The quantitative assessment of the effects of the morphology of urban complexes on the thermal comfort using the PMV/PPD model (a case study of Gheytariyeh neighborhood in Tehran)

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Abstract
In the present age, environmental sustainability has been severely challenged because of the human constructions and changes in the ecological landscape of cities so that the issue of the compatibility of urban development with these changes has become especially important. Changes in morphology, structure, form and geometry of the cities, which are themselves caused by changes in the form of urban complexes and geometry of buildings, have a profound effect on the micro-climate and sustainability of urban environments by the efficient adjustments. To assess environmental sustainability or unsustainability in urban neighborhoods, thermal comfort is considered as a good indicator. The assessment of this qualitative concept requires the use of quantitative indicators and assessment tools that can be spatially presented to urban planners and designers to help them in urban development plans. The PMV/PPD model uses heat-balance equations and empirical studies to calculate the ‘predicted mean vote’ and ‘predicted percentage of dissatisfied’, which are somehow derived from the parameters that affect thermal comfort. The innovation of the present study compared to the background of the researches is the evaluation of urban building design policies in thermal comfort, which fills the gap between the evaluations of the level and scale of architecture and urban planning in previous researches. An applied and descriptive-analytical research method has been used in the present study. Firstly, data needed to evaluate the main purpose of the research in the selected site located in the Gheytariyeh neighborhood of Tehran were collected. They are then simulated and analyzed. The results indicate that the difference in the geometry of the buildings and the city blocks can make a difference in the heating comfort of the different city neighborhoods and residents. The recent study has proven that the difference in the city blocks (3- and 4-dimensional and square shapes) can affect the comfort and temperature factors. Spatial simulations conducted in the present study by ENVI-met software show that compared to other indices studied, the PMV and PPD indices have the least distance from the ideal thermal comfort conditions in the design of trilateral high-rise buildings and have the greatest distance from them in the design of rectangular building blocks. It is worth noting that the adoption of policies and regulations related to the design and architecture of urban neighborhoods by the implementation of urban development policies is one of the measures required when the urban development plans are drafted and approved. The simulations model indicates that the minimum and maximum values of PPD index have been respectively...
1. INTRODUCTION

Due to recent changes in the urban density and street networks of contemporary urban context, controlling micro-climate of neighborhoods imposes difficult challenges to achieve human thermal comfort. Randomized and careless urban design leads to developing uncomfortable areas between building blocks. The complex human and natural structures of the urban areas affect considerably the urban microclimate [24]. The high rate of the growth of urbanization in recent decades has had many destructive effects on urban environments, including the increased temperature in the cities and the changes in their climates [19] that have caused the earth to be affected by various issues and lose largely its natural conditions, one of the consequences of which is the increase in temperature and climate change, especially in the residential areas of cities. The release of high heat energy, the increased greenhouse gas emissions and the changes in the land use are among the main causes of local climate change in cities [19]. With the expansion of the cities and urbanism after the 1930s, especially after World War II, local climate change appeared in urbanization [5]. Urban open spaces, streets and courtyards of buildings typically cover about 60% of a city’s total area, and as a result, their environments play an important role in the overall urban climate [22]. The increase in urban population and the change in the shape of urban buildings, especially in metropolises, have led to large changes in physical properties of the earth’s surface, released heat energy, air pollution, thermal comfort and other weather-related parameters [21]. Therefore, weather conditions can be different significantly in different parts of a city compared to similar parts in the same city. The reasons for this difference can be various factors such as the geometry of surrounding buildings, the morphology of the city, vegetation, height of roofs and walls and the materials used to build them, how air flows between buildings and so on ([11]). The process of urbanization and urban compaction are of great importance for the local climate and weather because they cause changes in the urban physical structure and texture. As a result, the change in the energy balance in urban areas causes more heat storage on the earth’s surface [32]. This change leads to a measurable difference between urban and peripheral areas, which is called the urban heat island (UHI) effect [21]. This phenomenon includes different types on a vertical scale: air UHI (including two types), surface UHI and subsurface UHI [25]. The shape and form of the city have a complex effect on the microclimate of urban environments. For example, a change in building density leads to a difference in temperature and air pollution ([8]; 36).

Today, with increasing concern about climate change, the issue of urban development compatibility with such changes has become especially important so that a conscious approach to this issue can ultimately lead to human comfort and environmental sustainability. That is why a part of various scientific studies, including urban studies, and in particular urban design, has been dedicated to topics related to the climate. Climate and climatic elements play an important role in the occurrence of human activities and providing human comfort in external environments. Therefore, a major part of the urban design activities has been devoted to this issue. In the present era, the studies related to thermal comfort in the field of urban planning and architecture seem necessary. However, most of the studies carried out in this relation have been concerned with the interiors of the buildings. Therefore, it has been tried in the present study that the effects of morphology and geometry of urban complexes as single cells of the urban configuration on the level of the thermal comfort are measured. Since the density in various districts of Tehran as a metropolitan has increased dramatically over recent years and this trend has intensified since 2003 by offering density bonus incentives [20], the city has been severely affected by various changes in its 22 municipal districts. Accordingly, after a brief review of the principles related to the research and the presentation of a conceptual model of assessment, it has been tried to study the effects of sub-climate parameters (temperature, humidity, wind, etc.) on the design of high-rise buildings to construct spaces where people can enjoy maximum physiological comfort in terms of temperature, humidity and light in their living environments. The sample studied in this research has been the development plan of a residential complex located in the Gheitariyeh neighborhood in district 1 of Tehran, which has been simulated using the four selected design options to assess quantitatively and spatially.

The innovation of the present study compared to the background of the researches is the evaluation of urban building design policies in thermal comfort, which fills the gap between the evaluations of the level and scale of architecture and urban planning in previous researches.
2. THEORETICAL FOUNDATIONS

2.1. Thermal comfort and the factors affecting it

In normal mode, the body temperature is 37 degrees and the skin temperature is 32 degrees Celsius. If the body is placed in an environment with a warmer temperature than the skin temperature, it starts to absorb heat and vice versa, it will gradually lose its temperature in a cooler environment. If due to this heat exchange, the heat produced in the body and the heat dissipated or absorbed from the environment is not balanced, the body will inevitably increase or decrease its internal heat to create balance, and thus it suffers from various difficulties [13].

In order to identify the contributing factors to urban thermal comfort, Figure 1 demonstrates a series of thermal comfort variables for outer space, sorted into three main categories of climate mean, urban morphology and building.

According to the ASHRAE Standard 55 [4], thermal comfort is the condition of mind that expresses satisfaction with the thermal environment. In other words, the thermal comfort of a person refers to a position where the person is emotionally and intellectually in the thermal comfort conditions. Many researchers believe that thermal neutrality is a more accurate interpretation of thermal comfort, because in such a condition, the human body does not feel the cold, nor the heat, nor the local discomfort caused by asymmetrical radiation, draft, cold room floor, heterogeneous clothes and so on. Thermal comfort results from maintaining the temperature balance between the human body and the surrounding environment [31].

A person's perception of his surroundings cannot only be expressed through the study of a climatic element, such as temperature, relative humidity or air flow because the combination of these elements affects the human. In addition, a similar case, for example, the optimum air temperature, is different for a person in summer and winter ([17]). Finally, it can be concluded that the desirable combination of air temperature, relative humidity, air flow and radiant temperature provides a certain range in which most people feel comfortable.

In early 1938, Bultner considered the combined effects of all thermal parameters when assessing the thermal effect of the environment on the human body. He believed that if a person wanted to study the effect of the climate on the human organism, he/she should evaluate all the thermal components of the environment. This view led to the modeling of human heat balance, which is presented by the following equation:

\[ M + W + R + C + ED + ERE + ESW + S = 0. \]

In the above equation, the SI unit of all terms is watts per square meter (W/m²):

- \( M \) = metabolic rate.
- \( W \) = physical work output.
- \( R \) = net radiation of the body.
- \( C \) = convective heat flow.
- \( ED \) = latent heat flow to evaporate water diffusing through the skin.
- \( ERE \) = sum of heat flows for heating and humidifying the inspired air.
- \( ESW \) = heat flow due to evaporation of sweat.
- \( S \) = storage heat flow for cooling and heating the body mass.

Obviously, if the body is gaining the energy, the terms of the equation have positive signs and if it is losing energy, the terms of the equation have negative signs. \( M \) is usually positive, but \( ESW \), \( ED \) and \( W \) are often negative [34]. Six main variables that have a direct effect on human response to thermal conditions are air...
Table 1. Reviewing of researches on urban microclimates and thermal comfort, 2001–2020 [23].

| Research title                                                                 | Author(s)          | Year | Dependent variables                  | Independent variables                        | Methods                      | Area of study                                      |
|--------------------------------------------------------------------------------|--------------------|------|--------------------------------------|-----------------------------------------------|-----------------------------|---------------------------------------------------|
| Numerical study on the effects of aspect ratio and orientation of an urban      | Ali-Toudert F.,    | 2006 | Air temperature                       | Height to wide ratio (H/W), Orientation       | Simulation (with ENVI-met)   | Ghar-daia, Algeria                                |
| street canyon on outdoor thermal comfort in hot and dry climate                | Mayer H.           |      |                                      |                                               |                             |                                                   |
| Impact of street design on urban microclimate for semi-arid climate            | Bourbia F.,        | 2010 | Physiological equivalent temperature | Sky view factors (SVF), wind speed            | Quantitative               | Cairo, Egypt                                      |
| (Constantine)                                                                  | Boucheriba F.      |      |                                      |                                               |                             |                                                   |
| Urban design in favor of human thermal comfort for hot arid climate using       | Barakat A. et al.  | 2017 | PMV, PET                             | Air temperature, relative humidity, MRT and   | Simulation (with ENVI-met)   | New Borg El-Arab, Dubai, Emirate                  |
| advanced simulation methods                                                    |                    |      |                                      | PMV                                           |                             |                                                   |
| Thermal perception, adaption and attendance in a public square in hot           | Lin T.             | 2009 | PET, thermal sensation (perception    | Air temperatures, mean relative humidity      | Quantitative/survey         | Taiwan                                            |
| and humid regions                                                              |                    |      | and attendance)                      |                                               |                             |                                                   |
| Thermal comfort investigation in three hot-humid climate                        | Koerniawan M. D.   | 2015 | PET                                  | Solar radiation, vegetation                   | Literature Review           | Theme parks in Jakarta                            |
| and Gao W.                                                                    |                    |      |                                      |                                               |                             |                                                   |
| Influence of building orientation on the indoor climate of buildings           | Januário M.,       | 2012 | Indoor temperature, absorbed solar    | Orientation, opened and closed windows        | Simulation (with DEROB-LTH) | Maputo, Mozambique                                |
| Climate and behavior in a Nordic city                                          | Rodrigues A. L.    |      | radiation                            |                                               |                             |                                                   |
| Thermal comfort in outdoor urban spaces: understanding the human parameters    | Eliasson I. et al. | 2007 | Thermal sensation (human emotion,    | Height/clearness index, air temperature, wind| Quantitative/survey         | Gothenburg, Sweden                                 |
| Studies of outdoor thermal comfort in Northern China                           | Nikolopoulo M. et  | 2001 | Globe temperature                    | Number of people outdoors                     | Quantitative/survey         | City-center of Cambridge, England                 |
|                                                                                | al.                |      |                                      |                                               |                             |                                                   |
|                                                                                | Lai D. et al.      | 2014 | Solar radiation, wind speed, and     | Air temperature                              | Quantitative/survey         | Tianjin, China                                    |
|                                                                                |                    |      | relative humidity/PMV, PET, UTCI     |                                               |                             |                                                   |

temperature, radiant temperature, humidity and air velocity of the environment, the clothing worn and the activity of the person. Temperature and humidity data are the most important indicators of heat detection [12]. On the other hand, air flow also causes heat exchange between the human body and the environment. Therefore, it has a great effect on thermal comfort. Table 1 surveyed some of the studies from 2001 to 2020 on thermal comfort, which have been done in different locations and climates.

2.2. PMV/PPD spatial model

It is interpreted that there is a lack of climatic issues awareness in urban planning and design [27]. Many studies identify that the street orientation and geometry can cause lower differences in air temperature [26]. Predicted mean vote (PMV) was developed for assessing thermal comfort. Following these considerations, Fanger proposes an index for the evaluation of the conditions of non-comfort (or discomfort) to an environment, expressed as a predicted percentage of dissatisfied (PPD) [23]. The PMV/PPD model was first developed by Fanger using heat-balance equations and empirical studies about skin temperature to define comfort. Fanger’s equations are used to calculate the PMV of a group of subjects for a particular combination of air temperature, mean radiant temperature, relative humidity, air velocity, metabolic rate and clothing insulation. The PMV value of zero is considered as the ideal value that represents thermal neutrality, and the comfort zone is defined by the combination of the six parameters for which the PMV is within the recommended limits. The PMV is an index on the 7-point thermal sensation scale ranging from −3 (cold) to +3 (hot) [33]. To calculate the value of this index, the following equation can be used:

\[
PMV = 0.303 \exp (-0.036 \cdot M) + 0.028 \cdot L.
\]

M: Metabolic heat production tax (W/m²).
L: Thermal load acting over the body (W/m²).
Table 2. The thermal comfort distribution for each of the votes [9].

| Predicted mean votes (PMV) | Predicted discomfort percent (PPD) | Predicted votes (percent) |
|---------------------------|-----------------------------------|---------------------------|
|                           |                                   | 0                         |
|                           |                                   | +1 or −1, 0               |
|                           |                                   | −2, −1, 0, +1, +2         |
| +2                       | 75                                 | 5                         |
| +1                       | 25                                 | 30                        |
| +0.5                     | 10                                 | 55                        |
| 0                        | 5                                  | 60                        |
| −0.5                     | 10                                 | 55                        |
| −1                       | 25                                 | 30                        |
| −2                       | 75                                 | 5                         |

Figure 2. The relationship between PMV and PPD [10].

Table 2 presents the thermal comfort distribution for each of the votes. The PMV may have values between +0.5 and −0.5 for the maximum percentage of 10% of dissatisfied people. Fanger has presented another equation for the relationship between PMV and PPD. This equation is as follows:

\[
PPD = 100 - 95 \cdot \exp\left[-0.03353 \cdot PMV^4 + 0.2179 \cdot PMV^2 \right].
\]

For a full comfort situation or PMV = 0, there will be a minimum percentage of dissatisfied of 5%. For the maximum percentage of 10% (PPD < 10%) of dissatisfied people, recommended as acceptable in ISO Standards 7730, the PMV may have values between +0.5 and −0.5 (−0.5 < PMV < 0.5) [33]. The given relationship was based on a study in which the samples were examined in a room where the internal conditions could be controlled accurately. This approach treats all residents in the same way and does not pay attention to the location and compatibility with the thermal environment [16]. Principally, it states that the ambient temperature should not change with the change in the season, but the temperature should be the same throughout the year. It takes a more indifferent position, indicating that humans should not adapt to different temperatures because the temperature will always be constant [14]. The relationship between the two thermal comfort indices of the PMV and PPD has been shown in the Figure 2.

2.3. Morphology of city buildings and thermal comfort

Urban geometry and morphology determine the ability of natural light to reach the building surfaces and the possibility of natural ventilation between buildings. Hence, urban microclimatic parameters have a direct effect on energy demand in single buildings and the entire city structure. In addition, the thermal comfort is affected by the properties of unnatural and built environments, such as building dimensions, the width of the passages, human heat, evapotranspiration of plants, trees shading and so on [15]. In general, there is a close and reciprocal relationship between buildings and their external environments. Each building changes the air around it. The geometry and cross-section of the city, the shape, height and size of buildings, the direction of streets and buildings and the surface area of open spaces are all factors that determine the microclimate of a city. Therefore, each urban human-made element forms a specific artificial climate around and above itself, which has always a reciprocal relationship with it. The shape of the city and its components not only affect the quality of the city and its spaces but also can change the city’s air quality [28]. Therefore, it can be said that atmospheric flows and air quality can be improved in cities by making changes in the shape of the city, both on a macro and micro scales [6]. The urban morphology indicators such as building heights, building type, plot coverage, plot size, block size, block form, setbacks, density and so on [30] not only can change the energy consumption but also can affect the amount of thermal comfort and air quality in urban textures. Since the morphology of cities has effects on the outdoor climates, as well as indoor climates, the buildings should not be considered as self-defined entities, neglecting their configurative contexts at the urban scale [1–3]. The regional and synoptic climatic conditions of a city and its neighborhoods can be affected by changes in urban morphology. In addition, the efficient arrangement of the urban configuration can lead to the long-term improvement of thermal comfort. Undoubtedly, considering micro-climatic parameters and the physiological and land cover features, changes in the morphological characteristics of urban textures can change the quantity of the thermal comfort indices, including PMV and PPD. Figure 3 shows the conceptual model of the present research.

3. METHODOLOGY AND SCOPE OF THE STUDY

As an applied research, the research method of the study is descriptive-analytical. The theoretical framework has been
developed using the literature review on the assessment of the various morphologies of urban buildings on the thermal comfort. In terms of the purpose, the present study has been applied research and a descriptive-analytical research method has been used in it. The theoretical literature review has been conducted by library research and the review of the literature related to the assessment of the effect of the morphology of various urban high-rise buildings on the thermal comfort. In addition, a site prepared for constructions and located in the Gheitariyeh neighborhood in the district 1 of Tehran was selected to do quantitative and spatial measurements (Figure 4).

This neighborhood is located in district 1 of area 7. The Gheitariyeh neighborhood is limited to Gheitariyeh St.—Saba Blvd—north of the Gheitariye Park from the north, to the Sadr highway from the south, to Gheitariye Boulevard—east of the Gheitariye Park from the east, and to Shariati St. from the west [18]. In terms of urban design, this district has a pseudo-rural texture. It is also considered as an old and important site in the city due to its special semi-mountainous structure that represents a blend of modern and traditional urbanism.

In this research, four selected options were firstly designed using the ENVI-met software. Several studies have used this
software to simulate micro-climatic parameters in urban areas. It has been designed by Michael Bruse at the University of Mainz in Germany to simulate the interaction between surfaces, plants and air in urban environments [7]. This software provides the analysis of the effect of small-scale changes in urban design (pattern, vegetation, building morphology, etc.) on the microclimate under mesoscale conditions defined at the beginning of the simulation (city climate, meteorological data, etc.) [29].

To simulate, all common physical components such as green spaces, fountain, access, passages and the placement of six blocks have the same boundaries in all design options. In addition, to increase the accuracy of calculations, parts of the surrounding green spaces were also simulated to provide wind-related results with relatively acceptable accuracy. In the produced model, building blocks with a height of 30 meters (10 floors), streets, gardens in the intermediary courtyard of the site with a low-rise green space and a fountain in its center and the tree cover around the blocks with a height of 10 meters were identified. Asphalt for the floor of the streets and the soil and concrete for the yards were considered in proportion to the type of pattern. The physical components of the simulation model input in four selected design options have been presented below. The geometry and morphology of the buildings on the designed site were considered to be trilateral in the option 1, four-lateral in the option 2, hollow blocks in the option 3 and rectangular blocks in the option 4 (Figure 5).

According to Figure 5, the green areas, the stone covered walkways, the water feature in the center of the area and the height and the construction material in all the four selected scenarios are equally similar. The only different factors in all the selected scenarios are the shapes of the individual blocks used in the construction.

The preliminary data for the modeling process were entered at this stage. These data have been related to geographic location (Tehran), including latitude and longitude, air temperature conditions, wind velocity and direction, relative humidity and the rate of pollutant gases and airborne particles at a height of 2 meters. The time considered for the simulation model has been 15 o’clock on 23 July 2018. The atmospheric input data were extracted from the nearest weather station in district 1 of Tehran, Gheytariyeh neighborhood. Table 3 represents the preliminary data used as the software inputs in four options considered for the simulation.

Table 4 also describes the clothing information and physiological and physical characteristics used to simulate in the software. According to Table 4, in the simulation model, the human metabolic factor is considered to be 1.2 and the height of each floor is considered to be 3 meters.
4. RESULTS

In this part of the study, to assess the degree of the thermal comfort changes in the various morphologies of the high-rise complexes, the PMV and PPD indices were calculated by the simulation of each of the four design options. As mentioned earlier, the ENVI-met was used to simulate the given options. To simulate, various environmental and physical features such as topography, wind velocity in the neighborhood, building density, the height of buildings and vegetation were defined similarly as the software defaults for each of the four design options. The following figure depicts the spatial outputs related to the PMV index for the four simulated options. In Figure 6, moving from the blue to the pink, the thermal comfort becomes closer to the ideal condition.

According to Figure 6, the amount of variety of the PMW in the center area (the water feature and the middle green area), which in selection 1 has 3-dimensional shapes, is upper than other selections. Therefore, the maximum average of the PMW in this selection has been estimated upper than other selections.

The results obtained indicate that the minimum and maximum PMV have been estimated to be respectively $-1.5$ and $-3.5$ for option 1. They also have been estimated to be $-2.85$ and $-1.60$ for the option 2, $-2.84$ and $-1.62$ for the option 3 and $-2.83$ and $-1.64$ for the option 4.

| Option | The PMV index in the intermediate outdoor space | PMW minimum | PMW maximum |
|--------|-----------------------------------------------|-------------|-------------|
| Option 1 | $-1.84$ | $-3.5$ | $-1.5$ |
| Option 2 | $-2.51$ | $-2.85$ | $-1.6$ |
| Option 3 | $-2.56$ | $-2.84$ | $-1.62$ |
| Option 4 | $-2.83$ | $-2.83$ | $-1.64$ |

Of course, it should be noted that as the purpose of the present study has been to assess the changes in the level of the thermal comfort in the indoor open spaces of the high-rise urban complexes, the criterion for the assessment should be the level of changes in the given indices for the internal spaces and the intermediary open spaces located in the studied site. As a result, with respect to the above outputs, the PMV index for the four simulated options has been presented in Table 5.

In Table 5 the average, maximum and minimum of the PMV have been simulated and selected in four different scenarios. The various shapes of PMV have been presented in Figure 6.

The outputs related to the PPD index have been presented below for the four simulated options. Moving from the blue to the pink, the thermal comfort becomes closer to the ideal condition.

![Figure 6. Simulation model of predicted mean votes.](image-url)
pink, the value of the PPD index increases and the thermal comfort becomes more distant from the ideal condition (Figure 7).

According to Figure 7, the amount of variety of the PPD in the center area (the water feature and the middle green area), which in selection 1 has 3-dimensional shapes, is lower than other selections (which is reverse of the results of PMV). Therefore, the minimum average of the PPD in this selection has been estimated lower than other selections.

The simulations indicate that the minimum and maximum values of PPD index have been respectively equal to 51.06% and 99.96% for the option 1, 56.09% and 98.26% for the option 2, 57.32% and 98.19% for the option 3 and 58.76% and 98.05% for the option 4. The PPD index for the intermediary open space in the studied has been presented in Table 6.

### Table 6. The PPD index for the four simulated options.

| Option | The PPD index in the intermediate outdoor space | PPD minimum | PPD maximum |
|--------|-----------------------------------------------|-------------|-------------|
| Option 1 | 72.4% | %51.06 | %99.96 |
| Option 2 | 81.7% | %56.09 | %98.26 |
| Option 3 | 83.1% | %57.32 | %98.19 |
| Option 4 | 87.6% | %58.76 | %98.05 |

5. **CONCLUSION**

As stated in the introduction, the innovation of the present study compared to the background of the researches is the evaluation of urban building design policies in thermal comfort, which the result of the study fills the gap between the evaluations of the level and scale of architecture and urban planning in previous researches.

The results of assessments and evaluation of the morphological effects of urban buildings on the thermal comfort in the study area indicate that the option 1 among other alternatives provides the optimal thermal comfort. The results obtained from the assessment of the effects of urban morphology and geometry on the thermal comfort in the studied site located in Tehran’s Gheytariyeh neighborhood using microclimatic simulations indicate that the option 1 enjoys more thermal comfort compared to other options. The outputs related to PMV and PPD indices in the simulation of the design option 1 with a trilateral building demonstrate that this type of design enjoys better conditions in terms of thermal comfort than other options. Additionally, option 4 with rectangular building blocks has the greatest distance from the ideal thermal comfort conditions compared to other design options.

The results demonstrate that the PMV/PPD spatial model has the ability to predict thermal comfort in different patterns of...
urban design. It can be claimed relatively that differences in PMV/PPD values indicate changes in the morphology of city buildings. Changes in the morphology of buildings, especially high-rise buildings, lead to changes in the rate of index of access to the sky. As this index changes, the microclimatic parameters also change and this eventually causes the change in the level of the thermal comfort in the studied outdoor space. On the other hand, the rapid growth of urbanization, the population growth and the increasing growth of industrialization in the cities have brought about significant changes in some meteorological quantities. Since there is a very strong relationship between the form and morphology of urban buildings and the rate of access to the sky, changes in the rate of access to the sky cause changes in the temperature of the cities. Therefore, changes in the form and morphology of urban buildings lead to changes in the parameters affecting the thermal comfort and other environmental factors, as well as the formation of the thermal islands in the cities. Therefore, considering different climatic conditions, the plan, shape and morphology of the urban buildings should be considered in the urban development plans. In addition, the lighting of the intermediary space between urban complexes, the heat balance in the interior spaces of the building, the location of the building with regard to its exposure to rain, snow and frost and finally the form of the building in relation to the disposal or reduction of the destructive power of the wind are considered as the climatic requirements of urban design and planning.

The data analysis shows that the PMV/PPD space model can predict the thermal comfort in different urban design patterns. In some ways, it can be admitted that the values of PMV/PPD indexes change by the morphology of urban buildings. Changes in building morphology, especially high-rises, alter the sky view factor, and also the micro-climate parameters, which will eventually affect the outdoor thermal comfort. All of them require special attention to the standards and regulations of construction in the urban development plans, including the detailed plan emphasizing the promotion of human thermal comfort. Therefore, to achieve sustainable development, designers and urban planners should pay attention to the above-mentioned requirements considering the geographical location and climatic features of the region. Consequently, the plan, shape and morphology of the urban buildings should be considered in urban development plans, with regards to the different climate conditions.

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