Concrete Buildings + Fractal Sunshade = Cool Island

*Satoshi Sakai[1], Hirofumi Sugawara[2], Ikusei Misaka[3], Kenichi Narita[3], Tsuyoshi Honjo[4], Nobuyoshi Kiyota[5], Makoto Nakayoshi[6]

1. Graduate School of Human and Environmental Studies, Kyoto University, 2. Defense Academy of Japan, 3. Nippon Institute of Technology, 4. Chiba University, 5. Hiroshima Institute of Technology, 6. Tokyo University of Science

Urban concrete is considered to be a cause in the city's heat island. In fact, concrete exposed to direct sunlight in the summer is higher by 30 ˚C than the surrounding temperature. However, for daytime, concrete with large thermal inertia should rather play a role of suppressing the temperature rise in the city. Nevertheless, the cause of extremely high temperature is not the characteristic as a material but the shape. Artificial objects such as buildings and roads have a surface of a size in meters. In contrast, the leaves of natural trees are about several centimeters in size. Since the heat transfer rate from an object with a large surface area is small, if heat from the sun is taken in to the concrete, it must be very high temperature to release it. On the other hand, a fractal sunshade is one which is an artificial object but has a shape close to the leaves of trees and keeps the heat transfer rate to the air low. By shading the sunshine with this sunshade and utilizing the high thermal inertia inherent in concrete, the city during the day should be a cool island.

In order to demonstrate this, we set up a fractal sunshade in the scale model for urban climate (COSMO) at Nippon Institute of Technology. The experimental site COSMO has a concrete slab of 100 m ×50 m on which 512 dice-shaped concrete blocks of 1.5 m square model buildings are arranged at intervals of 3 m. Since the area of the concrete surface including the wall surface is twice the ground surface area, the bulk thermal inertia is twice that of the concrete surface. Here we set up a 20 m ×20 m fractal sunshade and compared it with a section without a shade. The fractal shade has a three-layer structure with a layer that blocks solar radiation in the morning and afternoon, in addition to the layer that has the maximum light shading ratio in the south middle time, and it maintains the light shielding ratio of about 90% almost throughout the day . For comparison, observation at the grassland adjacent to COSMO was also conducted.

Temperature observation in the grassland adjacent to the COSMO, the concrete section under the fractal shade, the concrete section under the direct sunlight were made. The temperature during the day was the lowest under the fractal shade. Looking at the vertical distribution of the temperature during the day, in the grassland and the concrete section, the temperature is higher as the closer to the ground surface and the unstable stratification is made, whereas the air is stably stratified under the fractal sunshade. It was confirmed that the concrete was working as a heat sink.

Keywords: Fractal Sunshade, Heat Island, Thermal Inertia

