XV International Conference on Durability of Building Materials and Components
DBMC 2020, Barcelona
C. Serrat, J. R. Casas and V. Gibert (Eds)

Airborne Algal Growth on the Roofs of Membrane-Structured Residences in Cold Areas of Japan

Makiko Nakajima[1], Daisuke Masueda[1], Shuichi Hokoi[2] and Takayuki Matsushita[1]

[1] Department of Architecture, Graduate School of Engineering, Kobe University, 1-1 Nada-ku, Kobe, 657-8501, Japan, nakajima@gold.kobe-u.ac.jp

[2] Southeast University, Sipailou 2#, Nanjing, 210096, P. R. China, hokoi@seu.edu.cn

Keywords: *Roof Soiling, Airborne Algae, Surface Temperature, Condensation, Membrane Structure.*

1 Introduction

Discoloration of building facades due to airborne algae is observed in our surroundings. The growth conditions of these algae are not fully clear yet, and efficient preventive measures have not yet been determined. This study was aimed at investigating the influence of ambient environment and building structure on algal growth.

2 Method of Survey and Measurements

Measured building: A residential building in the cold region of Japan was surveyed. The roof was a multilayered structure consisting of a semi-transparent film, an air layer, an outside insulation layer, and was supported by rafters (Figure 1).

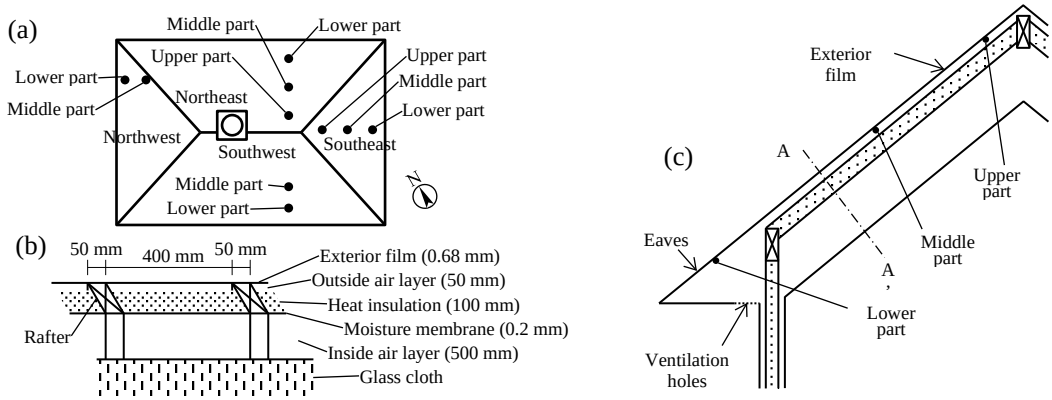

Figure 1. Measured house: (a) roof plan, (b) A–A' section of roof in (c), and (c) vertical section of the roof.

3 Surveyed and Measured Results

Soiling of Roof Surface: The stripe-shaped soiling extends vertically from the top to the bottom in the center of the northeast and northwest roofs. The soiling cannot be seen on the southeast and southwest roofs. The soiling hardly increased in the summer (July and August) and winter (December, January, and February) but increased from March to June and from September to November (Figure 2).

Surface Temperature of roofs: In summer, the temperature of the rafter part was 1 °C

higher than that of the air layer part during the daytime, and the temperatures of both were almost the same at night (Figure 3). In winter, the temperature of the air layer part was 3–5 °C

Figure 2. Photographs of northeast roof from September 2017 to March 2019.

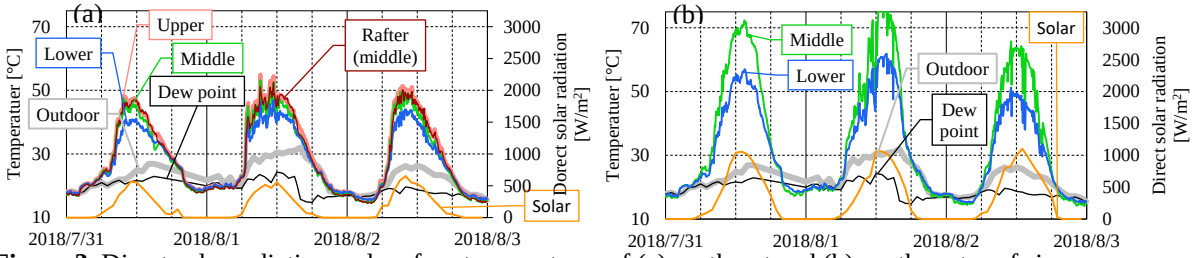

Figure 3. Direct solar radiation and surface temperatures of (a) northeast and (b) southwest roofs in summer.

higher than that of the rafter part in the daytime and 1–2 °C higher at night.

Annual change in surface temperature on each roof: On the northeast roof, the frequency of temperature higher than 45 °C was least, while persisted for a long time on the southwest roof.

4 Discussion and Conclusion

Roof surface temperature and roof structure: The roof surface temperature is higher at the upper part than at the lower parts, because of thermal stratification.

Surface condensation on roof: The surface temperatures on all roofs decreased below the dew-point temperature of the outdoor air from May to October.

Dependence of soiling on roof orientation: The frequency and period at which the surface condensation occurred did not show a large dependence on the roof orientation, and the algae can grow from May to November on all roofs. From May to November, the surface temperature on the southeast and southwest roofs was over 45 °C almost every day, therefore soiling did not occur. The frequency of the high temperature of over 45 °C was least on the northeast roof from May and November, and thus the algae grew most actively on this roof.

Difference between soiling on rafter and air-layer parts: The surface condensation on the rafter part occurred more frequently than on the air-layer part. Therefore, the algae are considered to grow more likely at the rafter part than at the air part.

Occurrence of Soiling Based on Time of Year: On the northeast roof, the surface temperatures were from 0 to 45 °C and condensation occurred from August to September 2017, the middle of July 2018, and from September to October 2018, thus the algae are predicted to grow during these periods. This corresponds well to the observed result.

ORCID

Makiko Nakajima: https://orcid.org/0000-0001-7753-4113