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THE INFLUENCE OF ROOF COVER MATERIAL ON GABLE MODEL TO CLIMATE PARAMETERS

Case Study: Rumah Instan Sederhana Sehat (RISHA), Puslitbang Permukiman, Bandung

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Abstract

A roof should be able to prevent and reduce the radiation heat. It is more recommended if it gives a good effect in both prevention and reduction of heat. Through this research, the author wanted to know the influence of the roof covering material to gable roof style towards the climate parameters, such as temperature of humidity and heat radiation. Gable roof style is considered as more effective rather than others traditional roof style. The ability of heat reduction and humidity performances of the gable roof was tested by using Asbestos, Roof Tiles, Metal deck, and Green Roof covering material to RumahInstanSederhanaSehat (RISHA) in for Housing Research and Development (PuslitbangPermukiman). Bandung. The variations of ceiling and non-ceiling were applied for knowing the result specifically in terms of the level of humidity and temperature in the room. By using quantitative descriptive method, Metal deck gave the fastest effect towards the temperature reduction, while Roof Tiles gave the best effect by using ceiling, and Green Roof gave the best effect by not using ceiling. Humidity aspect that gave the best effect occurred when using ceiling, either when using ceiling or not. Meanwhile, the lowest humidity happened when using Asbestos and Green Roof material. In the ability to reduce heat radiation, Green Roof had the best ability in reducing the heat or had worst ability in heat radiation, followed by Metal deck.

Meanwhile, Asbestos covering material had the best heat radiation ability.

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A. INTRODUCTION

The criteria of selecting roof covering material for this research are: easy and commonly found in Indonesia, and the ability to prevent and reduce the radiation heat. Based on those criteria, Asbestos, Roof Tiles, Metal deck, and Green Roof are good to prevent and reduce the heat.

A. Spanki (2007) stated that the more conductivity of roof covering material, the higher value of heat radiation will be. Roof with ceiling is functioned as isolator to radiant heat, as also mentioned by Bochari (2011). Because the ceiling affects the state of room temperature, therefore the use of ceiling or non-ceiling is considered in this research. Din (2007) explained that climate parameters comprise of rainfall, temperature, humidity, wind speed, evaporation, and solar radiation. In this research, the criteria to determine climate

parameters are related directly to the roof typology. In accordance with the availability of existing research instruments in the local laboratory, the selected climate parameters are: temperature, humidity, and heat radiation.

B. METHODOLOGY

The methodology that is used in this research is quantitative descriptive. Free variables for testing the gable roof style are Asbestos Roof, Roof Tiles, Metal deck Roof, and Green Roof. Moreover, ceiling is included in the testing of free variables. Non-free variables consist of: temperature, humidity, and heat radiation. Research population in this research is the room of RumahlnstanSederhanaSehat (RISHA) which stood in tropical seasons. The samples of this research are measured by

devices consisting of one outdoor point (point C) without direct exposure to the sun, and two indoor points (point A and point B). The following figures illustrate the placement of measuring devices on RISHA case study. The instruments that used in this research are thermometer, hygrometer, and globe temperature meter.

The duration of measurement is carried out based on the research in India by Madhumathi, S. Radhakrishnan and R. Shanthi Priya (2014) on roof tile and the research by Climate Protection Partnership Division (2010) on Green Roof. Both researches have proved that the roof covering material they tested could reduce radiation heat after a few days of research.

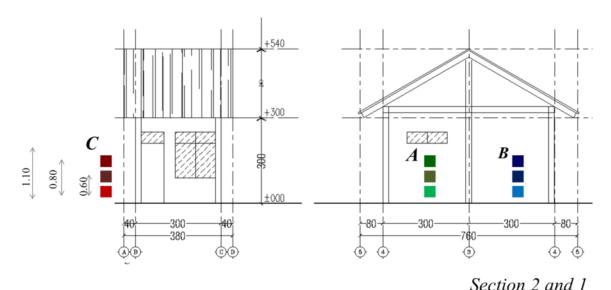


Figure 1. Measurement point positions Source: Author, 2016.

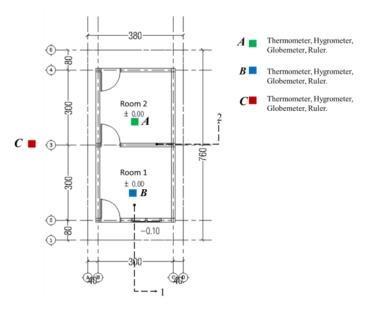


Figure 2. The placement of measurement instruments. Source: Author, 2016.

C. FINDINGS

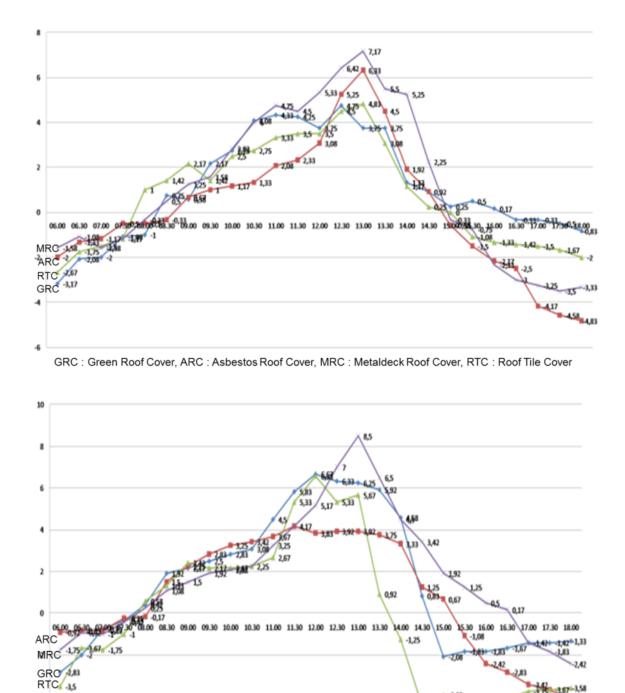
C.1. Measurement on day 1-2 (with ceiling)

The first temperature measurement was carried out to Asbestos roof covering in the morning. The measurement result indicated that the room temperature was warmer. Asbestos was the roof covering material that responded the heat quickly. In fact, the room temperature increased since 07.30 AM.

In the daytime, Asbestos temperature was higher that roof tiles, especially when it was compared with Green Roof with the difference 6.33°C at 01.00 PM. Asbestos absorb the heat so that the room temperature is increased until afternoon (and even until evening). Asbestos as roof covering material releases the heat longer,

same as the second day of measurement. At 09.00 AM, the measurement result showed the difference of temperature was lower than the others. Closer to the afternoon, Asbestos still stores the heat so that the differences value was the highest among the other roof covering materials, which was - 4.25°C. The comparison of measurement results of temperature differences in day 1 and day 2 decreased by 2.16°C. Measurement of Asbestos roof covering showed differences in temperatures from day to day, Asbestos was soaked in water or exposed to the rain on the surface. The direct contact with the water helped Asbestos to release the heat.

The result of humidity measurement day 1 on Asbestos in the morning, it showed that the humidity approached in the most ideal



GRC: Green Roof Cover, ARC: Asbestos Roof Cover, MRC: Metaldeck Roof Cover, RTC: Roof Tile Cover

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Figure 3. Temperature measurement day 1 and 2, using Asbestos roof cover. Source: Author, 2016

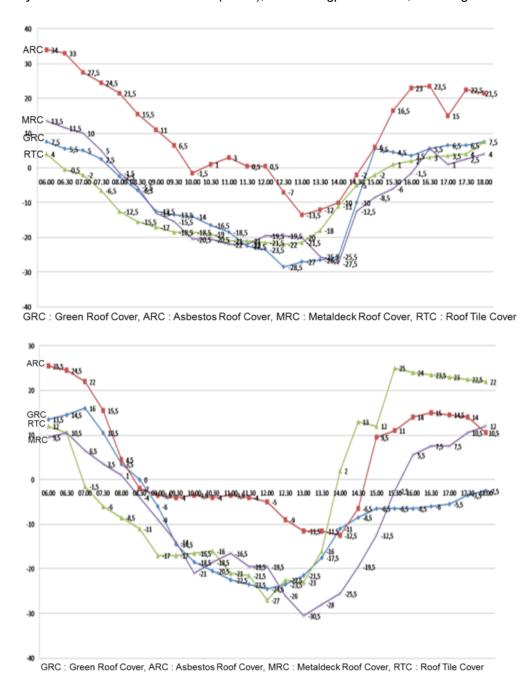


Figure 4.Humidity measurement day 1 and 2, using Asbestos roof cover. Source: Author, 2016.

percentage for tropical base climate such as in Indonesia, which was around 70%. However, from around noon, the humidity decreased until afternoon reaching 47% at 03.30 PM. It continuously decreased until

06.00 PM so the air was getting dryer. At the same time, the difference of humidity was 21.5% that showed from measurement result and this differences value was highest among the others. On

the second day of measurement, the humidity percentage of the room decreased until 11.50% because of Asbestos. At noon, the level of humidity reached the lowest value of 46%.

Indoor humidity of the Roof Tiles cover indicated low percentage in the morning. In the afternoon, the room humidity tended to approach the ideal value. The reason of why this condition did not apply to Asbestos because it does not easily release the heat as good as the Roof Tiles.

The character of heat radiation to Asbestos the longest reached in the morning. However, nearly at noon, Asbestos' surface radiates heat quickly; therefore, measurement result showed that Asbestos is a material that has the best capability to release heat with a value $31^{\circ} - 31,5^{\circ}$ C.

The result of temperature measurement day 1 in the morning of the Roof Tiles cover showed that temperature was not really warm neither cool. In the afternoon, the room temperature was around 28° – 30°C. Similar to the Asbestos, towards afternoon the Roof Tiles slowly released the heat. Compared to the Green Roof, the Roof Tiles was the second coolest. Room temperature on day 2 under the Roof Tiles became warmer in the morning compared

to the temperature measurement on day 1 and the room temperature became the warmest among other roofs covering. At noon, Roof Tiles is able to produce difference of 6.58° C. This value is the highest and almost equivalent to the value of Green Roof and Metal deck Roof measurements, although Green Roof is higher by 0.09° C. The temperature difference sequence from highest to lowest, is Metal deck on the top, followed by Roof Tiles, and Green Roof at the bottom, with the differences of is 1,75°C on day 1 and 2. At 11.00 AM, Roof Tiles cover gives the most ideal humidity among the other roof coverings. In the next hour, the humidity decreases after 03.30 PM progressively into the afternoon with consistent rated between 72 - 76 %. That value is not ideal enough compared to the Green Roof value. Roof Tiles' ability to radiate heat is relatively faster among other materials.

Measurement day 1, in the morning, using Metaldeck roof covering showed that the difference of temperature is relatively equal to temperature outdoor. At that time, room temperature is the coolest (with differences around 1.58° C). At 10.30 AM, the room temperature is still cooling (cooler than Green Roof) even though the sun is almost at the zenith above the roof. The largest temperature difference

Vol. 01, No. 1, August 2016: 39-54
The Influence Of Roof Cover Material On Gable Model To Climate Parameters
Case Study: Rumahinstansederhanasehat (Risha), Puslitbangpermukiman, Bandung

obtained at 01.00 is 7.17°C. This value made Metaldeck became the best material that is able to prevent and to reduce heat

Temperature measurement on day 2 showed that the temperature was not as cool as previous day, however Metaldeck

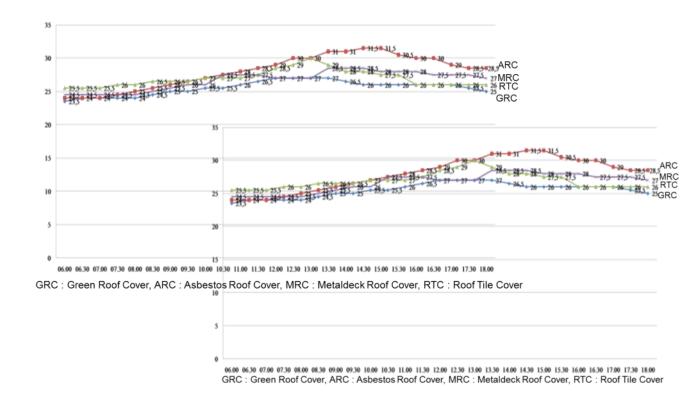


Figure 5. Temperature measurement day 1 and 2, using Roof tile cover. Source: Author, 2016

on day 1. Even after 04.00 PM, Metaldeck is still good although the differences in temperature is not as high as Asbestos.

is still able to cool the air in the morning compared to the other roof covering materials. Presumably Metaldeck reduced performance is because of the heat is still carried on from the previous day, and the estimated temperature will increase slowly to the next day. On the second day, Metaldeckis responded relatively slower to the heat, so as at 01.00 PM, room temperature is still low at 8.50°C temperature differences. Based on this value, Metaldeck is claimed as the most effective material in preventing and reducing the heat.

The duration of Metaldeck material in releasing and responding in temperature change is related to the character of its surface that has no pores, which is relatively difficult to be penetrated by the winds. It is in opposition to the Roof Tiles material, which responses faster to the heat (although not as fast as Asbestos) and quickly releases the heat because of the porous surface that enables the wind to come in and out easily. The value of temperature differences on day 1 and day 2 is 1.4°C and is assumed that the value will increase on the next day.

On day 1, the measurement result of Metaldeck cover is the humidity of opposite of the acquisition the of temperature When at noon. usina Metaldeck roof covering, the interior humidity is relatively high, even if it is the highest compared with the other roof coverings, and it reaches the highest value at 02.00 PM. Earned value was equal to the humidity differences when used Green Roof, that is 13.50%. Meanwhile in the afternoon, the humidity value is at the middle level among the others. The humidity on day 2of Metaldeck roof covering decreased from -27.50 % to become -30.50 %. It is predicted that the value will decrease and made the room felt very humid at noon. The higher the temperature difference is the higher humidity percentage in the room will be. The lowest heat radiation from Metaldeck is caused by its material that is longest to respond the heat.

Measurement result on day 1 of the Green Roof shows warmest temperature in the morning (until -3.17°C) compared with the other roof covering materials. This condition does not really change until noon, which means that the temperature chart on the Green Roof usage is the most stable compared to the others roof covering materials. However, differences in temperature value on the Green Roof are the lowest on day 1. Furthermore, towards the afternoon, room temperature is the lowest. Similar to the measurement of temperature on day 1, second day of the Green Roof measurement in the morning shows that the warm interior temperature is maintained even though the out door's temperature is lower. However temperature difference is not as high as

the Roof Tiles. At noon, Green Roof starts to actively working in preventing and reducing the heat, with the temperature differences of 6.67°C. This value is the highest following the metal deck and it is predicted as to increase in the next day. In the afternoon, room temperature with Green Roof is in the lowest level compared to the others.

Measurement of humidity on day 1 on Green Roof shows that the value in the room is the highest after Metaldeck, which is 81%. Similarly, at noon, the room is still felt humid, but later in the afternoon, the humidity is closer to the ideal value. The value is equal to the humidity of the Roof Tiles, which is 71 - 72 %. Humidity percentage on day 2 by using Green Roof the worst after Metaldeck. percentage is decreased slowly by noon and continued until afternoon, when it reaches the ideal value. Green Roof is the roof covering material that has the longest heat radiation value compared Metaldeck.

C.2. Measurement on day 3-4 (without ceiling)

Temperature measurement with Asbestos without ceiling on day 3 has shown warmer room temperature among the other finding. Early morning before the sunrise, outdoor temperature increment is

not in balanced with the lowering indoor temperature, so the room temperature became very hot. The differences in temperature value on day 3 decreased two-folds (although this differences is not as bad as in Metaldeck case), and making Asbestos as the roof covering with the lowest value in heat reduction. In the afternoon, room temperature is still high, even the highest among the other variants. On day 4 of measurement, there is no significant difference either in the morning, noon, or afternoon, but compared to day 3, the temperature differences is increased by 0.75° C. Even though the difference is small, it is predicted that the value will increase on the next day. It is inversely proportional to the character of Asbestos material with ceiling, which was the day the more minus increased. the temperature differences. This is due to the heat that is stored and isolated above the ceiling by Asbestos. Because of that, in the room without ceiling, heat load is reduced. In the afternoon, the condition is not different with previous day. From both experiments it is proven that the use of ceiling affects Asbestos' performance.

The experiment of humidity measurement on day 3 is on Asbestos roof cover without ceiling. The result shows that the temperature is almost on ideal level, as well as when using Metaldeck. The

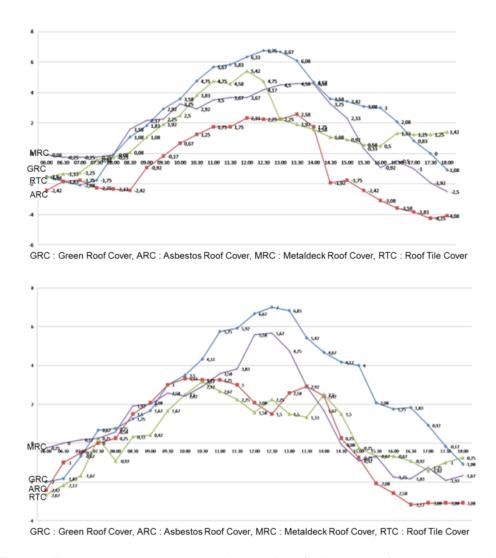


Figure 6. Temperature measurement day 3 and 4, of asbestos roof cover without ceiling. Source: Author, 2016.

experiment at noon showed the same condition compared to the 2 days earlier, which showed that the humidity difference is relatively low. It means the humidity percentage of the room is really low and it continues until afternoon. On the measurement day 4, the research result shows that Asbestos roof cover has the humidity percentage that is close to the ideal level of 73%. Difference in humidity

during the day is lower compared to the results on day 1 and 2 with ceiling (the room turns to not really dry). The increase of humidity value difference happens when the measurement is done without ceiling that the room becomes a little bit more humid compared to day 3. The same thing happened when the experiment is done with Green Roof, when the result of humidity percentage is higher. The

capability of heat radiation on Asbestos is the best among the others; it is around 31 – 32.5°C especially in the room without ceiling.

Temperature measurement on day 3 on the Roof Tiles without ceiling shows that there is impairment of the temperature difference. In the morning, the room temperature is not really different, compared to when ceiling is used. However, towards the afternoon, the room becomes cool. It is happened because of

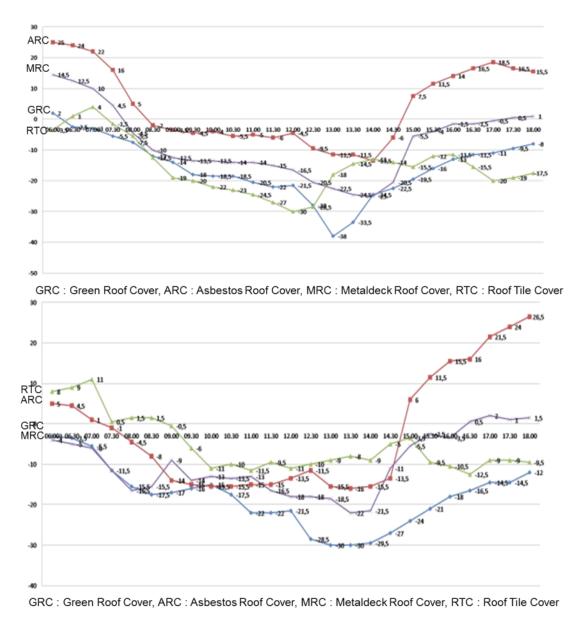


Figure 7.Humidity measurement day 3 and 4, of asbestos roof cover without ceiling. Source: Author, 2016.

the temperature inside the room at noon is easily and directly affected by the air movement in and out of the Roof Tiles pores. Temperature measurement on day 4 shows that the room temperature on Roof Tiles roof coveris lower compared to the previous day, with difference of 2.25°C. It is predicted that temperature difference will be lower on the next day. This value shows that Roof Tiles material is the worst heat resistor and it is reduced on the case without ceiling. Meanwhile, the humidity measurement on day 3that shows Roof Tiles has the highest humidity percentage among the others. Under the heat, the Roof Tiles that usually heated the ceiling, it is now heated the Roof Tiles only. The porous surface of Roof Tiles causes humidity difference during the day to become really low, similar to Green Roof, that is -30.00%.

Roof Tiles covering has high humidity value in the morning on day 4, below Metaldeck's value. Towards noon. humidity value is increased until 59%, and toward the afternoon the humidity percentage reached the highest value similar to the previous day, which is 80.50%. Heat radiation on Roof Tiles cover without ceiling becomes slow and the temperature of heat radiation is the lowest among the other that is 28.5 -29.5°C.

Among the other roof coverings, Metaldeck's performance is the most effective with ceiling, when the performance is decreased and it is the same value with Asbestos. Yet, the value of temperature difference of Metaldeck is bigger (measurement difference on day 3 and day 2) and even the biggest among the others. Even though in the morning on day 3, there is no difference between indoor and outdoor temperatures, however the room temperature is at noon, increased. It shows that Metaldeck is ineffective in preventing and reducing the heat. In the afternoon, room temperature under Metaldeck roof is the warmest after Asbestos. Meanwhile, on day 4, the research shows that the room temperature with Metaldeckis the coolest. During the day, temperature difference is increased from day 3 by 1°C.

Humidity measurement on day 3 in the morning with Metaldeck shows that the percentage almost in ideal value, that is 74.5%. This stage made Metaldeck performance is not stable where the heat that was isolated in the ceiling room suddenly gone and the heat spread to all over the room so that increasing the room temperature. However, on day 4, humidity percentage in the morning is really different compared to the previous day. The room humidity reached the highest

value on all roof covering materials. Allegedly, the heat load from 2 days before was reduced because of the using of ceiling. Humidity difference during the day is the lowest value after Green Roof.

Between the other roof coverings, Green Roof is the material with the capability of reducing the heat in stable condition when there is no ceiling. The value is consistently rising compared to the 2 days before when there is ceiling. However Green Roof shows a definite value of increasing temperature. In the morning the room temperature is cooler compared to

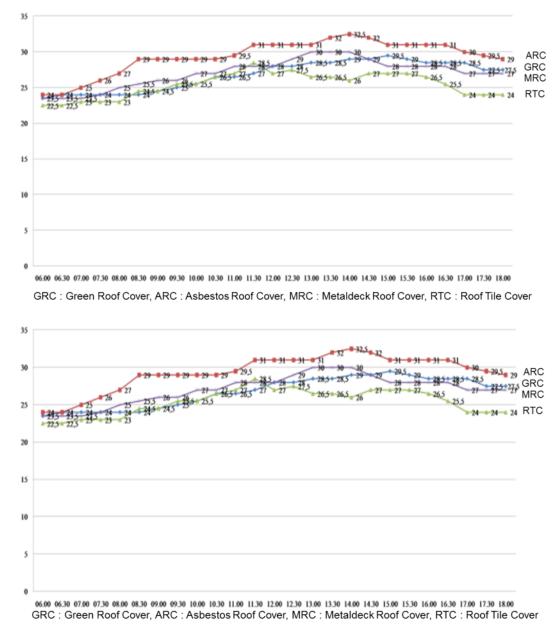


Figure 8. Temperature measurement day 3 and 4 using roof tile cover. Source: Author, 2016

when there is ceiling. The highest temperature is reached at 12.30 PM and stabilized. The value of temperature difference reached 6.67°C and this value is the highest among the other material. In the afternoon, the room temperature is still cool even though not as cool as the Roof Tiles case. On day 4 of measurement, Green Roof produces the highest difference. slowly temperature and consistently is increasing. The value of temperature difference on day 3 and 4 is 0.25°C. Around noon the room temperature stays cool and becomes cooler in the afternoon. In a room without ceiling, Green Roof is the best material in preventing and reducing the heat.

Humidity measurement on day 3 with ceiling, the value of humidity difference reaches the lowest value. Meanwhile in the afternoon, the room becomes dry. The percentage change between morning and afternoon takes longer time. On day 4, the humidity difference in during the day increases compared to day 3, with difference value of 8%. This value shows that Green Roof has the highest value of humidity difference. Green Roof is the material that has longest response to the heat after Roof Tiles.

D.CONCLUSION

Asbestos is the worst roof covering materials in terms of reducing temperature in the case with ceiling and without-ceiling. Humidity aspect is relatively low compared with the other roof covering materials, even though not as low as when ceiling is used. Asbestos is the fastest heat radiator and the longest to release the heat.

Roof Tiles is the covering material with biggest difference of rising daily temperature when the room has ceiling. Humidity aspect of Roof Tiles is the best in the room with ceiling and without-ceiling. Roof Tiles material is the fastest as radiator after Asbestos and the fastest in releasing the heat.

Metaldeck is the fastest roof covering material for reducing temperature in the room without ceiling, however it does not apply when the room uses ceiling. Humidity aspect continuously rising when the room does not use ceiling. Metaldeck is not good enough to radiate heat after Green Roof.

Green Roof can reduce the heat very well when the room uses ceiling or without ceiling, although it is not as good as Roof Tiles, and not as fast as Vol. 01, No. 1, August 2016: 39-54
The Influence Of Roof Cover Material On Gable Model To Climate Parameters
Case Study: Rumahinstansederhanasehat (Risha), Puslitbangpermukiman, Bandung

Metaldeck. Humidity aspect is really bad and getting worse when ceiling is not present. Green Roof is the lowest radiator and relatively stable.

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