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Microclimatic Conditions of an Urban Square: Role of built environment and geometry

Shahab Kariminia[a,*], Sabarinah Sh. Ahmad[a,b], Ahmadreza Saberi[a]

[a]*Faculty of Architecture, Planning and Surveying,*
[b]*Community of Research, Green Technology and Sustainable Development,*
Universiti Teknologi MARA, 40450 Shah Alam, Malaysia

Abstract

Geometry plays a dominant role in thermal situations within city structures. This study aims to seek how this role affects thermal comfort of the visitors in an urban square. Computer simulations were performed along with physical measurements in an urban square during peak hot conditions of summer in Isfahan, Iran. In addition to the influence of built environment inside the square, the results confirmed the role of geometry on thermal conditions. The amelioration effect for the aspect ratio was higher than that of the orientation. Findings are useful for urban design strategies dealing with thermal comfort.

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Keywords: Thermal comfort; urban square; geometry; built environment

1. Introduction

The residents' outdoor life in urban areas has been affected by the rapid development of cities (Kariminia, Sh Ahmad, Ibrahim, & Omar, 2010) along with the global climate change (Kariminia, Ahmad, & Hashim, 2012; Kariminia, Ahmad, Hashim, & Ismail, 2013). Meanwhile, thermal comfort is a key factor that contributes to the public perception and attraction of outdoor settings. Indeed, pedestrians are directly exposed to the outdoor environment and sensitive to the immediate microclimate they experience in urban spaces, which in turn influence their perceptions (Nasir, Ahmad, & Ahmed, 2012,

* Corresponding author. Tel.:+0-603-55211536;fax:+0-603-55444384.
E-mail address: sh.kariminia@salam.uitm.edu.my

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2013; Nasir, Anuar, Darus, Jaini, & Salleh, 2012). Furthermore, urban geometry in the previous studies appeared to be affecting microclimates across city structures. Appropriate urban design by using applicable strategies can ameliorate thermal stresses and enhance the residents' thermal comfort (Kariminia, Sh Ahmad, & Ibrahim, 2013). Several studies have investigated the effects of geometry of canyon structure on their thermal conditions (Ali-Toudert, 2005; Griefahn & Künemund, 2001). Very few studies focused on thermal comfort of urban squares (Kariminia, Ahmad, Omar, & Ibrahim, 2011; Kariminia & Ahmad, 2013). No previous studies investigated this issue in Iran. In addition, simulation methods were rarely used in this issue. Applying both empirical and theoretical methods, this study aims to seek the role of built environment and some geometrical factors of the square on its microclimatic situations and thermal comfort of the visitors in moderate and dry climate of Isfahan, Iran. Therefore, a series of measurements were conducted in an urban square and the recorded data were further used to compare different geometrical schemas of the square via computer simulations.

2. Materials and Methods

2.1. Study area

The field studies were conducted in Imam Square, located in a historical site of the city of Isfahan. This city is located at 51°41' E longitude, 32°37' N latitude and altitude of 1590 m above sea level. According to meteorological data, this city experiences hot summers and cold winters with low relative humidity (RH) throughout the year. Between 1951 and 2009, the highest and lowest monthly average temperatures were 28.8 and 3.7 °C, respectively. The highest recorded air temperature (T_a) was 43° C in July, whereas the lowest was -19.4° C in January. The average RH during the year varied between 25 and 60 percent. The square is flanked by long, low-elevation, two-storey buildings, except for the gaps created by two streets on the east and west sides. There are two thin lines of short evergreen bushes along the sides of the square. A pool, fountains and stone benches are located at the centre of the square. The ground surface is mostly paved with stone and grass while only a small part is covered with asphalt.

2.2. Environmental measurement

The field measurements were performed for a full week between 24 and 30 July 2010 as the critical hot weather conditions. Data were acquired from 10:00 to 18:00 at 10-minute intervals. The T_a, RH, wind speed (W_s) and solar radiation (R_s) were measured by a portable HOBO data-logging mini weather station. The equipment was placed 1.5 m above the ground on tripods. The instruments were placed at four pre-selected points in the square at different times to provide data more representative of the different environment of the whole square. The first point was located on an 80cm high platform surfaced covered by high albedo stone, near the entrance porch of Sheikh Lotfollah Mosque at a distance of 1m from the façade. The second point was positioned within the vicinity of the bushes. The third point was located next to the pool while the fourth point was positioned in the middle of a wide pathway. The locations were labeled as P1-P4, respectively.

2.3. Simulations

ENVI-met 3.1 is a 3D non-hydrostatic microclimate model with a wide range and detailed output variable prognosis. It was originally designed by Prof. Bruce of University of Mainz, Germany and was developed in collaboration with Flemish Institute for Technological Research (VITO) (Maerschalck et al.,