RESEARCH ARTICLE

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Comparative Effect of Roof Material Toward Thermal Condition on the Roof Space. Case Study: High Density Settlement in Semarang City

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The requirement for residential and the potential for building density in an environment will affect the physiological and thermal comfort of building occupants. The uncomfortable thermal conditions in the building are complained by building occupants due to the inappropriate selection of roof materials, thus making the building unable to achieve the expected thermal conditions. Selection of appropriate roof material will help in the process of air conditioning and decrese energy consumption for cooling space. Our study objects are single-storey house in the Perum Sendang Mulyo, Semarang City that represent high density settlement. Data measurement collected from roof spaces in saddle roof. The roof materials are tile roof, asbestos and zinc. The expectations of this research are to know thermal condition of roof space that generated from various type of roof material.

Keywords: Roof Material, Roof Space, High Density Settlement.

1. INTRODUCTION

In tropical houses, cooling is one of the major concerns in building. Buildings should be designed not only to satisfy biological, psychological and socio-cultural needs of users but also to provide required indoor conditions regarding climatic comfort.[1,2]

The heat of surface radiant will affect space thermal conditions and would increase energy consumption for space cooling. Energy transfer between building and its construction can effect building thermal performance. For a conditioned building, the estimation for heating and cooling load become one of main topic, because the excessive of energy consumption would cause a serious environmental problems such as urban heat island.[3]

The Handbook of Energy and Economic Statistics of 2011 indicate that energy consumption in Indonesia increased by 15% from 2009 to 2010. The country's energy consumption climbed from 446.49 million BOE in 2000 to 998.52 million BOE in 2011, given that 51% of the energy is still derived from fossil sources.[4,5] This information mean from an economic point of view, minimization of energy consumption in the buildings is important.

In other hand, as part of tropical region that receives a large amount of solar radiation, high temperature, high level of relative humidity and long periods of sunny days throughout the year, these condition can not avoided.

Based on field and its orientation, the roof of the building is the most exposed toward light and responsible toward the room comfort and also damaged that caused by the earthquake, hurricanes and fires.[6]

In the tropical countries, the path of the sun generally goes through high altitudes during the daytime, making the roofs got the intense of sunlight. Unlike vertical surfaces such as walls, the roof is exposed to the sun throughout the daytime in a year, significantly contributing to heat gain. Various heat exchange processes are possible between a building and the external environment. The solar radiation that spread through roof surface can affect thermal condition of roof space which often occurred on the lower surface of ceiling or on the lower surface of the roof, which is become one of primary concern to creat indoor thermal comfort.

Roof should be able to control the heat that went into the building space and provide a comfortable condition for occupant. In other hand, roof serves as a cover for the whole room, toward negative effect of heat, rain, wind, fire and dust.[7]

Since roof modifies the internal temperature, when appropriate properties are chosen. It is very useful to evaluate the effect of roof materials toward thermal condition in the roof space and will be possible to achieve and maintain comfortable internal temperature over a wide range of external conditions.[8]

Therefore, the main objective of this study is to study the influence of roof materials toward thermal condition in the roof space. It was based on the hypothesis that roof materials would influence the thermal condition in the roof space.

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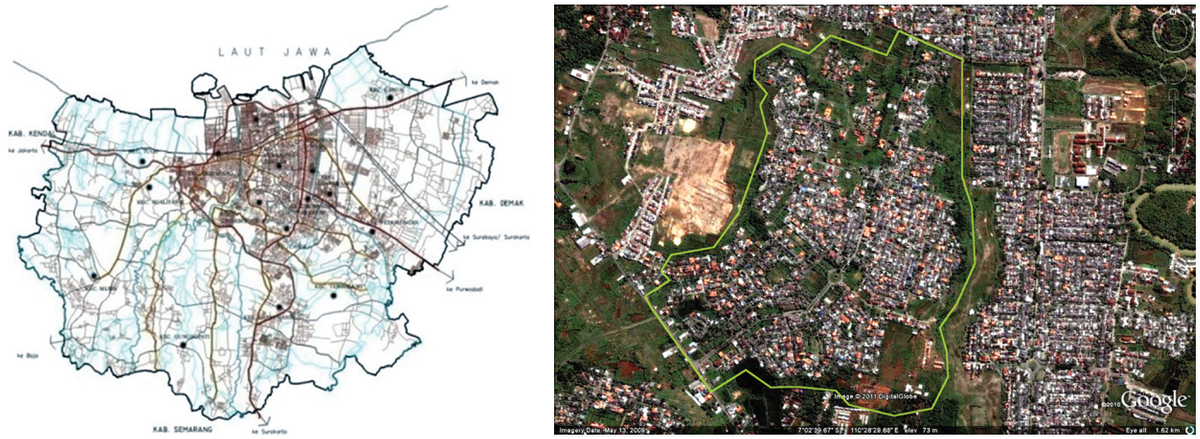

Fig. 1. Location of Perum Sendang Mulyo, Semarang city.
Source: https://maps.google.co.id, 2017.

2. EXPERIMENTAL DETAILS

The data measurement was done by measuring thermal condition in the roof space. It was include external surface temperature of roof material and indoor air temperature of roof space.

As object study was roof space of single-storey house in the dense settlement area in the Perum Sendang Mulyo, Semarang City, can be seen in Figure 1. The roof materials were roof tile, asbestos and zinc. The roof shape was saddle roof. As for roof materials selection was based on the opinion that these materials are widely used in the low-cost housing construction.

The experiment was conducted during three days on the August 2017; from early morning (08.00 am) until evening (08.00 pm). The interval of data measurement was at every one hour. Thermo hygrometer was placed in the roof space. It is used to monitor temperature development. The roof space considered sealed. The aim was to isolate the effect air flow toward thermal condition in the roof space.

The arrangement of data collection on the thermal condition of object study can be seen in the Table I.

3. RESULTS AND DISCUSSION

The discussion is based on the temperature profile that occured during the course of the day. Both for roof space temperature and roof surface temperature.

Table I. The arrangement of data collection.

Days sequence	Roof materials
First day	Tile roof
Second day	Asbestos roof
Third day	Zinc roof

Table II. The average temperature of roof space and roof surface based on the roof materials.

Roof materials	Temperature of roof space	Temperature of roof surface
Tile roof	26.75	30.28
Zinc	28.66	34.85
Asbestos	27.77	33.38

Based on the data measurement, the average temperature of the roof space and roof surface was different among the roof materials, can be seen in Table II.

Generally, both for roof space temperature and surface temperature, tile roof is lower than asbestos and zinc roof. The different between surfece temperature of tile roof and asbestos roof is 2,54 °C. The higher different happened with zind roof 4 °C. As for space temperature, tile roof has 0,89 °C lower than asbestos roof and 1,92 °C than zinc roof.

The position of the roof that exposed to the solar radiotion (without shading from trees and other buildings) make roof materials has optimum temperature profile. Possibility caused the temperature different among the material is high enough.

Based on the material type, zinc roof has a tendency to increase the temperature of the roof space. Thermal conductivity of zinc is 0,482 W/m °C and also has thinner form than asbestos and tile roof. It makes its ease to absorb solar radiation.

The data analysis will be divided into two based on the comparison of thermal measurement on the temperature of each roof space and roof surface.

Based on the Figure 3, the results of the analysis as follows:

a. Generally, during the process of data collection, the average of air temperature on the roof space of tile roof was lower than asbestos and zinc roof.

b. Higher thermal conductivity made roof space temperature of zinc roof higher than other materials.

c. Although in the beginning, tile roof had the lower roofspace temperature, but after 2 PM, air temperature of asbestos roof became the lowest. The decrease temperature happened until 5 PM. At that moment, it can be caused by environment

Fig. 2. House in Perum Sendang Mulyo, Semarang city.

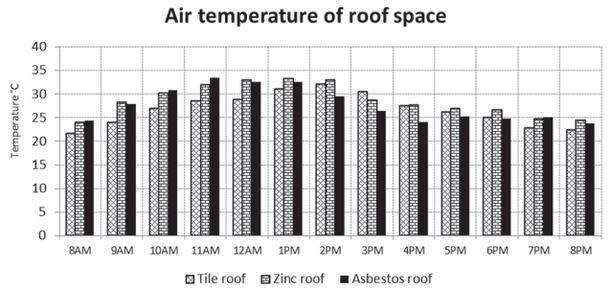

Fig. 3. The comparison of data measurement on the thermal of roof space.

condition, such as wind velocity and solar radiation that occoured around the house with asbestos roof.

d. The thermal profile that showed the relative steady condition at the afternoon was on the asbestos roof. The increase of thermal profile was 0.3 °C–3.5 °C and more showed a decline trend (0.9 °C–3.1 °C).

From the first analysis, we can conclude that among the roof materials in this study, tile roof can create the cooler temperature in the roof space. While the asbestos roof can give a tend steady thermal profile in the roof space. As for high density settlement, tile roof as roof materials are more appropriate to create indoor thermal comfort.

While based on the profile of extenal surface temperature in the Figure 4, we get the following analysis:

a. Overall, the average of surface temperature on the tile roof was lower than surface temperature on the asbestos and zinc roof. Different with space temperature, the trend of surface temperature of tile roof tend to steady. Data measurement also proved that tile roof is better in the reduction toward solar radiation and make the building become cooler.

b. The highest different among the surface temperature is zinc roof while the lowest is tile roof. The different reach 33 °C. Roof material that made by zinc will be faster in the heat transmission and has great role in the increasing building temperature.

c. In the evening, the three of roof material has relative same surface temperature profile. It can be due to weather and the shading provided by trees.

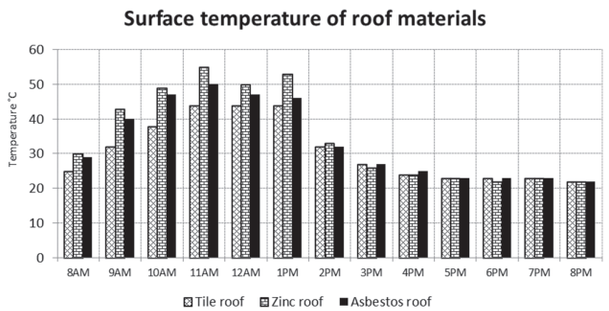

Fig. 4. The comparison of data measurement on the roof surface temperature.

4. CONCLUSION

This study was conducted to examine the influence between roof materials and thermal condition in the roof space. Based on the hypothesis, thermal condition in the roof space influenced by roof materials. The heat that occured in the building transmitted from solar radiation through conduction from roof surface.

In the first analysis, the coolest thermal profile in the roof space showed by tile roof. It proved that tile roof is better in the solar radiation reduction and makes the air temperature in the roof space was cooler than zinc roof and asbestos roof. Zinc as roof material that has highest thermal conductivity and also has the highest thermal profile in the roof space and highest surface temperature. Therefore, based on the first and second analysis, we can conclude that types of roof material will affect the thermal condition in the roof space. Another result of this study was the effect of roof materials toward solar radiation reduction on the roof surface temperature.

This study encouraged to indicate key to maintain the indoor temperature than the outdoor temperature, especially during the daytime. In the end, it would be quite useful to develop strategies that could be included in designing modern passive houses.

5. RECOMMENDATION

Result highligh the effect of roof material toward thermal condition in the roof space can effect the thermal condition in the building. Possibility, it will not only influence thermal condition in roof space but also in the all of building parts. To further establish these results, the deeper study must be done especially related to the data measurement and data analysis. Many factors such as wind velocity, solar radiation, roof shape, high of building and building orientation may influence building thermal condition. However these factors not analysis yet. Therefore, future study can be done by studying the impact of these factors toward thermal condition in the building.

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