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The Impact of Urban Structure Changes on the Airflow Speed Circulation in Historic Karbala, Iraq

Dhirgham Alobaydi[1], Haider Mohamed[1], Hussein Attya[2]

[1]*The Univesity of Kansas, 1450 Jayhawk Blvd. Lawrence, KS 66045, United States*
[2]*University of Calgary, 2500 University Dr. NW, T2N 1N4, Canada*

Abstract

This study investigates a dynamic air flow circulation in the urban historic structures of Karbala, which is one of the typical examples of historic nuclei in Iraq as well as the Middle Eastern region. The mechanism of natural urban ventilation system of the city is continuously facing forces of change for different reasons, such as socioeconomic, political, and environmental. These changes in the city form included but not limited to: large parts of urban historic structures have been removed and new concrete structures and modern streets, that have different geometry, dimensions, and materials, have been added. Such changes affect ~~a~~ the pattern of street networks and the mass-void proportions in the old urban structures, which were built in efficiency providing ventilation and cooling naturally, and could have great impact on the speed and behavior of the air flow circulation. For the analysis purposes, two phases which are remarkable in forming the old structure of Karbala have been selected and digitized. These phases include the organic urban structures before the initial acts of road building in the beginning of the previous century, before British mandate in 1920, as well as the new comprehensive master plan that was carried out for the city during 1990s, after the end of the Gulf War II. The study area was strictly defined to represent traditional environment relied on using natural ventilation system. Four simulation models of the study area have been created for the aforementioned phases. The first set has shown the air flow speed, while the second set has presented LMA, i.e. the local mean age. The simulation process was supported by surveyed and historic meteorological data. Results show that the changes of old urban structures affect the air flow circulation speed significantly, but more importantly, these results offer a useful source for contemporary urban planning, using comprehensive plans, in historic nuclei with similar characteristics to Karbala in both local and regional areas. One significant limitation of this study, however, is that it has not involved single urban blocks or residential units in the analysis.

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1. Introduction

Built with a high sense of using traditional architecture solutions and organic growth, historic Karbala is one of the remaining examples of the old urban structures in Iraq and the Middle Eastern region. Located about 100km (62 miles) southwest of Baghdad, Figure (1), its old structure is primarily characterized by two central monumental shrines, zigzag street networks, and urban compact units containing open areas are called courtyards. Across long span of its evolution, more than 1000 years, the old urban structure is continuously facing forces of change. In particular, a hugely change of the city form can be noted between two phases. In a very beginning of the last century, the city form was compact and relatively small. Then, the city expanded enormously and its old structure was complemented by massive new urban developments since 1990s till now. Large parts of the old structures have been cleared away and new concrete structures, which have different geometric, constructional, and environmental characteristics, have been added [1], as shown in Figure (2). The pattern of old street networks and the compact residential clusters were built and developed to accommodate the prevailing continental climate conditions such as high temperature and frequent dust storms [2]. Such a compact and high density urban development has been compensated by a natural ventilation system (NVS) to achieve an effective airflow circulation for both indoor and outdoor environments [3]. This NVS has worked based on two sets of components: the first set is existed inside the compact residential units including *Badgirs* (wind catchers), courtyards, and *sirdabs* (basements). The second set is formed by the network of zigzag streets that cause continuous changes in the air flow speed and direction [4]. To illustrate performance of NVS, this study aims to address this question: what could be the effects of altering the old urban structures on the airflow speed circulation of the NVS? Mechanism of the NVS is essentially working based on the movement of the airflow, which is going to be analyzed through simulation models of the urban structures in both cases of before and after introducing the changes. The study is organized in six sections including: a main background of the study, mechanism of the NVS, relevant works, methodology, results and discussion, and finally conclusion.

Fig 1: a-the location of Karbala, Iraq; b-the selected site of the study area. Source: (Attia, 2009).

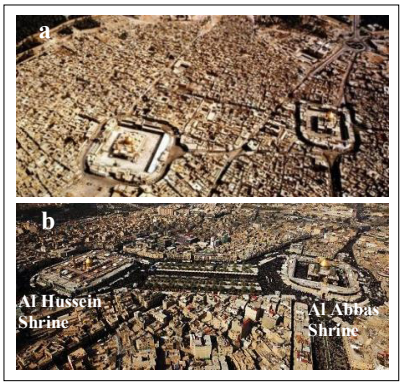

Fig 2: a- the old site; b-the new site (after changes). Source: (Attia, 2009)

2. Mechanism of the Natural Ventilation System

Mechanism of natural ventilation system relies on the efficiency of airflow circulation between street networks and a set of architectural components inside urban clusters Figure (3). Basically, air streams flow from street networks into *badgirs* that are placed above roof surfaces of compact units in relation with their parapets. They often have faced northwest air streams, prevailing winds, to gain maximum benefits of cool breezes during summer months. Then, cool breezes move from the urban clusters through *badgirs'* shafts to the basement floor, known locally *'sirdab'*, and finally move into the courtyard through narrow windows for ventilating and cooling purposes [3][5]. This mechanism has worked in traditional urban structures for many decades on the basis of convection