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Investigation of urban canyon microclimate in traditional and contemporary environment. Experimental investigation and parametric analysis

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ABSTRACT

The paper presents the results of extensive measurements which took place in two sites with different characteristics in terms of street geometry, urban density and materials. The first experiment site was a traditional settlement in the island of Tinos, Greece, while the second was a relatively newly built part of the capital city of Tinos. The experimental measurements, which include air and surface temperature, air humidity and air velocity, were carried out in two sets, during the summer and winter period. The experimental measurements were compared to simulation results obtained by a special computer tool. The comparison led to the conclusion that experimental measurements and program results were in good agreement for the summer period, and the tool was subsequently used in order to perform parametric analysis of microclimate in urban canyons. Main parameters that affect urban canyon microclimate were examined, that is street geometry, street orientation, effect of trees, horizontal surface albedo, wind speed and wind direction.

The paper aims in presenting the results obtained by the comparison of the two sites and in analyzing the effect of parameters such as urban layout, street geometry and orientation on urban canyon microclimate, with special reference on the characteristics of traditional architecture of the Cycladic islands. Also, the parametric analysis aims in investigating the parameters involved and their degree of influence on urban canyon microclimate.

1. Introduction

Climatic response in urban design is an issue of great importance since it is associated with microclimatic conditions and thermal comfort in outdoor spaces, as well as with the energy performance of buildings. Therefore there is an increasing interest by researchers on the impacts of microclimate on pedestrian comfort as well as on the impact of several parameters that influence the microclimatic conditions in open spaces and urban canyons. Such parameters include canyon geometry, street pattern, height/width ratio and use of materials.

2. Experimental investigation

2.1. Site selection and method

The first experiment site is a traditional settlement in the island of Tinos, Greece, while the second is a relatively newly built part of the capital city of Tinos (Fig. 1). The traditional settlement is located on an SE −facing slope and is characterized by compact design, high density, high H/W ratio, undulate street pattern, covered parts of streets, extensive use of stone for both walls and for the ground and white-washed walls. On the other hand, the newly built site is located on flat terrain and is characterized by straight streets, lower H/W ratio and use of cement and asphalt for ground cover. The local climate is characterized by high solar intensity and strong northern winds.

The experimental measurements, which include air and surface temperature, air humidity and air velocity, were carried out in two sets, during the summer and the winter period, simultaneously in both sites. The axes of the streets where the measurements were carried out have the same orientation in both sites (Figs. 2 and 3). The measurements in the traditional settlement were carried out in four streets, two of which were parallel to each other (B1, B3), one was perpendicular (B2) and one was a covered street (B4). The H/W ratio is between 4 and 2. (Fig. 5) The measurements in the contemporary site were carried out in two perpendicular streets (A1, A2). The H/W ratio is significantly lower: 0.9 and 0.7 respectively (Fig. 4).Ambient air temperature and humidity measurements were also carried out for both sites.

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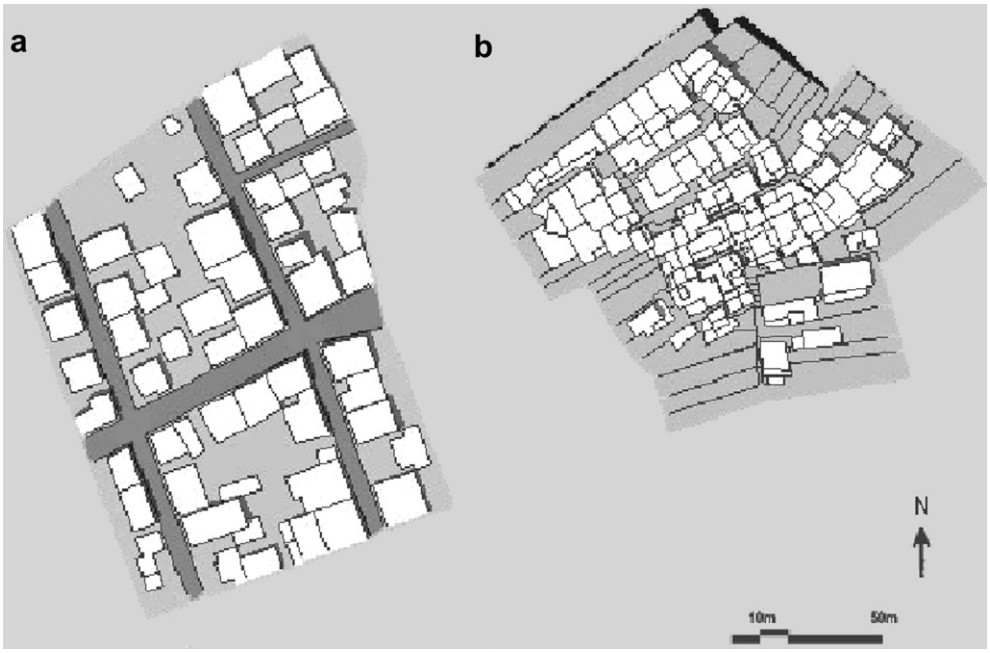

Fig. 1. The contemporary (a) and the traditional (b) site.

2.2. Results

2.2.1. Air temperature

By comparing air temperature in streets perpendicular to each other at the traditional site (B1–B2) in the summer period, no significant differences were observed except for slightly higher temperatures in street B1 which is possibly due to lower wind speed. (Fig. 6). By comparing air temperature in streets parallel to each other with different street geometry (B1–B3) air temperature in B3 was either similar to that in B1 or lower by 0.5–1.0 °C. Consequently, although shading in B1 is higher due to higher H/W ratio, the higher air movement in B3 contributes to lower temperatures. The air temperature inside the streets was lower than the ambient temperature during morning hours (oasis effect) but higher by 0.5–2 °C during the night (heat island effect).

By comparing air temperature in streets perpendicular to each other at the contemporary site (A1–A2) no significant differences were observed. Street temperature was generally higher than the ambient temperature by 1–2 °C (Fig. 7). The heat island effect is more intense during the night.

During wintertime, air temperatures in perpendicular streets and in streets parallel to each other with different h/w ratio, were very similar (Figs. 8 and 9). The air temperature inside the streets in the traditional site was higher than the ambient temperature by

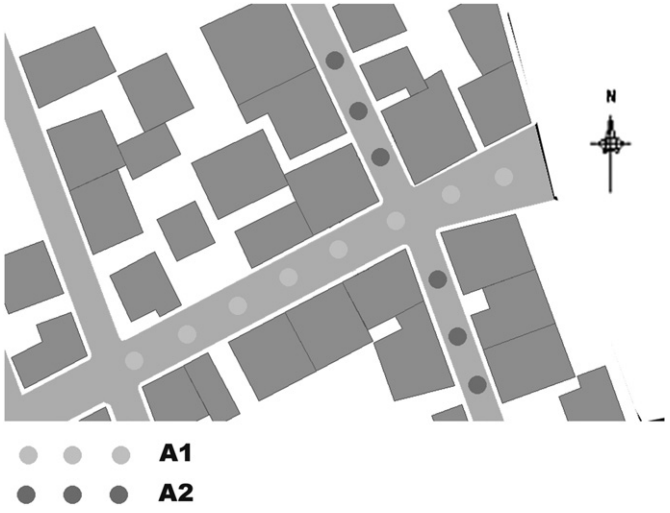

Fig. 2. The contemporary settlement.

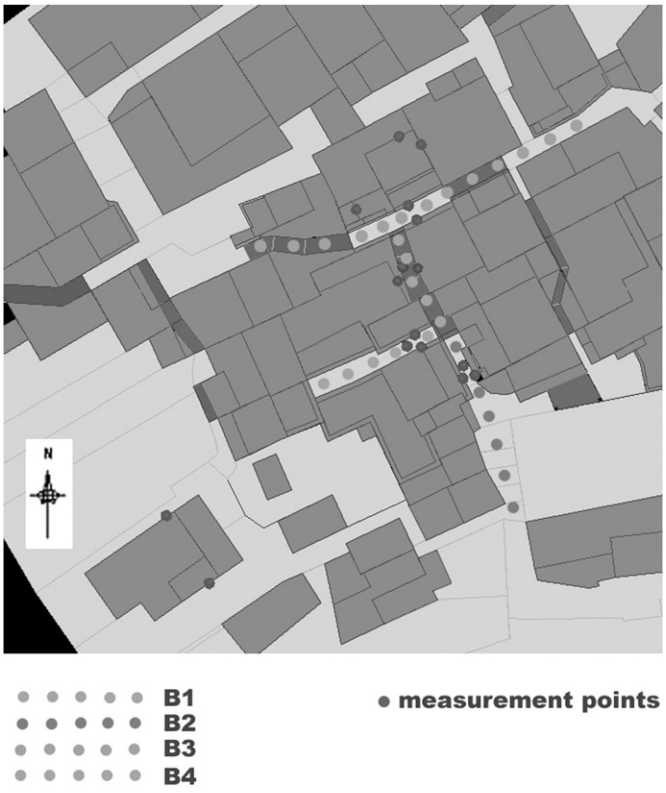

Fig. 3. The traditional settlement.