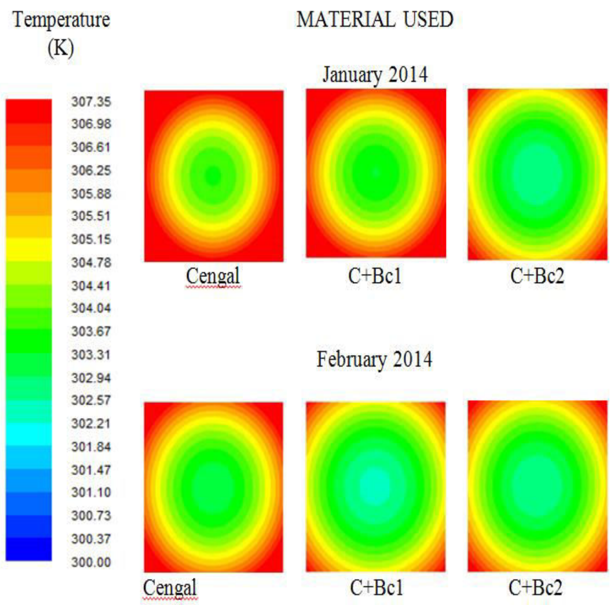
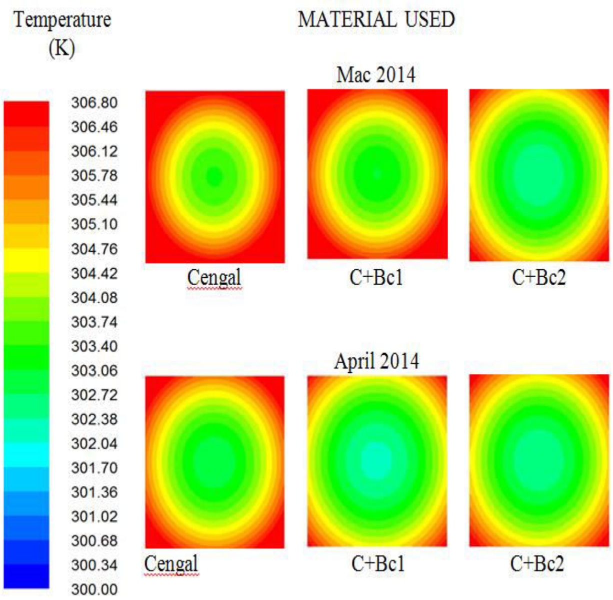
Table-2. Simulation result for Cengal in Kelvin (average temperature per month) for six months.





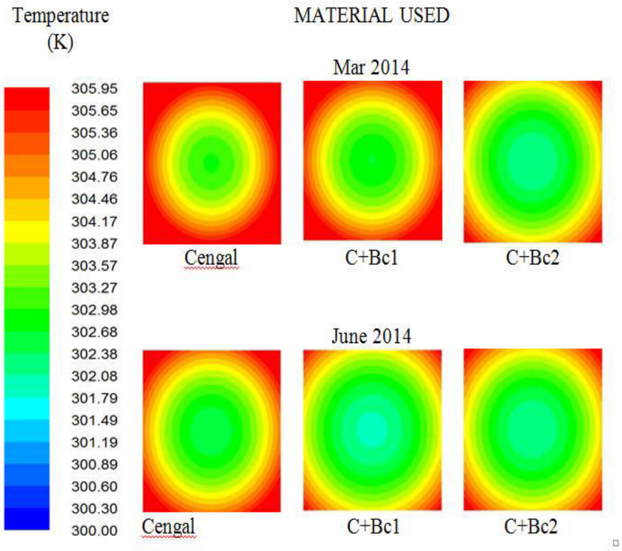
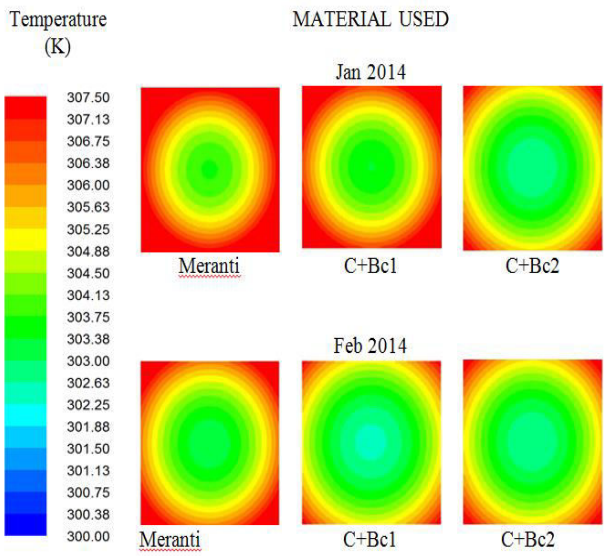


Table-3. Simulation result for Meranti in Kelvin (average temperature per month) for six months.



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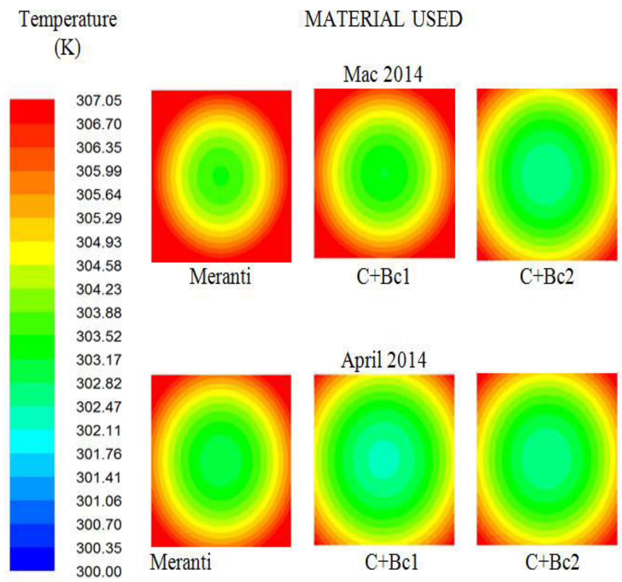

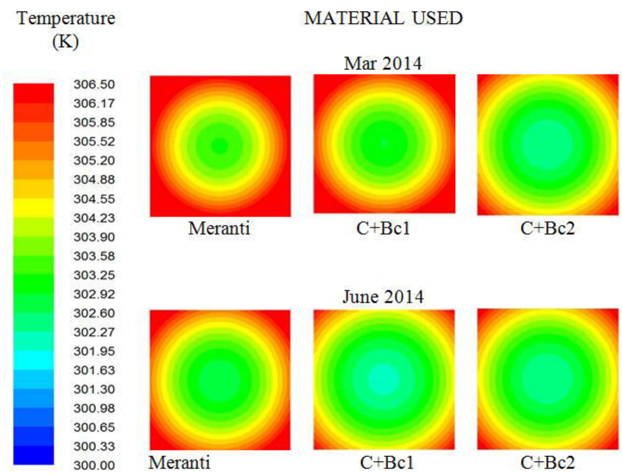

Percentage of difference

Table-4. Percentage of differences between Cengal and Meranti.

Month	Average temperature (Celsius)		%differences
	Cengal	Meranti	
Jan	33.8	34.2	1.21
Feb	32.4	34.0	4.94
Mac	31.6	33.8	6.96
April	31.2	33.4	7.05
Mar	30.8	32.6	5.84
June	30.4	32.2	5.92

CONCLUSIONS

Percentage of differences between Cengal and Meranti were calculated from Table-4. The overall percentage of differences between simulation and experimental is small, which is around 1.21-7.05%. In January 2014, the difference is the lowest compared to the others. However, the highest percentage is occurring in April 2014 whereby the difference is7.05%.

After comparing the result between Cengal and Meranti, we found that the Cengal was able to disperse heat more effectively compare to the Meranti. It is suggested by using Cengal in order to produce green building material due to its thermal conductivity and resistivity that are better compared to Meranti.

We also found that biocomposites from clay has a highest cooling effect in indoor temperature. Both readings of clay biocomposites from Cengal and Meranti wood show the lowest value. It followed by biocomposites from saw dust and rice husk.

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REFERENCES

[1] P. Agarwal. 2009. Simulation of heat transfer phenomenon in furnace using Fluent-Gambit. Doctoral dissertation, National Institute of Technology Rourkela.

[2] A. Alias, M. Mohamed, H. Yusoff, M. H. M. Amini, M. S. A. Aziz and Z. I. Rizman. 2015. The enhancement of heat transfer of wood (Neobalanocarpus Heimii, Shorea Sp, Instia Palembanica Miq) of bio-composite materials for green building in Malaysia. ARPN Journal of Engineering and Applied Sciences.10 (1): 357-369.

[3] N. A. A. Aziz, M. Mohamed, M. Mohamad, M. H. M. Amini, M. S. A. Aziz, H. Yusoff and Z. I. Rizman. 2015. Influence of Activated Carbon Filler on the Mechanical Properties of Wood Composites. ARPN Journal of Engineering and Applied Sciences.10 (1): 376-386.

[4] 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.

[5] Cengel Y. A. 2008. Introduction to thermodynamics and heat transfer. 2nd Ed.Mc Graw Hill Higher Education, Nevada, USA. pp. 371-403.

[6] Howe J. C. 2010. Overview of green buildings. In: The law of green buildings: Regulatory and legal issues in design, construction, operations, and financing. M. B. Gerrard (Eds.). pp. 3-14.

[7] S. A. Ibrahim, M. Mohamed, S. F. M. Ramle, M. H. M. Amini, M.S. A. Aziz and Z. I. Rizman. 2015. Biocomposite material to enhance heat transfer of wood (Shorea Faguetiana and Palaquim Sp.) for green building in Malaysia. ARPN Journal of Engineering and Applied Sciences. 10(1): 301-312.

[8] M. H. M. Isa,Z. Xudong and H. Yoshino. 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.

[9] P. Joseph and S. Tretsiakova-McNally. 2010. Sustainable non-metallic building materials. Sustainability. 2(2): 400-427.

[10] S. Katipamula, D. O'Neal, W. D. Turner and W. E. Murphy. 1987. Experimental study of heat transfer in attics with small scale simulator. In American Society of Heating, Refrigerating and Air-Conditioning Engineers Conference. pp. 122-133.

[11] M. Mazlan, R. Atan, A. M. M. A. Bakri, M. I. Ahmad, M. H. Yusoff and F. N. A. Saad. 2012. Three dimensional simulation of thermal pad using nanomaterial, nanosilver in semiconductor and electronic component application. Advanced Materials Research. 626: 980-988.

[12] M. Mazlan, A. Kalam, N. R. Abdullah, H.-S. Loo, A. M. M. A. Bakri, M. S. A. Aziz, C. Y. Khor, M. A. Ayob and M. R. M. Sukhairi. 2013. Development of nano-material (nano-silver) in electronic components application. Advances in Environmental Biology. 7(12): 3850-3856.

[13] M. Mazlan, A. Kalam, N. R. Abdullah, H.-S. Loo, A. M. M. A. Bakri, M. S. A. Aziz, C. Y. Khor, M. A. Ayob and M. R. M. Sukhairi. 2013. The effect of gap between plastic leaded chip carrier (PLCC) using computational. Advances in Environmental Biology. 7(12): 3843-3849.

[14] M. Mazlan, A. Rahim, M. A. Iqbal, A. M. M. A. Bakri, W. Razak and M M. R. M. Sukhairi. 2013. The comparison between four PLCC packages and eight PLCC packages in personal computer (PC) using computational fluid dynamic (CFD), FLUENT software TM using epoxy moulding compound material (EMC). Advanced Materials Research. 795: 174-181.

[15] M. Mazlan, A. Rahim, M. A. Iqbal, A. M. M. A. Bakri, W. Razak and H. M. N. 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.

[16] M. Mazlan, A. Rahim, A. M. M. A. Bakri, M. A. Iqbal, W. Razak andM. S. Salim. 2013. A new invention of thermal pad using sol-gel nanosilver doped silica film in plastic leaded chip carrier (PLCC) application by using computational fluid dynamic sofrware, CFD analysis. Advanced Materials Research.795: 158-163.

[17] M. Mazlan, A. Rahim, A. M. M. A. Bakri, W. Razak, A. F. Zubair, Y. M. Najib andA. B. Azman. 2013. Thermal management of electronic components by using computational fluid dynamic (CFD) software, FLUENTTM in several material applications (epoxy, composite material and nanosilver). Advanced Materials Research. 795: 141-147.

[18] M. Mazlan, A. M. M. A. Bakri, R. Wahab, A. K. Zulhisyam, A. M. Iqbal, M. H. M. Amini and A. A. Mohammad. 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.

[19] M. Mazlan, A. M. M. A. Bakri, R. Wahab, A. K. Zulhisyam, M. R. M. Sukhairi, M. H. M. Amini and A. M. 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, Fluent™. Materials Science Forum. 803: 243-249.

[20] M. S. A. Aziz, M. Z. Abdullah, C. Y. Khor, Z. M. Fairuz, A. M. Iqbal, M. Mazlan andM. S. M. Rasat. 2014. Thermal fluid-structure interaction in the effects of pin-through-hole diameter during wave soldering. Advances in Mechanical Engineering. 6: 1-13.

[21] N. H. A. N. Rosdi, M. Mohamed, M. Mohamad, M. H. M. Amini, M. S. A. Aziz and Z. I. Rizman. 2015. Effect of biocomposite materials to enhance durability of selected wood species (Intsia Palembanica Miq, Neobalanocarpus Heimii, Shorea Plagata). ARPN Journal of Engineering and Applied Sciences. 10(1): 313-320.

ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

[22] S. Yusoff, M. Mohamed, K. A. Ahmad, M. Z. Abdullah, M. A. Mujeebu, Z. M. Ali and Y. Yaakob, 2009. 3-D conjugate heat transfer analysis of PLCC packages mounted in-line on a printed circuit board. International Communications in Heat and Mass Transfer. 36(8): 813-819.