The Effect of Asymmetrical Street Aspect Ratios on Urban Wind Flow and Pedestrian Thermal Comfort Conditions 2016

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Abstract

Due to the need to expand the Saudi urban configurations over the last six decades, the design of urban neighbourhoods has changed from organic and pedestrian-oriented to geometric and vehicle-oriented, which has greatly influenced the pedestrian use of outdoor spaces. Combined with the high ambient air temperatures, these current trends affect wind flow patterns and pedestrian thermal comfort conditions in the hot arid region of Madinah in Saudi Arabia. Numerous studies were conducted correlating the configuration of urban street geometries (presented by height to width H/W aspect ratios) with thermal comfort, but mostly conducted in relation to exposure to solar radiation. Most of the previous studies have focused on symmetrical canyon studies, which are more representative of actual urban areas. The study of multiple asymmetrical urban street aspect ratios (ie, diverse buildings height to street width), based on optimising the buildings' height to influence wind flow rate, has not received much attention in the context of urban pedestrian thermal comfort, particularly in low wind speed environments within hot arid regions.

The present study aims to evaluate the effects of multi-asymmetrical street aspect ratios on urban pedestrian microclimate and outdoor thermal comfort conditions, through a case study of Quba Road, to find ways to enhance the thermal comfort level compared to the existing urban configuration. The road is a commercial/residential route linking between two prominent religious sites in Madinah. Computational Fluid Dynamics (CFD) ANSYS Fluent 13.0 software is used as a numerical modelling tool to simulate the urban pedestrian microclimates for comparative studies, and results validated by field measurements. The CFD analysis is used for analysing the air temperature and wind velocity measurements within the windward and leeward canyons of Quba Road. Thermal comfort was expressed by means of the physiologically equivalent temperature (PET) index using RayMan software.

The findings indicate that a leeward gradual increase in multiple asymmetrical aspect ratio of 1 – 1.3 – 2.3 reduces the air temperature by 3.43°C and increases wind velocity by 169.2% (ie, from 0.65m/s to 1.75m/s), which is recommended for enhancing urban pedestrian microclimates in low wind speed environments. Indicating that, a small increase in wind speed significantly improves pedestrian thermal comfort conditions, with the average measurement difference of 4.8˚C in PET temperature.

Keywords: Multi-Asymmetrical street aspect ratio; CFD Numerical Modelling; Hot Arid; Pedestrian Microclimate; Thermal Comfort; Urban Canyon.