Radiant heat reducing effect of the rooftop greening material with moss or lawn layer on a porous ceramic base using waste silica

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Abstract

To recycle silica byproducts, which are discarded as industrial waste, a porous ceramic with a high water-absorption capacity was produced by mixing waste silica powder with clay and then firing the resulting mixture. Following this, two kinds of greening materials, where the silica/clay ceramics were covered with moss and lawn, respectively, were produced. The front surface-temperature, the amount of water evaporation, the heat flux acting between the sample rear surface and the floor during a constant radiant heat reception on each sample were measured in laboratory experiments, which were performed using a halogen lamp instead of solar radiation. The surface-temperature increase suppression ability of the lawn sample was slightly lower than that of the moss sample due to a smaller water evaporation quantity.

Keywords: Waste silica, moss, lawn, rooftop greening material, radiant heat reducing effect

1. Introduction

To recycle silica byproducts, which are produced during the manufacturing of the merchandises such as desiccants and toiletries, the authors produced a porous ceramic by mixing the waste silica powder with clay and then firing the resulting mixture.

Focusing on the high-water absorption capacity of the silica/clay ceramics, the rooftop greening materials to moderate the heat-island phenomenon, where the ceramic was covered with moss or lawn, were produced.

In this study, the radiant heat reducing effects for the two kinds of greening materials were examined by performing the laboratory experiments using a halogen lamp instead of solar radiation. Particularly, in the experiments, to enable the temperature reduction effect by water evaporation heat on the samples to be investigated, the front surface-temperature, the amount of water evaporation, the heat flux acting between the sample rear surface and the floor on each sample during a constant radiant heat reception were measured simultaneously.

2. Materials and methods

Figure 1 shows the process used to prepare the moss and lawn samples. A porous ceramic from clay and waste silica powder was covered with moss or lawn.

Figure 2 shows a schematic of the measurement setup in a laboratory experiment. Moss and lawn samples in the water-absorbing state were used for the experiment. The samples had areas of 187 mm ×187 mm. The

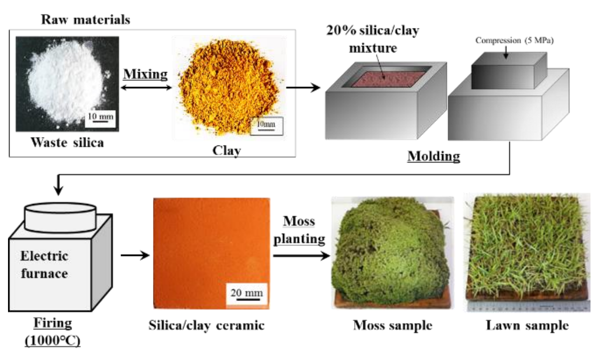


Fig. 1 Process used to prepare the moss and lawn samples

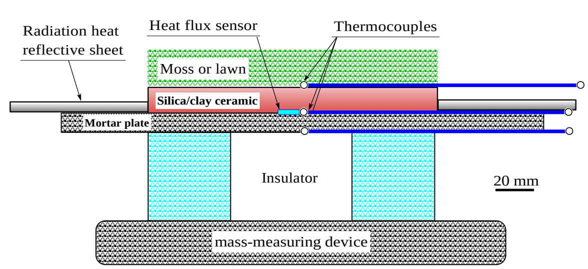


Fig. 2 A schematic of the measurement setup

thickness of the ceramic base was approximately 13 mm. The height of only moss was approximately ~50 mm. The moss few contained the soil. The height of only lawn was also approximately ~50 mm, whereas the lawn contained soil with a thickness of approximately 20 mm. The samples were used for an experiment in a predominantly saturated-water-absorbing state.

The surfaces of these samples were simultaneously irradiated with a radiant intensity of approximately 500 W/m^2 using a halogen lamp in a dark room. The front and rear surface temperatures of the samples, the rear surface temperature of a mortar plate under the moss or lawn sample during radiant-heat reception, the heat flux between the rear surface of the sample and the floor (a mortar plate with a thickness of 10 mm), and the amount of water evaporated from the sample were measured simultaneously.

3. Results and discussion

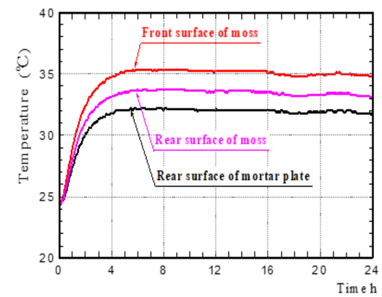
Figure 3 shows the front and rear surface-temperature changes of the moss and lawn samples, and the rear surface temperature of a mortar plate under the sample. The front and rear surface-temperatures of the moss sample were slightly lower than those of the lawn sample. The rear surface temperature of a mortar plate under the moss was also the same. This result shows that the suppression effect of the temperature increase caused by radiant heat of the moss sample is slightly larger than that of the lawn sample.

Figure 4(a) shows the cumulative water that evaporated from the samples. The amount of water that evaporated from the moss sample was larger than that from the lawn sample. The reason is thought to be because the water holding capacity of the moss was larger than that of lawn.

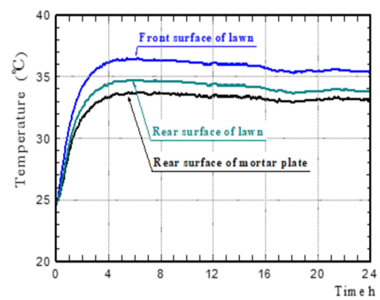
Figure 4(b) shows the heat of water evaporate. Here, the heat of water evaporation per unit time was estimated by multiplying the rate of water evaporation for each sample by the heat of water evaporation per unit mass (2400 kJ kg^{-1}). The heat of water evaporation per unit area was approximated by dividing the heat of water evaporation per unit time by the front surface area of the sample. The heat of water evaporation of the moss sample was larger than that of the lawn sample. Therefore, it is presumed that the temperature of the moss sample was lower than that of the lawn sample.

4. Conclusion

The suppression effect of the temperature increase caused by radiant heat of the lawn sample was slightly smaller than that of the moss sample. It is considered to be due to a smaller water evaporation-heat.

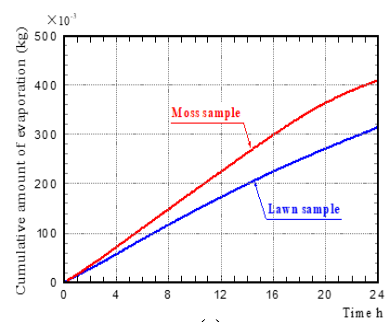


(a) Moss

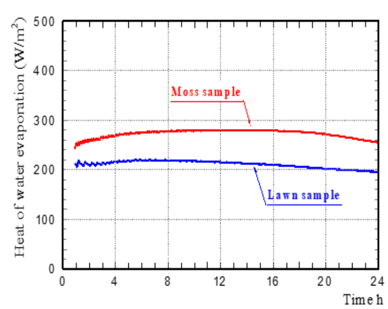


(b) Lawn

Fig. 3 The front and rear surface-temperature changes of the moss and lawn samples, and the rear surface temperature of a mortar plate under the



(a)



(b)

Fig. 4 (a) The amount of water evaporated from the samples, and (b) the heat of water

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