## Passive Cooling Design Options to Improve Thermal Comfort in an Urban District of Rome, Under Hot Summer Conditions

Giorgio Galli<sup>#,1</sup>, Andrea Vallati<sup>#,2</sup>, Carla Recchiuti<sup>#,3</sup>, Roberto De Lieto Vollaro<sup>\*,4</sup>, Fabio Botta<sup>#1</sup>

<sup>#</sup>Department "DIAEE Area Fisica Tecnica", University "Sapienza" of Rome, Via Eudossiana 18 – 00184 Rome, Italy

<sup>1</sup>giorgio.galli@uniroma1.it <sup>2</sup>andrea.vallati@uniroma1.it <sup>3</sup>carla.recchiuti@uniroma1.it

Department of Engineering, Università degli studi Roma Tre, Via della Vasca Navale 79, Rome - 00146, Italy <sup>4</sup>roberto.delietovollaro@uniroma3.it

<sup>5</sup>fabio.botta@uniroma3.it

*Abstract*— The aim of this study is to investigate how the air temperature is affected by the urban design and how it can be modified to improve the thermal comfort in the city of Rome. The physical and geometrical properties of the buildings and the presence of green areas have a large impact on the urban climate and on thermal conditions of the people who use open spaces; it is obvious how the role of a urban planner is important to reduce the thermal stress and to design comfortable outdoor spaces for humans. In this study, several numerical simulations using ENVI-met have been performed to evaluate the impact of urban morphology on the microclimate within a city center in summer. Although some very hot conditions were recorded, there were evident examples of more acceptable comfort conditions and cooling potential for some orientations and degrees of urban compactness due to the clustered form with green cool islands and wind flow through the main canyons. Some design guidance on how to form urban passive cooling systems is presented.

Keywords: Urban Heat Island, Thermal Comfort, Air Temperature.

## INTRODUCTION

I.

In the last decades significant results on the comfort improvement have been achieved in Italy through appropriate planning laws and important researches on materials used as surfaces coating and on urban geometries. Nevertheless, several factors have to be considered to reduce their impact on the urban thermal comfort. An open urban configuration guarantees a natural ventilation but the surfaces are highly exposed to solar radiation. Instead, a compact urban structure increases the solar shading but reduces the wind flows [1,2]. Several studies [3, 4, 5, 6, 7, 8, 9, 10] have been performed about the impact of urban morphology and green area design on the outdoor thermal conditions, and the mitigation of the urban heat island. Furthermore, the increasing electric energy demand can be linked to the urban microclimate within a urban region and the urban configuration plays a crucial role on the need of air conditioning systems inside the buildings. The urban heat island phenomenon affect the pedestrian thermal comfort for the persons and reduce the air conditioning demand in buildings. In this paper, we investigate the impact of urban geometry and green areas design on outdoor thermal comfort, including air quality and airflow in urban canyons, by means of on-site monitoring and microclimate simulation.

## II. CASE STUDY

The boundary conditions set for the simulation of the study area are:

 $41^{\circ}$  53' 33,5 latitude and  $12^{\circ}$  29' 31 longitude, Start of analysis: 25/07/ ore 07.00, Wind: South-West- (3 m/s at z= 10m), Potential temperature (2500m) 304 K and Specific Humidity (2500m) 7 g/Kg

The first analysis considers the state of fact of the area (case A), which is characterized by small areas of residual green and low-rise buildings, with sheet metal covers and by impervious soils. The ventilation is good on the whole area and the shadows areas are scarce in summer.



Fig.1 Envi-met map of case A

Fig. 2 Aerophotogrammetric map of case A

The case B disrupts the arrangement of the area by introducing a green boulevard, with areas of grass and trees of medium and small heights, this space is bounded by two fronts of buildings with plaster or brick facing. The ventilation is low because hindered by the two continuous sides, while shading is moderate in summer and excessive in winter.



Fig.3 Envi-met map of the case B



Fig. 4 Three-dimensional scheme of the case B

From these considerations, with the same basic design approach the type of vegetation (tall deciduous trees) and the soil covered are changed (concrete slabs with higher albedo): case C. The ventilation remains the same as in the previous case; the summer shading is changed because of the taller trees with higher LAI.

In case D a wide green area is placed along the Aurelian walls and the new buildings forming small courtyards and following the equisolar orientation are designed. Ventilation, not encountering too many obstacles, is good and shading in summer and in winter it is controlled and positive.



Fig.5 Envi-met map of the case C



Fig. 6 Three-dimensional scheme of the case C



Fig.7 Envi-met map of the case D

Fig. 8 Three-dimensional scheme of the case D

The most favorable solution as regards ventilation and shading is the case E. The open space proposes the solution of the green corridor, bounded by two rows of buildings with a larger number of tall trees. Two underground buildings are proposed, covered by roof gardens, so that the open spaces are structured on two levels. This ensures greater accessibility for users, because it improves the access to the area.



Fig. 9 Envi-met map of the case E



Fig. 10 Three-dimensional scheme of the case E



Fig. 11 Air temperature of recptor  $n^{\circ}4$  at z=1.5 m

Fig. 12 Air temperature of recptor  $n^{\circ}5$  at z= 1.5 m





Fig. 14 Air temperature of recptor  $n^{\circ}7$  at z=1.5 m



Fig. 15 Air temperature of recptor  $n^{\circ}9$  at z=1.5 m











As can be seen from fig 11 to fig. 25, Case A, that is the existing urban configuration give the worst performance: higher air temperature both in daytime and in nighttime. This effect is less marked for receptor 5 that in case A is in a green area. The green alley proposed in case B improves the thermal conditions at any time and further improvements are obtained using taller trees and building and pavement surfaces with higher albedo (case C).

Extending the green areas with lawns and scattered shrubs and trees, as in Case D gives only marginal differences compared with Case C. A significant improvement is represented by case E: extended green areas with tall trees, well spaced building blocks that favour ventilation, building and street surfaces with higher albedo. Even from the limited number of urban projects considered in this study, it can be said that, depending of the urban design, variations of the air temperatures of more than 3K can be obtained, with significant improvements in the environmental comfort and in energy use of air conditioning.

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