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Investigating the effect of building geometry on outdoor wind flow performance in residential complexes

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Abstract

Airflow is one of the most fundamental parameters of outdoor thermal comfort, which is influenced by various factors, including the geometry of buildings.

The present study investigated the effect of geometric modifications of buildings on wind flow pattern around the blocks in a residential complex. The case study is a residential complex consisting of 9 midrise blocks. The geometric shape of the blocks was modified and simulated in three steps and the effect of these modifications on the outdoor wind performance was evaluated.

The main research method was descriptive analytical method with numerical simulation strategy and analysis of the results was conducted by logical reasoning. The models were simulated in Ansys Airpak 3.0.

The results of numerical simulations proved the effect of building geometry on the outdoor wind flow pattern. The results indicated an increase of 13.83% and 6.76% in average and maximum outdoor air velocity under the influence of buildings geometry modification. Among the studied geometries, the T-shaped form with proper wind flow conduction improved wind behavior in inter-block and inter-row domains. However, L-shaped forms (M3 model) significantly reduced the flow velocity in the inter-block areas by blocking the wind flow.

Keywords: Wind, Open space, Flow pattern, Geometry, Building.

1. Introduction

E Nowadays, 55% of the world's population live in urban areas, but this number is predicted to increase in the next years. According to the predictions, it is expected that about 68% of the world's population will live in cities by 2050 [1].

Currently, due to high population density and the need for housing, the construction of residential complexes in Iran (especially the city of Tehran) has become very common. The development of residential complexes in Iran initiated in the 1330s, with the growth of urbanization and increased migration to Tehran [2]. The construction of residential complexes in the 1370s and 1380s by numerous companies became very popular. Currently, the construction of this building typology is growing gradually and in many cities it meets the growing housing needs of citizens.

Open space in residential complexes is a context for the formation of social relations. This space, with its greenery mitigates most of the environmental problems, and helps to balance the density of the building. Providing thermal comfort condition is one of the most essential factors to attract people to these spaces. Air flow, radiant energy, humidity, temperature, etc. are the most important components of outdoor thermal comfort. Meanwhile, air flow is one of the factors that has a direct effect on the outdoor thermal comfort [3].

The stagnation of flow in large cities due to the increasing density of the constructions has decreased the potential of outdoor and indoor ventilation significantly. The air flow pattern in open spaces is influenced by numerous architectural and urban features. Geometry of buildings is one of the fundamental parameters affecting outdoor wind flow. This research investigated the effect of 3 geometries on air flow pattern in open space of a residential complex in Tehran.

2. Material and Method

The case study in this research is a residential complex consisting of 9 7-storey blocks in Tehran. Each floor consists of a residential unit and the geometry of the blocks is chosen so that the external surfaces of all of them are equal. The number of floors, the total area of the side surfaces and the number of windows in all models are equal to each other. These blocks have been measured with three different geometries. The specifications of the blocks and the geometric form of each of them are given in the table below. Considering that the main purpose of this study is to investigate the effect of the geometric form of the building on the external wind behavior, all blocks were considered as rigid and without opening. The size of length, width and height in all models are equal to 15, 10 and 21 meters This article investigates the effect of building geometry

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on wind flow around buildings. The purpose of this research is to study the behavior of wind around 3 different geometries to achieve to an optimal form that can improve outdoor airflow performance.

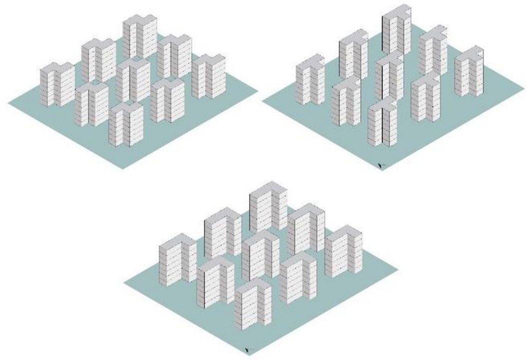


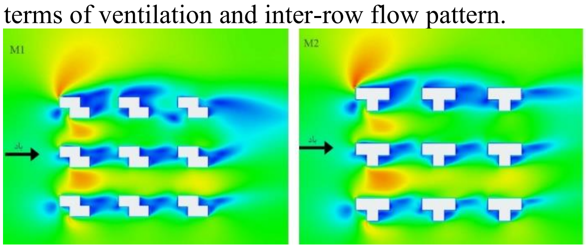
Figure 1. Perspective of simulated models; (from left to right), M1, M2, and M3

The research method in first section is descriptive, and the theoretical information is collected using library resources. Research strategy in the second part is semi-experimental. Numerical analysis was conducted by CFD simulation tools.

Validation of software outputs was performed based on the results of wind tunnel experiments of AIJ Research Institute of Japan. The simulated model are residential complexes consisting of 9 midrise buildings.

3. Results and Discussion

Tables A comparative study of graphic velocity contours indicated that geometric modifications of the blocks can affect the wind flow patter around the buildings. These changes are observed in the areas between adjacent blocks and the space between rows. Model M2 with T-shaped blocks directs the wind flow to the space of the block sequence and thus increases the flow velocity in the inter-block space. Meanwhile, the form of blocks in the other models causes a stagnation of wind speed in the trail area of the building by creating a flow blockage. The geometric shape of the buildings in the M2 model, in addition to increasing the inter-block velocity, is also able to increase the flow velocity between the rows. The L-shaped M3 model blocks make it easier and smoother in the earrings of the blocks, and this has led to an increase in the average wind speed in the space between the rows. All in all, M1 model blocks have the weakest performance in terms of ventilation and inter-row flow pattern.



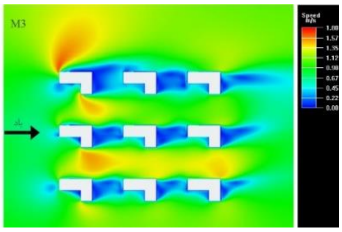


Figure 2. Wind contours on the vertical plane

It was proved through investigations that by changing the form of blocks, the average and maximum wind speed as well as the flow pattern in the space between the rows of blocks changed. But it should be mentioned that the most positive changes in the space between the blocks were observed in the western column (wind direction).

The results of the simulations in this study showed that the change in the geometric shape and physical structure of the blocks can affect the speed and flow pattern in the area of residential complexes. These results are consistent with the findings of studies by Zhang et al. [4], Tsei et al. [5].

Investigations indicated that among the simulated blocks, the M2 model with the shape of T-shaped blocks has the best performance in comparison to other models.

It was also proved that the average and maximum wind speed values in this model increased up to 23.40 and 14.13% compared to the base model (M3). This form of blocks, with proper air flow performance, speeds up the sequence of blocks and the empty space between successive rows.

The results showed that among the studied models, the M3 model with L-shaped blocks has the lowest values of wind speed in the distances between the blocks. Due to its special structure, this form blocks the wind flow and significantly reduces the wind speed in the trail area. However, the pattern of wind flow at intervals between successive rows is appropriate in this model.

Among the studied models, the M2 model showed similar behavior to the M3 model, however, the small values obtained for natural ventilation measures in the distances between the blocks indicate its better performance compared to the M3 model. The average and maximum flow velocities in the best growth mode were about 13 and 6.17% compared to the base model. It should be noted that the form of blocks in this model, by creating a kind of obstruction, has led to a decrease in wind speed in the distances between successive rows.

4. Results and Discussion

The aim of this study was to investigate the effect of building form on outdoor wind flow performance in residential complexes. The studied models were three residential complexes consisting of 9 blocks with 7 floors. The results of numerical simulations proved the effect of geometric changes of the building on the pattern of wind flow around the building (in the yard). The best result was a 13.83% increase in average velocity and a 6.76% increase in maximum flow velocity. Among the studied forms, the T-shaped form with proper flow conduction, improved wind behavior in inter-block and inter-row domains. However, L-shaped forms (M3 model) significantly reduced the flow velocity in the inter-block areas by blocking the wind flow.

All in all, it can be acknowledged that in situations where improving the air flow and natural ventilation is one of the factors in the selection of the form, the T-shape can be a suitable option to help the designer in achieving the desired goals. The results of this research can be used as a design aid model to guide architects in designing buildings that can provide comfort to passers-by in the passages around the building in warm climates by intensifying and strengthening the currents around the building.

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