Int. J. Urban Manage Energy Sustainability, 2(2): 43-53 Spring 2021

DOI: 10.22034/JUMES.2020.242515

Case Study

Evaluation of thermal comfort condition in urban morphology in approach to micro-climatic transformation in Tehran city

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Received 10 Jan 2020 revised 11 Feb 2021 accepted 19 Jul 2021 available online 25 Aug 2021

ABSTRACT: Parameters of urban morphology and its elements such as building mass density as well as the type of direction and width of passages and block structure in addition to climate change, also affect the behavior of citizens, targeting the type of variable change and indexing and the quality of sub-branch communication. Their works are among the most essential analytical provisions. The main purpose is to investigate our relationship between variables affecting the creation of urban climate-micro according to the different morphology of the urban fabric of Tehran metropolis, which is practically not the type of fabric in the form of scenario, which can be referred to our relationship between SVF and urban FAR. In addition, the analysis of the effects of urban morphological parameters on micro-climate variables such as enclosed temperature (T) and mean radiation temperature (mrt) can also show optimal results in the form of parametric study considering the interactions between urban morphology and urban micro-climate. As a result, according to the general analysis and results in the current research, the two groups of the mentioned scenarios have a significant and affected relationship between morphological parameters and variables of urban micro-climate. This research is based on field perception, data and simulation using It is one of the basic software and also energy analysis in the topic of urban climate such as ENVI.met. In addition, the two groups of findings can be expressed in such a simple way that one; The SVF decreases when the BSC is increasing at a constant FAR. In addition, in the case of a sample with a fixed FSI, this factor increases as FAR increases. Enclosed temperature and average radiation temperature are also strongly correlated with urban morphological parameters in the presence of a constant FAR. According to these results, the BSC 25 was the best manifestation of reducing and calming the intensity of the heat island as well as the thermal comfort of the climate during summer nights.

Keywords: Urban Morphology, Artificial Climate, Urban Micro-climate, Building Density

RUNNING TITLE: Urban Morphology and Urban Micro-Climate

INTRODUCTION

In the relationship between buildings and the environment, each building changes the climate around it. These changes occur under the title of urban climate-micro and the impact of factors such as geometry and cross-section

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of the city, shape, height, size of buildings, the direction of streets and buildings and the level of open spaces (Bahraini, 2012). Urban man-made elements, due to the effects they have on climatic factors, can create an artificial climate in the micro-structure of the climate that always interacts with each other. Therefore, urban morphology, considering its effects on climatic factors, directly and indirectly affects the change of energy consumption in cities, especially heating energy, and building species can not be considered as an independent and without considering the location and conditions on an urban scale. In the subject of micro-structure of urban climate, parameters of urban morphology can be proposed that examine and explain the relations with a morphological approach. Elements such as masses, passages and blocks as the main cases of urban morphology have indicators in which the title of this meaningful relationship can be analyzed practically the most accurate effects. Measuring the density of the constructed environment as well as indicators such as Ground Space Index (GSI), Open Space Ratio (OSR) and floors can also be considered as the main intervenors of the research. In a general definition, the study of the form and shape of settlements can be called urban morphology (Carmona, 2006). Urban morphologists agree on the nature of morphology, but disagree on how to study the form of cities (Gauthier and Gilliland, 2006: 41). In different definitions, this is how to study; Madanipour (2008) Behnglaz Clark (1985); Small and Vitrick (1986) and Godal (1987) state that urban morphology is a systematic study of the form, shape, map, structure and functions of the diverse fabric of cities and the origin and evolution of this fabric over time. Gordon (1984) says, urban morphology means urban plans, buildings, uses, streets, maps, and landscapes. Morphology; The study of the physical or constructed fabric of the city form, and the people and processes that shape the city (Jones and Larkham, 1991: 55), the study of the form of cities over time (Scheer, 2002; 2001), a study of the urban construction process and its results and products (Moudon, 1998) and is generally a term for a set of researches that focus on the physical form of urban areas (Whitehand, 2001). The effects of man-made factors around and above, climatic factors; Temperature, humidity, speed and direction of wind and especially radiation change and cause the formation of artificial climate that the existing shape and the resulting artificial climate always have interactions with each other (Nasrollahi, 2014). By considering the effects of morphology on the mentioned climatic factors, which are directly and indirectly done in terms of shape and urban function, it is indirectly able to change the amount of energy consumption in cities, especially the heating and cooling energy demand of residents. (Adolphe, 2001). In practice, it can be concluded that one of the main elements of urban morphology can be the behavior of the building mass under sub-criteriaes such as density and especially its variables with topics such as energy and urban climate to provide more and deeper analysis.

Studies have shown that density is calculated not only on the basis of building density but also a combination of it with the indicators of floor area ratio or compaction level on the ground floor, the ratio of open space or pressure on unbuilt space and floors to be created to efficiently differentiate between different urban forms. Therefore, in these studies, a diagram was created to evaluate all four variables simultaneously, which is called space mate, consisting of two vertical and horizontal axes, the vertical axis of which is the building density as a construction and its horizontal axis floor area ratio as a measure of the compactness of the built environment shows the ratio of open space and floors after obtaining the previous two indicators appear in the diagram. the most common index of building density is Floor Space Index (FSI), but this index alone can not calculate the spatial characteristics, and therefore other variables such as Ground Space Index (GSI), Open Space Ratio (OSR) and floors are used to explain the density of the built environment that GSI is size of the built-in environment on the ground floor and OSR is intensity of unused land use (Berghauser Pont and Haupt, 2007). These four variables are btained using the same data (net area of the floors, area of the constructed area, and total area of the design) and are therefore mathematically interdependent (Zakerhaghighi et al., 2010). Considering the structure of urban morphology and variables such as building coverage ratio and FAR as the main density variables and physical examples of micro-climate, according to the heat islands, Sky View Factor (SVF) is also involved, providing a more accurate relationship analysis and impact level in the direction of concepts such as climatic and thermal comfort.

Mag Brooker (2018) in a study entitled "Urban effects on the urban micro-climate" in a comprehensive way to study the effective parameters of urban design, including morphology, and analyzed these effects in the elements of urban fabrics. Delmastro et al. (2018) in a study entitled "Selective method of applying energy policies for buildings on an urban scale", have addressed the issue of energy efficiency policies in urban contexts with a focus on the function of buildings in order to low carbon cities that provides models and strategies for policy-making in program structure and urban design. Another case, entitled "Urban morphological indicators for solar energy analysis" by Morganetti et al. (2018), which is parallel to the current research approach, but in-depth analysis and the type of analysis method on a large scale. Rousseau et al. (2017) in a study entitled "Analysis and Innovation on High-Efficiency Building Materials with the approach of energy performance and urban climate-micro in residential contexts" began to explore a kind of micro-scale and examine the variables affecting urban climate-micro and the type of characteristics of various materials in the building, which finally extracted its results from the obvious characteristics of materials such as the level of surface reflection and the type of urban facade impact. Lopez and Gonzalez et al. (2016) in another study on "Energy efficiency for energy planning in residential areas" with a case study in La Rioja, Spain, discuss the concept and importance of energy in the city and energy efficiency resulting from the shape captures urban fabrics that have consequently assessed energy consumption and provided scenarios for energy recovery.

In general, most of the mentioned researches have raised the issue of climate in the macro scales of urban and have taken steps to study the variables in relation to linear relations in the direction of micro-climate. In the structure of urban morphology, there is practically no in-depth analysis. The analytical structure in the researches is based on standard variables, while variables such as the ratio of building surface area or FAR from the density branch are mainly mentioned, which naturally reduces the certainty of the results. As a result, according to the mentioned research background, in the present study, an attempt is made to take an innovative look and introduce accurate evaluation methods and variables, trying to analyze these parameters in the field of urban morphology in the field of urban climate micro based on a new conceptual model.

MATERIALS AND METHODS

The main purpose is to investigate the relationship between variables affecting the creation of urban micro-climate according to different morphology of urban fabric, which can be referred to relationship between sky viw factor and urban density, in addition to analyzing the effects of urban morphological parameters on urban micro-climate parameters such as enclosed temperature (T) and mean radiation temperature (MRT) can also show optimal results in the form of parametric study considering the interactions between urban morphology and microclimate. Sample parts are considered as hypothetical areas in the urban context, without considering the type of fabric, and by default in the metropolis of Tehran with specific climates and coordinates. All scenarios according to a homogeneous configuration type are assumed to be checkered in shape. All building blocks are in 4 pieces (white) in dimensions of 40 by 40, which are matched by rows of species in the immediate urban area (gray) and also the impact of plants and changing conditions of green space has not been considered in the current research. All scenarios are presented, taking into account the FAR and BCR, which is expressed as a percentage.

In the process of urban design approach to the subject, FAR is usually determined by the relevant organizations. In this study, all the assumed parts have the same value of FAR and their shape will not show various choices. BCR, the number of floors as well as the design of the masses can be considered varied.

This study includes two groups of scenarios; the first group has the same value of FAR. In any case, the BCRand the number of floors (L) of each scenario will be different. In fact, the purpose of this group analysis is to study the relationship between the BCR and the SVF with the same FAR. On the other hand, in the second group, the aim is to analyze the relationship between FAR and SVF at the same BCR. (Figures 2 and 3)

SVF, T, MRT of these two scenarios groups have been calculated with ENVI-met analytical software. All simulations from 12: 0: 1 in the morning on July 1, 2016 according to the weather conditions of the city. Tehran is considered for 24 hours a day and a temperature of 25 degrees Celsius. The humidity is approximately 50% and the wind speed and its path are 4.5 m/s and also within the specified climatic boundaries. (Tables 1 and 2)

Conceptual variables examined

Issues and problems related to micro-climate analysis are also complex in terms of indicators and variability, so that the development of these concepts requires a model. (Marcel & etc., 2015) However, in the field of variability of concepts such as urban morphology and micro-climate, the number of effective variables in research is practically high that it is not possible to comprehensively study it in the form of an article, but the most important effective variables can be identified, explained and selected.

Sky View Factor

The main reason for creating a heat island is the temperature difference between urban and suburban environments, which is applied in 24-hour cooling processes, which are mainly applied by long-wave output radiation. In urban areas, the three-dimensional geometric configuration of urban surface coverage plays an important role in limiting heat loss and radiation levels, as well as helping to change temperature indoors in the flat environment created by the skyline. (Eliasson, 1996) (Oke, 1981) In general, the highest intensity of the heat island is more than the day (Gal & Unger, 2014). The sky view factor is the most appropriate parameter to describe urban geography (Eliasson, 1996). This factor is often referred to as the ratio of radiation received by flat surfaces and radiation emitted by the space hemisphere. (Wilson & Johnson, 1987) Therefore, for this factor there is a dimensionless value that is explained between the numbers 0 to 1. (Oke, 1988) Finally, can be said that the regression analysis of thematic measurements shows a strong negative relationship between the sky view factor and the heat island intensity. (Unger, 2009) The amount of calculation of the sky view factor is also modified from the stein method, and the adaptation of the calculation of this amount is extracted through fish vision photography. Each view of the fish is a certain amount of rings that contain a multiple of n (n=360) which can be used to calculate each ring, taking into account the ratio of sky pixels to the total pixels of the image. (Steyn et al., 1986; Chapman et al., 2001; Middel et al., 2017)

Density parameters in urban morphology

According to a 2005 study by MBPont and Per Haupt, diagram tools express general density variables in urban geography (Pont & Haupt, 2005). This tool is actually called the Space Mate. With this tool, urban environment can be expressed using density variables such as FSI, GSI, OSR. These quantities can describe both diverse urban environments and characterization.

For the four variables mentioned in Space Mate, which prove the geography of an urban site, it is possible to determine the differences between an area on a medium scale and other areas. In fact, these variables Explains the mass is quite useful and effective. The floor space index (FSI), also known as building density, indicates the intensity of the built environment.

This variable is also widely reflected in the design and development as the amount of floor built, which can indicate the amount of base balance and the amount of massification. Gross space index (GSI), in other words, the amount of coverage is also proportional to the amount of construction, which proves the relationship between built and unbuilt space. The open space ratio (OSR) does not describe the intensity of the ground, and finally the amount of floors is the average number of floors in the environment.

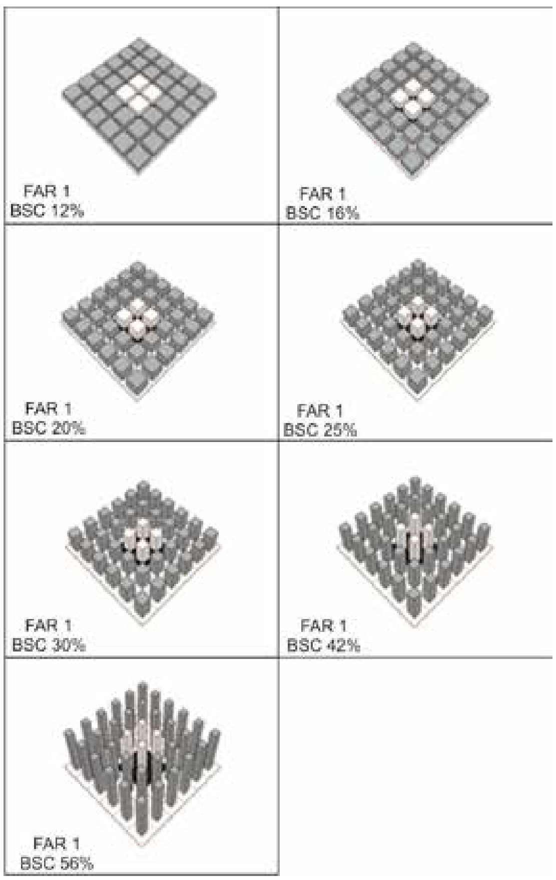


Fig 1: The first group of scenarios with the same FAR

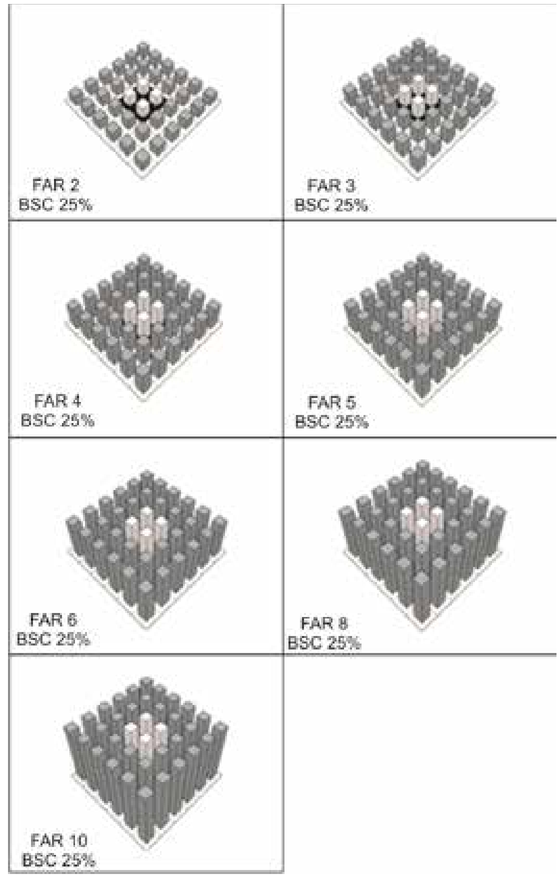


Fig 2: The second group of scenarios with the same BSC

Tab 1: The first group of scenarios proposed with the same FAR

FAR	BSC	Number of floors	Gross area of all floors (Square meters)	Ground floor area (Square meters)	Length of the building (Meter)
1	12%	8	1530	196	14
1	16%	6	1530	256	16
1	20%	5	1530	324	18
1	25%	4	1530	400	20
1	30%	3	1530	484	22
1	42%	2	1530	676	26
1	56%	1	1530	900	30

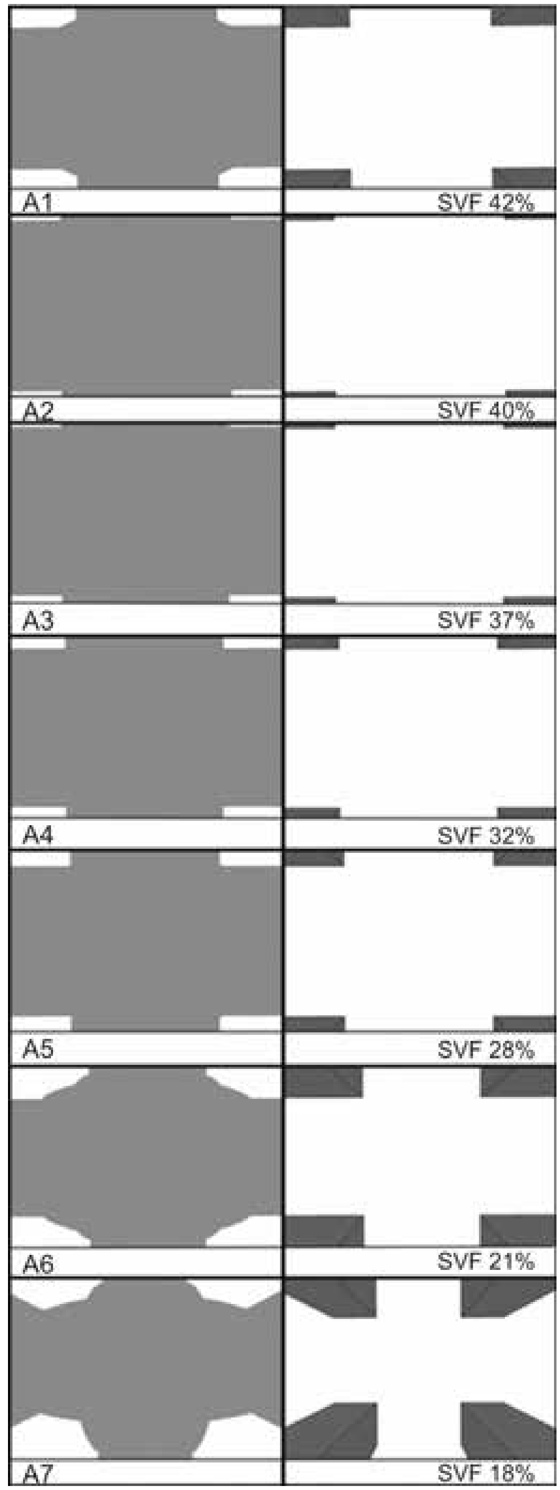
Tab 2: The second group of scenarios proposed with the same BSC

FAR	BSC	Number of floors	Gross area of all floors (Square meters)	Ground floor area (Square meters)	Length of the building (Meter)
2	25%	8	3200	400	20
3	25%	12	4800	400	20
4	25%	16	6400	400	20
5	25%	20	8000	400	20
6	25%	24	9600	400	20
8	25%	32	12800	400	20
10	25%	40	16000	400	20

Result and discotion

According to the mentioned topics, for each of the presented scenarios, the amount of sky view factor was calculated, which according to the proposed simulation, can be considered by considering the type of calculation of Stein, its numerical value in the following tables for each. (Tables 3 and 4) The main relationship between this factor and density variables also shows the points that can extend the current research in a conceptual structure to the results, so that the sky view factor of the first group of the numerical value of 0.41 in the BSC 11 to 0.17 with relativity the BSC is changing from 69 while the FAR remains constant. Therefore, we can point to the decrease in the value of the sky view factor. On the other hand, when this ratio is constant and the BSC is increasing, then the GSI is increasing while increasing the height of the building. The reduction of the distance between the buildings and the increase of the ground floor is in the same direction. At the same time, the SVF in the second group of scenarios with a fixed BSC of 25% has the same results as the first group with a FAR. The numerical value of this factor was between 0.48 to 0.21, which indicates the difference in the BSC that the GSI is fixed in each scenario and only the variables of the number of floors and building height are variable. Therefore, when the height of the building is increasing proportionally, due to a certain ratio of the FAR, SVF is increasingly blocked by the height of the buildings.

Fig 3: The first group of scenarios with the amount of SVF



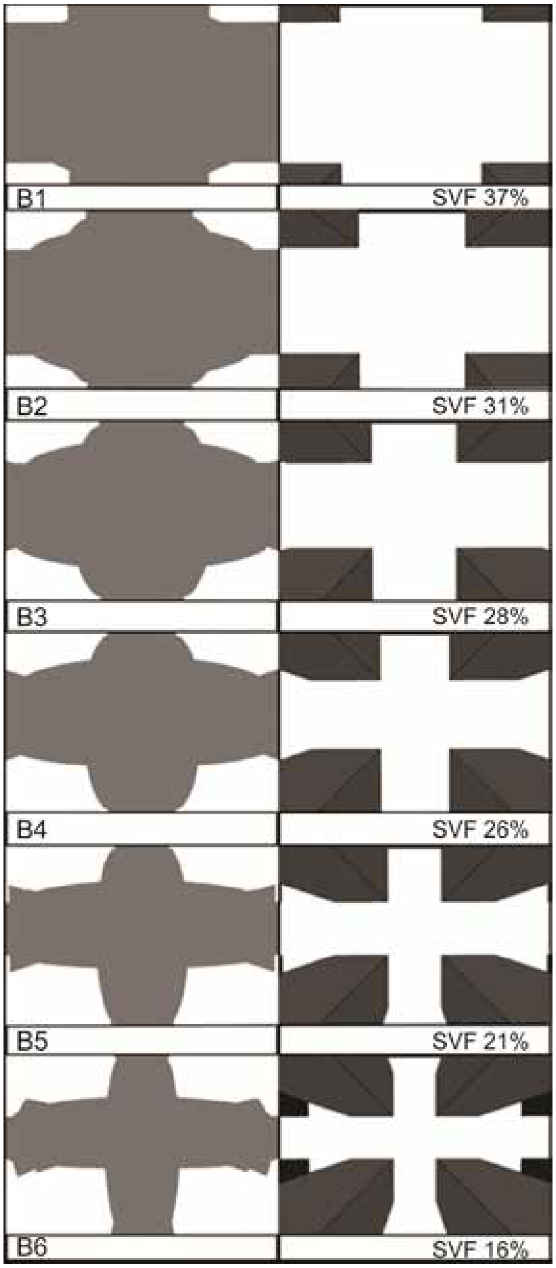


Fig 4: The second group of scenarios with the amount of SVF

Investigating the effect of building density on the microclimate of urban climate

The effect of building coating surface ratio on the average radiation temperature

Then, the analysis of the effect of urban micro-climate with the BSC in a fixed FAR of 1 was investigated. According to the conceptual framework presented in the research method, the effect of building coverage on the average temperature and radiation temperature. Enclosed has been considered that using simulation and analysis in the relevant software has the following results;

The average temperature profile of the first group was analyzed for different scenarios according to Figure 5, according to which the amount of this variable indicates that the amount of this variable is low at night. But during the day it increases from 3.3 ° C at night to 20.7 ° C during the day, and this decreasing trend decreases as it gets closer to sunset. According to the same analysis, all scenarios reach their peak at 12:00 and reach their lowest point at 5:00. Therefore, the average temperature of the average radiation at 5:00 is the lowest and also at 12 o'clock is the highest.

In fact, the relationship between the minimum average radiation temperature and the BSC is shown in Figure 5. Also, this value of the general line shows the increase of FAR 1 in the amount of BSC from 11.67 ° C in the amount of 11 to 13.68 ° C in the amount of 69. According to the previous section, the SVF decreases when the BSC increases. Therefore, it is important to prove that the minimum average temperature of radiation increases when the SVF increases. At night, virtually urban areas with a high SVF have a lower radiant temperature than an outdoor space. Comes with 17%. It is also observed that the minimum average temperature of the radiation reaches its lowest level at the coverage level of 11%. In fact, it can be concluded that urban morphological factors are practically significant by considering the SVF and the BSC. Also, the mentioned figures show the maximum average temperature of radiation at 12:00 when the FAR is 1, the maximum temperature of which increases when the coating level reaches from 60.13 ° C to 39.59 ° C. According to researchers such as Oke and Unger, maximum radiation occurs when there is high aperture during the day. In this case, according to previous researchers, when SVF decreases, the shading of solar radiation increases. The only scenario that is in line with the main lines of calculations and results is when there is a BSC 69 at a FAR of 1, which is probably due to the maximum shading of the building at BSC of 56%. (Figures 6 and 7).

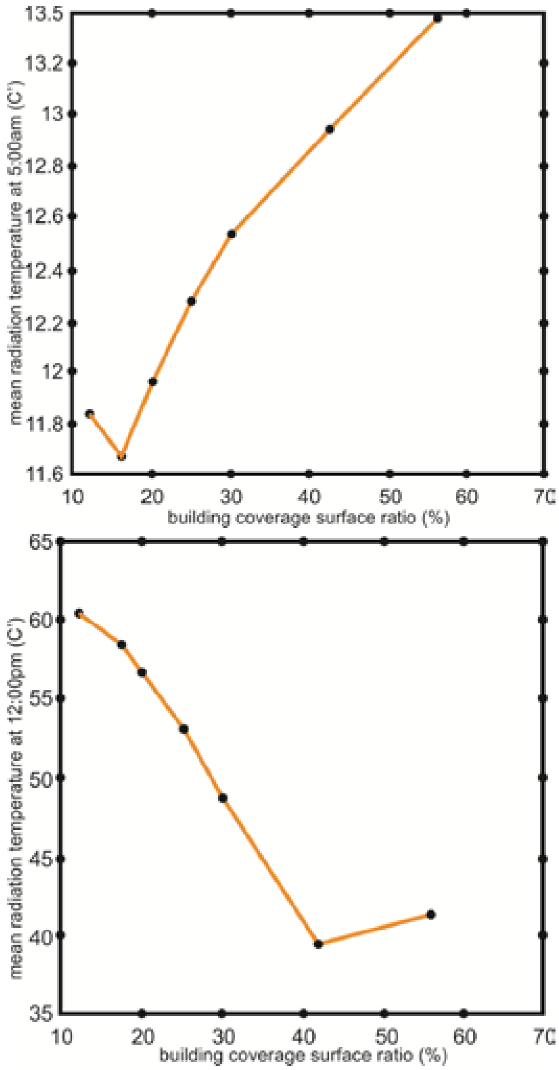
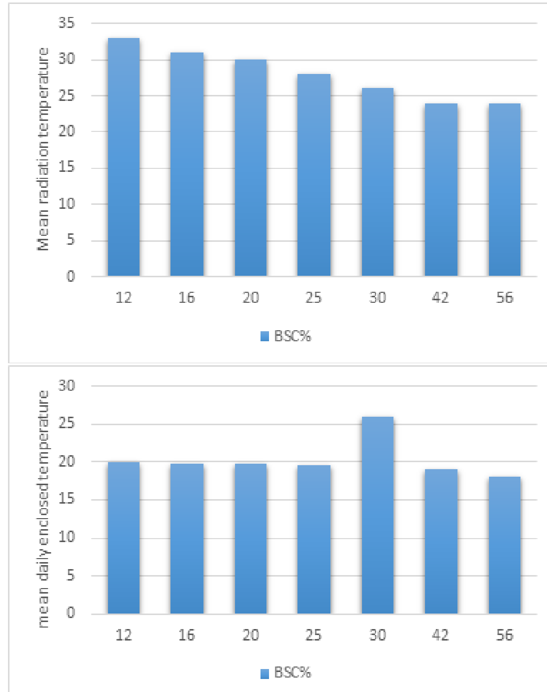


Fig 5,6: Minimum average average radiation temperature at 5 o'clock (top) and maximum at 12 o'clock (bottom) for the first group of scenarios

A closer 24-hour study of the average radiation temperature shows the relationship between the average radiation temperature and the BSC. As the average irradiated temperature is decreasing from 32.15 ° C with a BSC 11% to 24.34 ° C with a BSC 56%. In general, the meaning of these numerical values indicates that it is important that the shading of buildings during the day has a great impact on the average temperature of radiation and the comfort of pedestrians. Therefore, the overall design with high BSC and low SVF will be beneficial to reduce this amount during the summer season in Tehran by keeping the FAR constant in the absence of plant planting.



Cart 1,2: Mean radiation temperature for the first group of the scenario (top) and mean daily enclosed temperature for the first group of the scenario (bottom)

Influence of BSC on enclosed temperature

Following the analysis in the current study, the enclosed temperature of the first group was also examined, which is specified in Figure. The corresponding figure shows the average hourly profile of the enclosed temperature. In general, it describes the decline of this amount in all scenarios at 6:00 in the morning and its peak at 12:00. This type of profile is completely different from the average radiation temperature diagram because it occurred due to the exhaustion of time in the transfer of temperature to the air. During the night, the minimum air temperature cavity scenarios are much more limited and thinner.

On the other hand, during the day, the temperature enclosed in different scenarios reached a maximum at 4.12 ° C, which occurred at 13:00, so this hole will be much higher during the night than it is during the day. (Figure 8)

The following figures show the average enclosed temperature of all scenarios that descend at 6 am and peak at 2 pm, as more detailed studies of enclosed temperature and average radiant temperature show the relationship between this variable and Urban morphology shows. The next figure also shows the relationship between the minimum temperature and the ratio of the building surface that the minimum temperature is decreasing from 19.96 ° C in relation to the surface of the cover 11. It also reaches the bottom of the profile at 16.02 ° C and shows a surface ratio of 25%. According to a previous analysis of SVF, this amount actually decreases as BSC increases. In fact, there is the fact that increasing the enclosure and blockage also increases the amount of heat released, which in turn overshadows the temperature of the space for the concept of comfort and its desired temperature. When GSI is less than 25%, the profile shown does not follow the general rules. Therefore, BSC 25 is the best choice to reduce and calm the intensity of the heat island in summer and during the night in the metropolis of Tehran. Also, the effect of this BSC on the maximum temperature when the FAR is constant will be more visible. The maximum temperature is increasing from 23.75 ° C to 19.89 ° C due to BSC, which according to the research background can be seen in other studies of researchers close to the results. On the other hand, it is observed that urban areas with higher openness (low BSC and high SVF) offer the highest maximum temperature during the day, which consequently occurs the highest maximum temperature in the BSC 25 (Figure 9) In the previous diagrams, the minimum and maximum temperatures indicate different trajectories, and the average enclosed temperature in 24 hours indicates the effective relationship between the average enclosed temperature and morphological parameters.

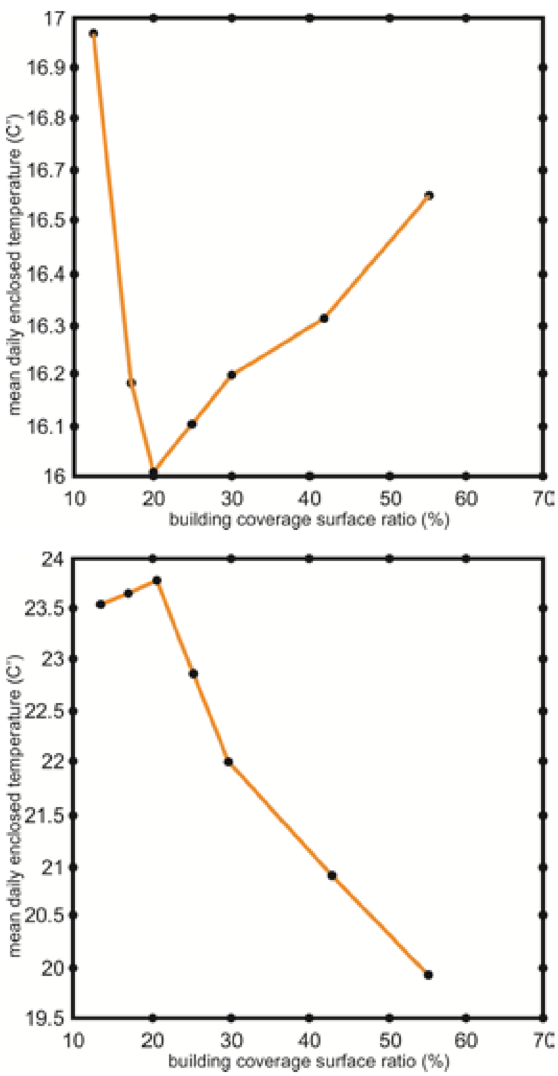


Fig 7,8: Enclosed minimum temperature at 6 am (top) and maximum enclosed temperature at 2 pm (bottom)

CONCLUSION

As a result, according to the generalities of analysis and results in the current study, the two groups of the mentioned scenarios have a significant and affected relationship between morphological parameters and micro-variables of urban climate. In other words, it is important to note that urban morphological parameters have a direct and tangible effect on the microclimate of the urban climate. In addition, the two groups of findings can be expressed in such a simple way that one; The SVF decreases when the BSC to the constant FAR increases. In addition, in the case of a sample with a fixed roof surface area ratio, this factor increases as the FAR increases. Sequndly, enclosed temperature and average typing temperature are also strongly related to urban morphological parameters in the presence of a constant constant FAR. During the night, the minimum average radiation temperature is increasing according to the BSC. The same is true for the minimum temperature. According to these results, BSC 25 was the best manifestation of reducing and calming the heat island intensity during summer nights. In general, it can be acknowledged that the current study and its results can be the main criterion for the design of morphology and variability of urban morphological parameters in Tehran, so that the standardized impact of these results was the most desirable for urban morphology with urban climate, which subsequently by considering all aspects of these laws, the desired comfort temperature will be brought in the enclosed space in the urban masses. In addition, in future research, parameters such as wind and velocity and its direction, as well as the structure of humidity and the intensity of its impact can be examined and in a comprehensive analysis to the rules and codes of urban design guidance.

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