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Effects of Different Pavement Materials on the Urban Thermal Environment

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Pavement, Heat Island, Urban Environment, Outdoor Experiment, Numerical Analysis

1 Introduction

It is well-known that the ground surface in the urban area, where a large portion of the surface is usually covered by asphalt and concrete, can act as a heat reservoir to absorb incoming solar radiation during the day, which together with anthropogenic heat released by human activities create the so called urban heat island (Asaeda and Vu, 1993).

The purpose of this study is to investigate heating characteristics of different pavements by out-door experiment and numerical analysis. The effects of ceramic porous pavement on the improvement of microscale thermal climate are investigated by a numerical model for the wind and air temperature field coupling with heating processes at the ground surface and surfaces of walls, roofs of buildings.

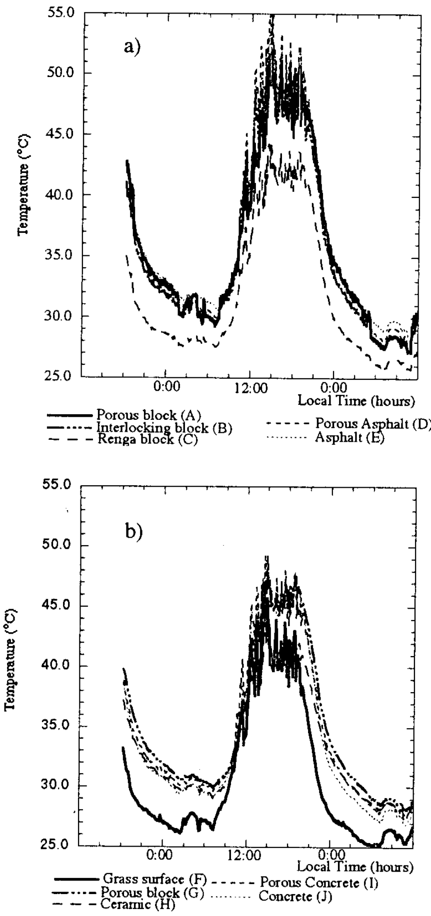

Figure 1: Surface temperature of various pavement samples on August 8-10, 1994

2 Field Experiment

During the field experiment, temperature and ground heat flux at the surface and various depths below surface of ten pavement samples together with meteorological conditions such as air temperature, relative humidity, wind velocity, solar radiation, downward longwave radiation were recorded at 5 minutes interval continuously from August, 1994 to May, 1995.

Surface temperatures of various pavement samples measured during the extensive observation of 8-9 August, 1994 are depicted in Figs. 1 (a,b). At noon, surface temperature of the porous asphalt pavement reaches 52°C, which is almost the same as that of the normal porous block and 3°C lower than that of the asphalt pavement, which reaches 55°C. At the same time, temperature at the surface of ceramic pavement reaches only 42°C, almost the same as that of the surface of the natural grass.

The high surface temperature of the normal porous pavement can be explained by the effects of the pore size in pavement materials on the subsurface moisture transfer. The normal porous block, having large pores, can not keep the water inside and is dried up rapidly. This makes its surface temperature at noon as high as that of the normal impermeable concrete pavement. On the other hand, ceramic porous pavement, possessing small pore can absorb a large amount of water during a rainfall and from the underlying soil. The water contained inside the pavement sample is later evaporated, which helps to keep the temperature at the surface of the ceramic pavement much lower than that at the surface of other porous pavements.

Figs. 2(a-c) depict heat balance at the surfaces of different pavements evaluated by a numerical model, coupling the subsurface heat and mass transfer. It is shown in the figures that the sensible heat at noon for the asphalt pavement can reach 400W/m^2, while the sensible heat at the grass surface and surface of ceramic pavement is smaller than 150W/m^2. Thus, the asphalt pavement heats the air much more than the other pavements.

3 Analysis of the Effects of Pavement on the Urban Microclimate Based on a LES Model

In order to investigate the effects of ceramic pavement on the urban microclimate, a turbulent model of the Large Eddy Simulation (LES) type has been developed (Vu et al, 1996).

The computational region is assumed of the size 120m(long)×120m(width)×100m(height). A building of the size 20m(long)×15m(width)×25m(height) is supposed to be constructed in the computational region as shown in Figs. 3(a,b). Computations were performed for two cases: the ground surface is covered totally by asphalt and the ground surface is covered totally by ceramic porous pavement.

Figs. 3(a-b) depict the horizontal distributions of air temperature and wind velocity at 2 p.m. for the cases that the

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ground surface is covered by ceramic and asphalt pavements, respectively. From the figures, it can be seen that the air temperature at 3.5m above the surface for the case of asphalt pavement surface is in general about 1.5K higher than that for the case of ceramic pavement surface. For the hottest region near two edges of the building, this difference is amounted to more than 2K.

4 Conclusion

The utilization of the normal porous pavement material does not improve the thermal environment of the urban areas since the surface of this kind of pavement is usually very dry and evaporation can not occur.

From the results of field experiment and numerical model, it is remarkable that significant improvement of the urban micro-scale thermal environment can be achieved if ceramic pavement surface is used.

Acknowledgement

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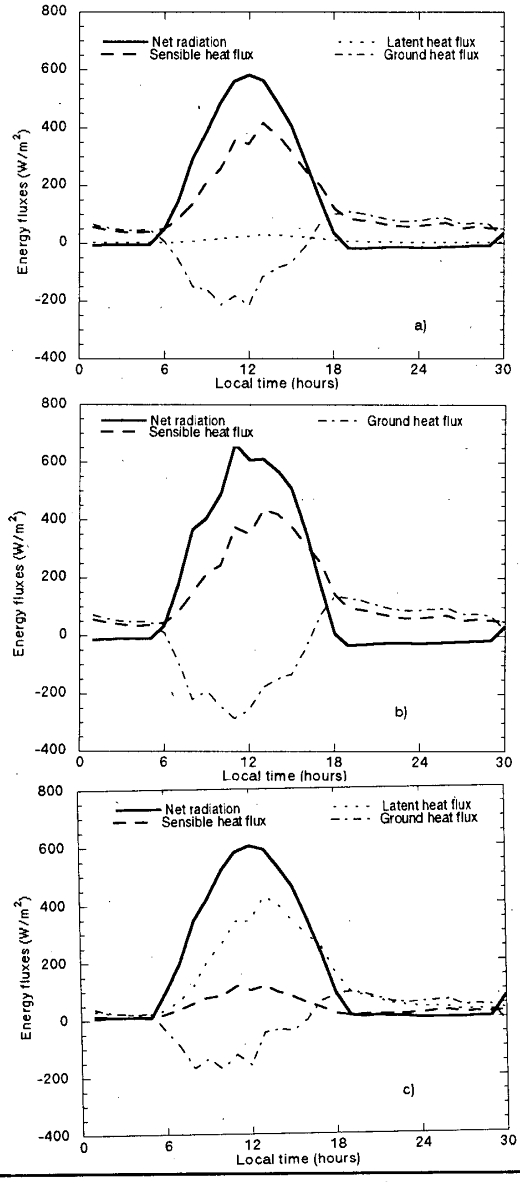
References Vu, T.C., T. Asaeda, Y. Ashie, T. Tanaka (1996) *Wind Engineering Symposium*, Japan, 133-138.



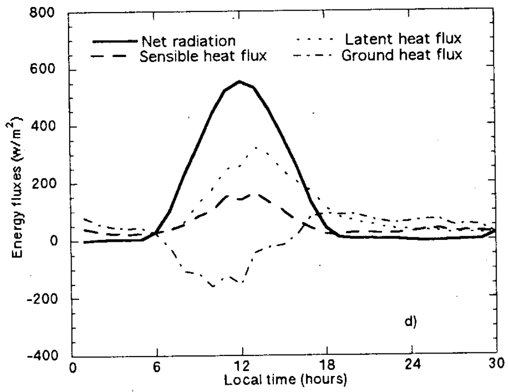


Figure 2: Heat balance at the surfaces of a) normal porous pavement, b) asphalt pavement, c) grass surface, d) ceramic porous pavement, on August 8-10, 1994

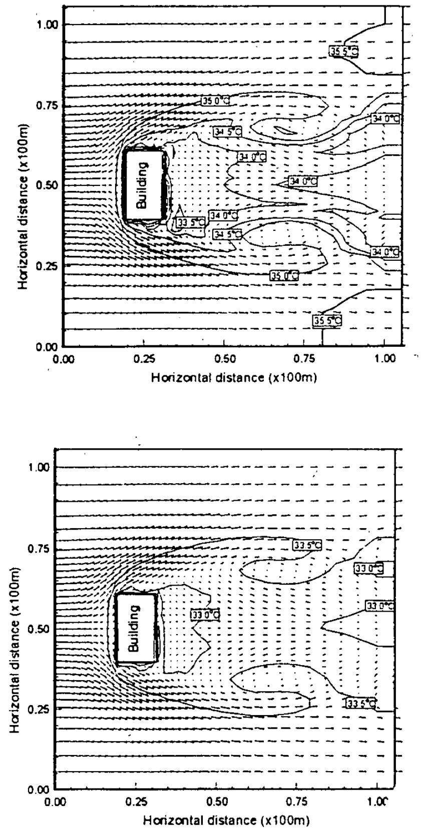


Figure 3: Horizontal air temperature and wind velocity at 2p.m. at 3.5m above the surface of a) asphalt pavement, b) ceramic porous pavement

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