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COMPOSITE WALL INSULATION PERFORMANCE IN TROPICAL ENVIRONMENT FOR INDOOR FARMING STRUCTURE

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Abstract: Composite wall is an option to replace the conventional material such as brick wall and concrete wall in building construction. Every component within the composite plays the roles to take the advantages of each material. In this context, one of the reasons is to get advantages of insulation from polyurethane that prevent the heat pass through the wall. This study investigated the heat transfer performance from outside into inside composite wall in the tropical climate for indoor farming structure. Data comparison in between in and out temperature is taken using thermocouple place on the wall and expose to the sunrise and sunset. The finding shows the temperature was reduced approximately by 40% with an average of 18 degree Celsius. An application of composite wall has significantly reduced the effect of heat transfer from the outside environment and has the potential to use for agriculture in the future to replace the conventional method.
Keywords: Indoor farming; composite wall; heat transfer; tropical environment.

1. Introduction

Agriculture remain as an important role to feed the nation. Currently, agriculture can be practice in the building with closed and effectively controlled environment. For past decade, nation such as Malaysia that has humid climate and sunshine all year around, has some argument which is maybe it is not necessary to have close and control environment for agriculture. They should utilize vital natural resources especially sun lighting to grow the plant. Some more, indoor farming is costly to build the infrastructure and has to select appropriate materials to maintain the temperature inside the structure However, when coming to the problems such as higher food demand in the urban area, lack of space and low productivity in agriculture due to weather and disease, maybe it is time to explore and innovate new approach at it.

Is it good to have sun all year round, but the challenge is, the temperature increases during the day time, which it can achieve 80°C on the roof surface and wall. Higher temperature increase means a lot of energy consumption needed to cool down inside temperature. About 50% of the heating load in residential buildings and 60% in commercial buildings results

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from flows through walls, foundations, and the roof (DOE, 2015). The main factor of determining wall material when considering energy consumption is the thermal mass of the wall. Mathur and Chand (2003) recommended that the thermal resistance of a wall can get better by adding an air cavity. In different study, Mallick (1996) stressed that adjusting the wall thickness can create a significant difference in the comfort level of houses in tropical weathers. He stated that a building material with high thermal mass and sufficient thickness delays the effect of temperature changes from the outside wall into the interior wall.

Currently, most of the new building used an air conditioning system to lower down the temperature inside of the building. In order to save the vast energy consumed by air-conditioning system, the building envelopes should be well designed such that the unwanted heat gain and loss within environment can be minimized. Nevertheless, sustainability environment always being an important role to make sure energy consumption in very low usage. Thus, the technology evolves in building materials has provide innovation in the construction so that it can be used for the structures in agriculture.

There are so many types of construction materials that can be used to construct a good shell for particular building. Conventional method using concrete and bricks in the construction of walls consume a long time to be completed. Also, it requires skilled workers, and it is difficult to obtain good quality surface finishing and member’s connection if not carefully implemented. Nowadays, some technologies help save the time of project completion as well as deliver quality finishes. Currently, the composite panel has been used to a new building designed for intensive indoor farming research activity located in MARDI Headquarters, Serdang, Malaysia. Compare with others, this type of panel provides superior energy performance and moisture protection compared with many other wall systems (Seeber et al., 1997). Conversely, precast concrete sandwich panels (PCSPs) have been used for several decades in wall construction because of their structural and thermal efficiency as compare to others materials (Henin et al., 2014). The objective of this paper is to evaluate the performance of the application of the composite panel to see the difference between outside and inside temperature on the wall surface.

2. Material & Methods

2.1. Materials. Experimental building was constructed by other parties using composite cement fibre materials as the shell wall. The thickness of the wall is 60 mm which consist of 12 mm thickness of cement fibre and 36 mm foam in the middle (sandwich type panel).

Structure was built using portal frame method to speed up the construction duration and easy the installation of composite panel.

2.2 Methods. This study adopted on site measurement to identify temperature on the surface at outside and inside of the composite wall panel. Eight (8) points were taken at different locations on the surface and divided into 2 part (4 points each side) the left and right of the structure as Figure 1. The sensors were located at 1.5 meter and 4.5 meter from the floor finish level on the selected panel to observe the overall temperature at inside and outside. Thermocouple sensor type K was used in this experiment and mounted at the surface of the wall (back to back) (see picture 1 & 2) using modified casing. Data logging are set at 10 minutes interval and logged by using customize control panel prepared by others.

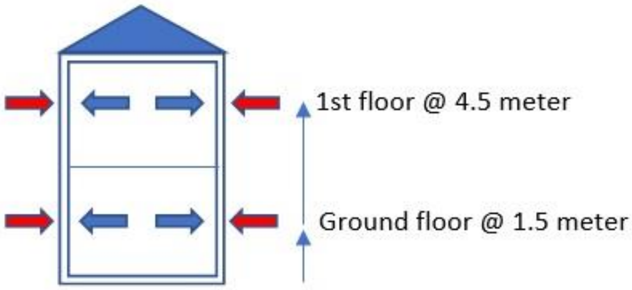
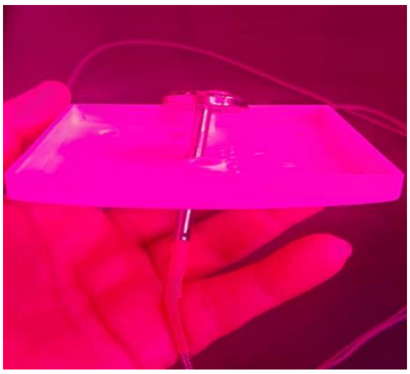
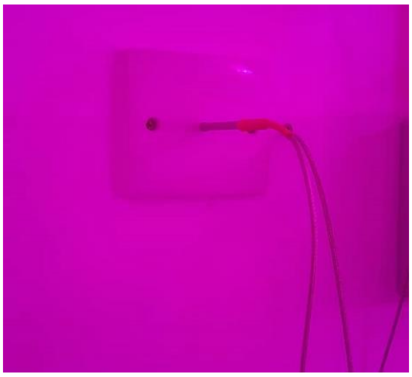


Figure 1 Eight (8) sensor points located on the wall



Picture 1 Thermo-couple type K



Picture 2 Sensor plugged on wall

Working flow of the overall process describe as figure 2 below;

From data collections, information of temperature and time stamp each location for left and right of the structure panel were grafted accordingly in the findings and discussion.

3. Findings and Discussion

As showed in Figure 3a and Figure 3b, the results for temperature data taken from sunrise side of the wall and vice versa for Figure 4a and Figure 4b. The different value is at average of 10 °C in between in and out of the surface. Maximum temperature different from the right and left side is around 10 °C in daylight at 11 am, and the minimum temperature difference is about 5°C. Graph shows quite similar pattern from early morning to night with bell shape.

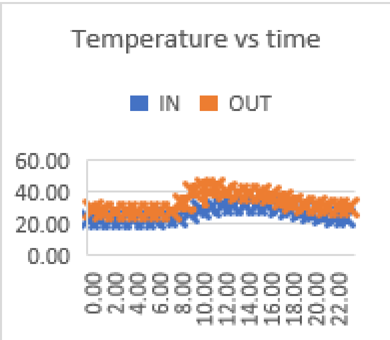


Figure 3a Temperature data at ground floor (1.5 meter) for sunrise

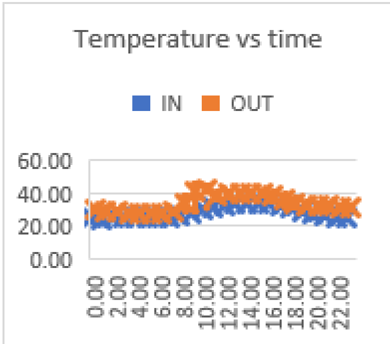


Figure 3b Temperature data at 1st floor (4.5 meter) for sunrise

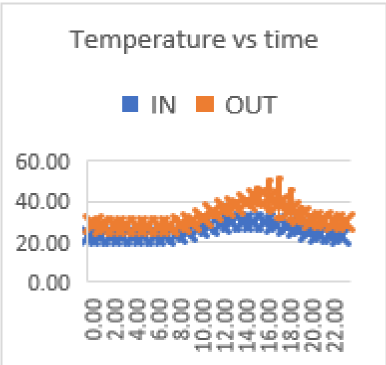


Figure 4a Temperature data at ground floor (1.5 meter) for sunset

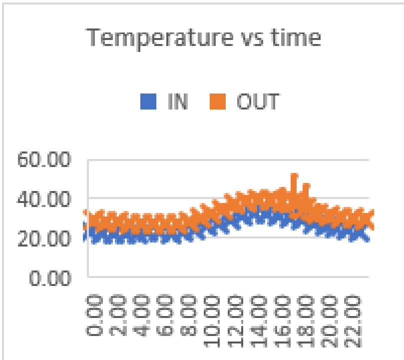


Figure 4b Temperature data at first floor for (4.5 meter) sunset

The figure also showed that the highest temperature reached at 10 a.m. is about 46 °C as the sun rises faced on the outer surface for both the ground and 1st floor panel. On the inner panel surface, the highest temperature recorded at the same time was 30 °C with a difference of 16 °C. Overall the outdoor surface temperature starts around 30 °C and increases until noon and then gradually decreases into the afternoon. Both upper and lower panels show the same pattern.

In the evening the temperature on the composite wall shows the maximum temperature at 5pm with a maximum temperature of 51.7 °C. On the inner surface, the highest temperature is around 28 °C with a difference of about 20 °C. The pattern here shows the temperature rising and reaching the maximum at 5 pm and gradually decreasing until next morning. This observation shows tested composite wall helps reduce the impact of external temperatures by a relatively around 34.7 % in the morning and 45 % in the afternoon.

4. Conclusion and Recommendation

Findings show the impact of using composite wall where it minimizes the heat transfer coming from outside. The outside temperature was reduced by 40 % of average, and this will help active cooling to save the electrical energy and maintenance cost. This study will help the agriculture industry players to make choices and option of materials others than old conventional materials, especially for indoor farming which most expected allocate in the urban areas.

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