The Thermal Qualification of Vetiver Grass Insulation

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Abstract

The Northeastern region of Thailand located in hot and humid climate area, where average temperature and relative humidity were high all year round. Heat and humidity have been transferred from outside into the buildings through their envelopes as roofs and walls then, thermal discomfort condition has been emerged. If the air conditioning system (A/C system) was used to drain heat and humidity out, it consumed more energy and CO_2 emission that cause recent global warming problem. This research objective is to develop the agricultural residual material as Vetiver Grass to become the natural thermal insulation that use to minimize heat transferring from the outside into the building by local labor work and simple process. The result shows, the insulation from this raw material with appropriate roof cavity ventilation can decrease the heat transferring through roof of test cells, presented by the average temperature in test cell which lower than the controlled test cell without any insulation and ventilation around 2.5-3 degree Celsius in daytime.

Keywords: Thermal Insulation, Vetiver Grass, Energy Conservation,

1. Introduction

In hot-humid climate as The Northeastern region of Thailand, average temperature ranged between 27-35°C and average relative humidity ranged between 65-80% in daytime [1]. Heat and humidity from outside always transfer through the building's envelopes cause human discomfort. The human comfort condition ranged between 22-27°C and 20-75% of relative humidity [2][3] that lower than climatic condition, the thermal insulation must be used to minimize the heat transferring by installed with the building envelopes especially in roof of the building. The reason why the insulation would be installed with roof is, this region located in tropical zone near to the equator where the direct sunlight always shines perpendicular to the plane of roof and then causes the major heat transferring of the building [4].

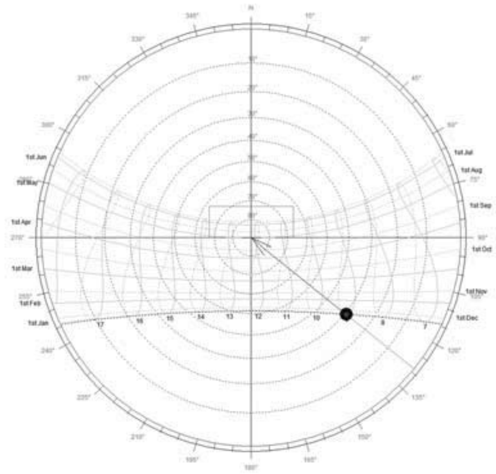

Figure 1. The stereo graphic diagram of the center of Northeastern Region of Thailand shows the direction of sunlight that mostly perpendicular to the roof's plane.

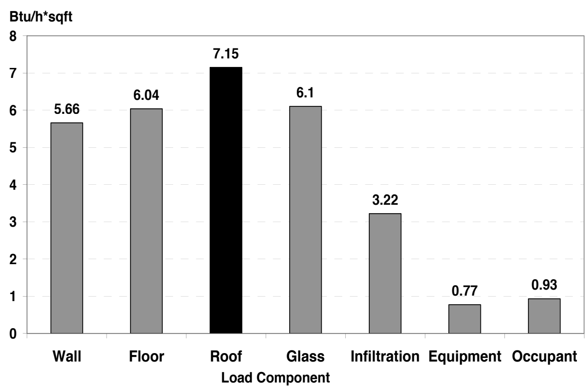

Figure 2. The load component for air conditioning system of typical houses in Thailand, the major heat transferring comes from roof of the building (Adapted from [4]).

This research has originated from "The Vetiver Grass Planting Project" initiated by his majesty the king of Thailand. The main purpose of this project was to protect the soil and topsoil corrosion from storm water in rural area by growing the long-rooted plant as Vetiver grass. From this great project, the by-product was created in form of grass leaves with hole inside. This physical character was granular qualification that would possibly apply as building's thermal insulation to enhance the thermal comfort condition and to decrease cooling energy demand which cause recent global warming problem [5]. Harmony with the literature reviewing, the residual materials which have air hole inside such as rice husk [6] and hay can be used to be thermal insulation because of the apparent thermal resistance from air space inside these materials [7] [8].

2. Methodology

The experimental method was used for this research; start with the preparation for the Vetiver Grass. First; It was dried in the direct sunlight by exposed in open area (or in solar drying machine) to decrease the moisture lower than 5% [9] because the moisture or humidity ratio would minimized the thermal resistance of insulation material, and then cut for the size at 0.6 meter. Second; the grass would be weighted for the right density of the insulation blanket volume 0.6*0.6*0.15 m^3 at 44-51 kg/m^3 [10]. At last; the grass would be covered with the plastic bag with silica gel inside to protect the insulation from moisture, and then covered with the aluminum foil to lower the emissivity value of the material's surface. (Fig.3-5)

The insulations would be installed in the test cells made with 6-inches polystyrene foam with the metal sheet roof and gypsum board ceiling. The details of each test cell can be shown like table 1.

Table 1. The comparison data between 4 test cells.

Number of Test Cell	Vetiver Grass insulation installation	Roof cavity ventilation Using
1	No	No
2	No	Yes
3	Yes	No
4	Yes	Yes

The temperature data such as: outside air temperature, roof cavity temperature, and inside air temperature of these tested cells were collected by data logger and sensors for 2 weeks in summer and the temperatures in test cells (Number 2-4) were compared with the temperature in controlled test cell (Number 1). The test area has been located on the building roof of the department of building technology, Faculty of Architecture, Khon Kaen University. The data of this study can be shown as figure 6 to figure 10.

Figure 3.The physical character of sun-dried 'Vetiver Grass' that used to make local thermal insulation.

Figure 4.The plastic bags and silica gel were used to cover the grass to protect insulation from moisture and insects.

Figure 5.The final covering with aluminum foil.

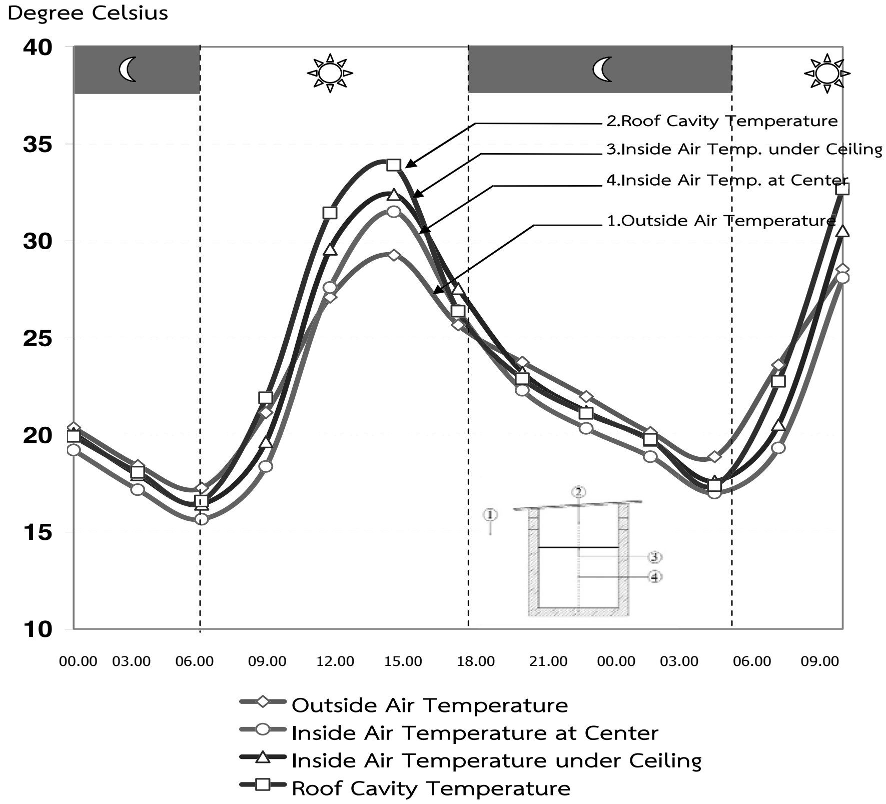

Figure 6. The temperature of each positions of the controlled test cell (Number 1) without insulation and without roof cavity ventilation compared with the outside air temperature.

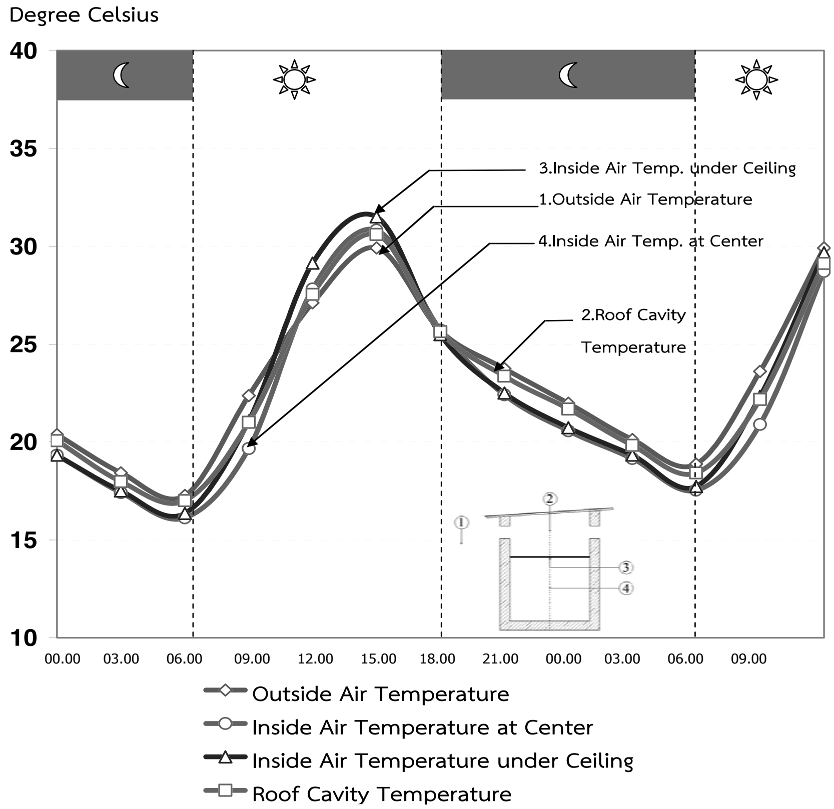

Figure 7. The temperature of each positions of the test cell (Number 2) with only roof cavity ventilation compared with the outside air temperature.

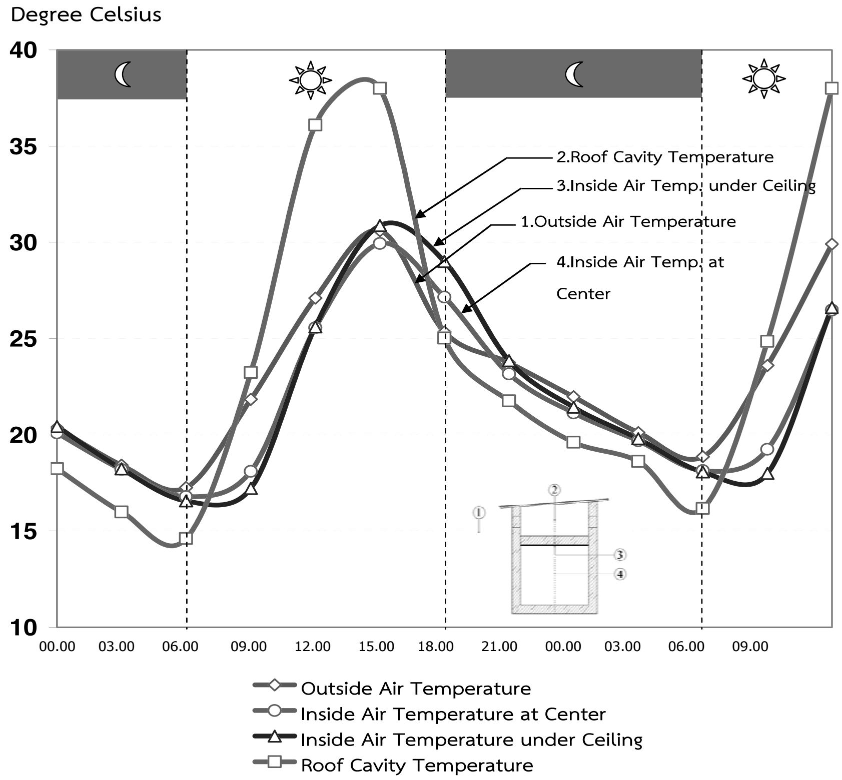

Figure 8. The temperature of each positions of the test cell (Number 3) with only Vetiver Grass insulation compared with the outside air temperature.

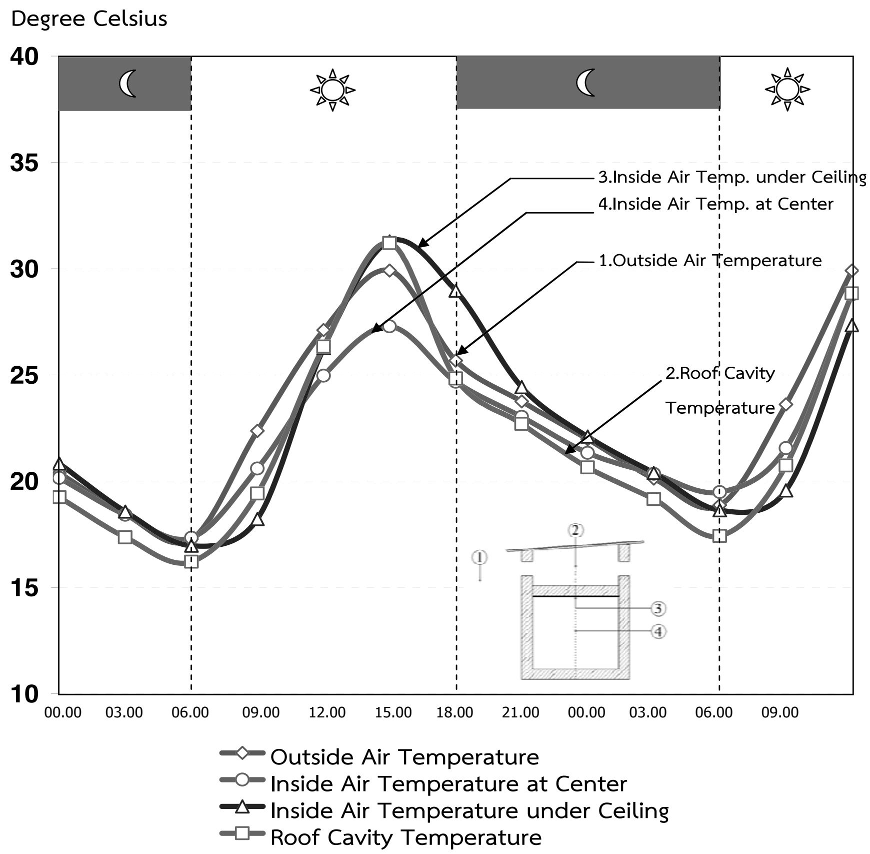

Figure 9. The temperature of each positions of the test cell (Number 4) with Vetiver Grass insulation and roof cavity ventilation compared with the outside air temperature.

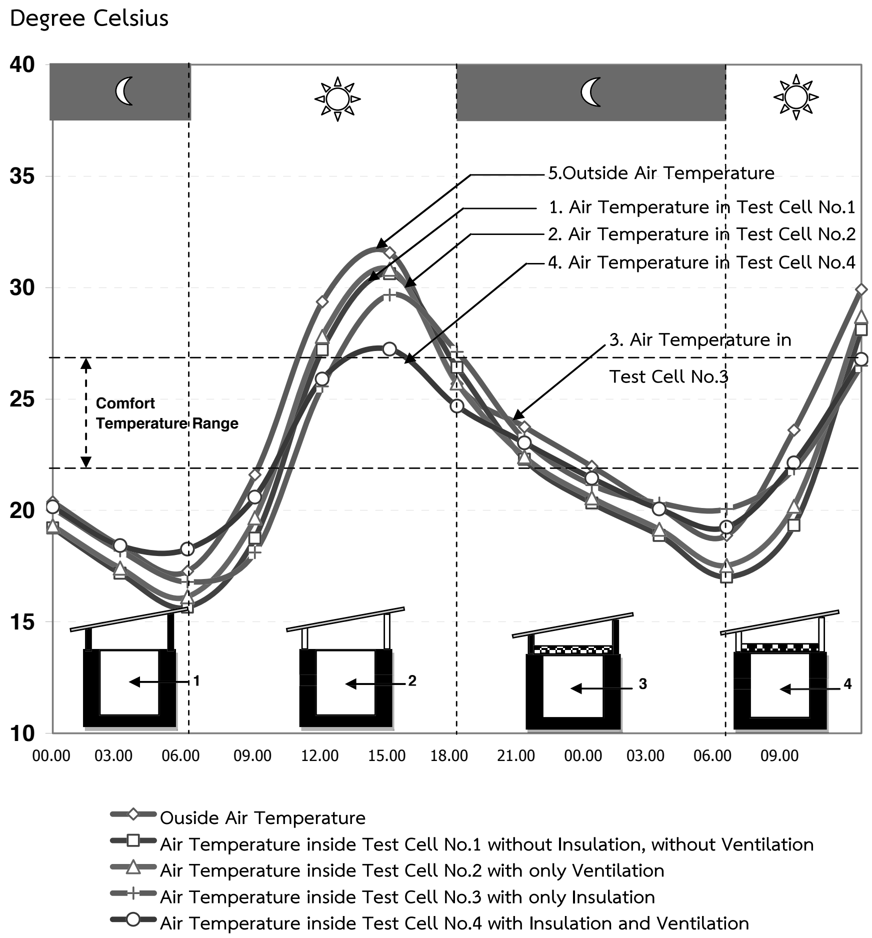

Figure 10. The inside air temperature at the center of each test cells compared with the outside air temperature.

3. Results

From 2 weeks of data collection, in the first test cell (Fig.6), when the outside air temperature range 17-29 degree Celsius, all of temperatures in this controlled test cell are higher than the outside air temperature in daytime. However, all of them is little lower than the outside air temperature in nighttime. In the second test cell (Fig.7), all of the temperatures in this test cell are difference from the first one. They always conform to the outside air temperature because the roof cavity ventilation technique is used to drain out the heat in the roof cavity.

When the insulation from Vetiver Grass has been placed on the ceiling of the third test cell (Fig.8), the temperature of roof cavity is the highest in daytime because of the thermal resistance of this insulation. The inside air temperature at the center of test cell is lower than outside air temperature around 1.5 degree Celsius in daytime but conforms to the outside temperature at nighttime. The last test cell (Fig.9), when the insulation and the roof cavity ventilation are used, the air temperature inside this test cell is lower than the outside air temperature around 3-3.5 degree Celsius in daytime. Different from daytime, the temperature in test cell is higher than the outside air temperature around 1-1.5 degree Celsius due to thermal resistance of the insulation that obstructs the heat loss from inside of this test cell at nighttime.

5. Discussion

When the air temperature inside every test cells are compared together like Figure 10, the Vetiver Grass insulation with the roof cavity ventilation is a most efficient solution to decrease the heat from outside test cell, represented by the average temperature in daytime, the using of this insulation with ventilation can reduce the heat transferring through the roof by thermal resistance qualification, presented by the peak temperature in test cell that lower than other test cells and controlled test cells, but in nighttime, although the roof ventilation can bring the heat that accumulate in test cell during daytime by heat convection, the air temperature in test cell is still higher than the outside air temperature because of its thermal qualification of the insulation.

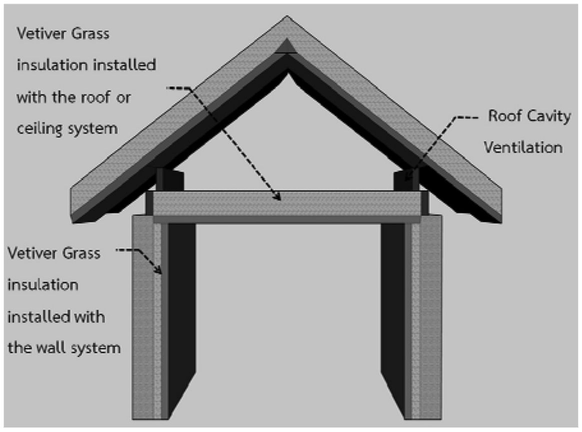

Figure 11.The suggestion of the Vetiver Grass applications for the building construction.

6. Conclusion

From the results of this thermal qualification study, Vetiver Grass can be used for the building as a thermal insulation by local labor work and low expensed material in many solutions such as roof, ceiling, or wall insulation (Fig.11). If this study will be applied for real buildings, the density control and the time-scheduled for their opening will be considered. Otherwise, many residual materials can be found in our local area and can be applied as the building insulation like this grass. The applications of local materials or residual materials will be an appropriate solution for human to environmental awareness because they can reduce the transportation energy that used to convey them from one place (production area) to another place (construction area), and we can add the value of residual materials by applying them in order to reduce our energy demand and enhance human thermal comfort in our buildings. Furthermore, in case of Vetiver Grass, if we can apply this material for our building, the demand of this raw material will be higher and the soil and topsoil of this local area will be protected from corrosion by the grass planting itself.

7. References

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