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The impact of scale dimension of urban form on thermal comfort and aesthetics quality

Case study: Mahmoudabad

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Abstract: *Scale dimension of urban form is a qualitative measure of massing and relative height of buildings. Most studies, in the field of form aesthetics buildings have been focused on facades of buildings and the most research has been focused on understanding two dimensional patterns and shapes and less studies have been conducted on aesthetics of urban massing combination. Also, the form of building has much impact on macro- and micro-climate of city, urban design knowledge is in its infancy in the dimension of climate. In this regard, the important note is to translate the knowledge and findings of climatology to the principles of urban design. Another problem is the contradictions which are between climatic design consideration and other design consideration. The present study aimed to review the wide consideration of scale dimension and to mine operating principles and to use them in design process. In this regard, in the form of comprehensive process, designing the scale of urban form in the case study of coastal Mahmoudabad City has been performed regarding different dimensions, especially aesthetic quality and thermal comfort.*
Keywords: *thermal comfort, urban space, aesthetics, urban microclimate, Mahmoudabad*

1. INTRODUCTION

Department of Environment, Transport and urban and rural areas and the Commission for Architecture and the built environment in Britain (2000) define scale as “the size of building to what is around it, or the size of the components of building or its details, especially in relation to the size of a person " (22) and according to them, it includes two dimensions of scale and massing. “The height determines the impact of construction on the views, scenery and skyline” (22) and “massing is the combined impact of organization, volume and shape of a building or a group of building in relation to other buildings and spaces” (22). It should be noted that “scale dimension is the qualitative measure of massing and relative height of buildings and density is a quantitative measure reflecting a number of units on the certain area of the earth” (American planning Association, 2006: 468).

Organization of the overall volume of building is called massing. Is the overall volume, reflecting the internal function and external conditions, a tall and narrow tower or a short block and/or a combination of components with different heights? (American Planning Association, 2006: 469). In fact, massing is the three-dimensional expression of construction in a specific land (Department of Environment, Transport and the Regions et al., 2000: 22). Economy, attention paid to the background, symbolism and identity are the considerations taken into account for massing by American planning Association (2006). Height can be expressed as the number of floors, the height of parapet of edge or the overall height and/or a combination of each of these with others as the proportion of building height to the width of street, space as well as the height in relation to specific urban signs or the buildings in the background with strategic views (Department of Environment Transport and the Regions et all., 2000: 22). American planning Association (2006) takes into account some considerations such as the proportion of height to the width of street, enclosure of public space, symbolism and identity, attention paid to the background, economy and environmental considerations for the height.

“Usually when designers think to complexity and simplicity in form aesthetics of buildings, they aim to reform the facades of buildings. Most studies have been focused on understanding two-dimensional patterns and shapes” (Lang, 2002: 221) and less studies have been conducted on aesthetics of urban massing combination. Also, the form of building has much impact on micro- and macro-climate of city. But, to what extent does the urban design progress in this field? John Lang (2005) knows the urban design at the beginning of its way in the aspect of climate and even in some fields such as winds and air flow control, know it in infancy (16). In this regard, the important note is to translate the knowledge and findings of climatology to the principles of urban design and the need for the cooperation between these two fields (Eliasson, 2000). Another problem is the contradictions which are between climatic design consideration and other design consideration. In the dimension of climate, urban design should take steps in order to achieve appropriate design strategies to deal with different types of climate and to create microclimate as well as to balance the considerations of aesthetics, economy, etc. (Lang, 2005).

The case study of the present research is located in Northwest Mahmoudabad City, in vicinity of the sea and at the west entrance of the city with temperate climate and high Caspian Sea rainfall and its daily and annual temperature fluctuations are lower than other regions in Iran. In general, the climatic characteristics of the region are moderate climate throughout the year, high relative humidity, abundant rainfall and sea breezes. In the city, most buildings are villas and small apartments. In the recent years, a wave of construction of high-rise buildings, especially in areas vicinity of the sea, has been started. These constructions are associated with high economic benefits and they are not qualitatively controlled. This leads to visual disturbance induced by the contrast between high-rise buildings and small-scale buildings, weakens climatic comfort and obstruct the view to the sea. Now, diversity of volumetric forms, from simple native to new and complex forms, can be observed in the city. In many cases, different forms are directly placed next to each other without any relationship.

Comfort

Comfort is a basic need: “the need for food, drink, shelter against environmental elements or a place to rest when tired, everyone needs to have a level of comfort for satisfaction" (Carr; Francis; Rivlin and Stone, 1992: 231). Psychological comfort is placed at higher level: “social and psychological comfort is a sense of security, a sense that man and what his property are not vulnerable and at risk" (Carr et al., 1992: 232). Thus, the task of urban design is to meet the physical and psychological comfort in the public places in the city. In the area of physical comfort, "relief from environmental elements, resting and sitting down" (Carr et al., 1992: 238) are concerned. It can be said that of the physical needs identified by Abraham Maslow, a need for shelter are mostly influenced by urban design. John Lang and Moleski (2010)010) suggest that four dimensions about shelter that should be considered. First, materials, structure and building don’t risk the lives of residents. Second, the internal function of building provides favorable conditions for comfortable living. Third, they should provide health environment and forth, the building doesn’t have negative impact on the surrounding (113). The impact of building on its surroundings has been paid attention more than ever because the owners are responsible for observing legal provisions about the creation of shade or side effects on wind turbulence in their buildings (Lang and Moleski, 2010: 113). In the fourth dimension, the most important issue is to provide thermal comfort. “Human thermal comfort depends on what they are doing, air temperature, mean radiant temperature, humidity, air flow and what they have worn” (Lang and Moleski, 2010: 119). So, in order to create comfort, designing should be performed in order to create the optimal balance among above factors and any place demands its design policy depending on its climatic situation.

"With the advancement of technology, heating and cooling systems has improved. These improvements enhance people's expectation for comfort level of environment"(Lang, 1994: 229). “Now, we need higher levels of comfort and taking inappropriate measures in relation to climate could result in high cost” (Lang and Moleski, 2010: 112). “Improvement of the quality of indoor has led to extensive changes in the location and nature of semi-private, semi-public and public open spaces in the cities” (Lang, 1994: 229). Today, we see the decline of public open spaces and people’s growing tendency to malls. Presence in urban open spaces in the difficult climatic periods of a year is more painful than ever and People are looking to spend the least possible time in these spaces. Lang and Moleski (2010) suggest reduction in comprehensive reliance on artificial heating and cooling systems and the use of designing strategies (127).

Radiation and wind management

Local wind speed and radiation environment are the significant microclimate parameters that largely depend on urban planning (location of the site, form of buildings, geometry and orientation of open spaces, etc.). Hence, designers can use the interaction between climate parameters and urban morphology to enhance the comfort of walkways in public spaces (Reiter, 2010: 2).

It can be said that the first serious study on sunshine observations has been conducted by Ralph Knowles (1980), he introduced solar envelop and established a new approach in the field of urban regulations for favorable solar access of buildings. In urban scale, the idea of solar envelop is a tool for setting regulations in order to place the development in the mental ranges based on the motion of the sun. Within these ranges, the buildings don’t offer shade surrounding more than desired level during the important periods of day and year. Solar envelop provides the possibility of setting zoning regulations in order to provide low-impact development and open new ways in the fields of aesthetics in architecture and urban design (25). In fact, “solar envelop involves all possible solutions to a given problem” (Caputelo and Shaviv, 2001: 275). In some recent studies, the use of solar envelop to ensure access to urban public spaces has been taken into consideration (Caputelo and Shaviv, 2001).

Also, in order to achieve thermal comfort, enough skill on inhibition, regulation and direction of wind should be gained. For this, first of all, the required information on change in the conditions of wind around the architectural constructions and its subsequent impact must be collected (Razjouyan, 2007: 66). If several buildings are constructed adjacent to each other in such a way that their aerodynamic zones is different from single building aerodynamics, these buildings together form building set (Razjouyan, 2007: 102). Knowledge of wind behavior in housing complexes is essential for design in harmony with the climate because in practice, it can be rare to design single buildings that their aerodynamic zones are not affected by the construction or they don’t affect the aerodynamic zone of surrounding buildings (Razjouyan, 2007: 102).

“Today, there are only assessment tools for conscious designing in terms of wind comfort. These tools are wind tunnel studies or estimates of computational fluid dynamics (CFD). CFD models are very so powerful that they require heavy computing but also, they provide detailed results so, new design alternatives can be thought and reevaluated so that a good and responsive design is achieved” (Capuleto et al. 2003: 827). CFD modelling is an affordable designing tool in terms of costs and time. In addition, estimates of CFD provide quantitative and qualitative data on wind flow in the entire studied volume, not just a few points depending on the amount of available measurement tools (Reiter, 2010: 3 & 4).

In modern cities, much more than before, there are high-rise constructions and complex forms than can create many problems in terms of wind comfort in the spaces around these buildings (Reiter, 2010: 1). While the relationship between urban geometry and the local wind currents are reported and documented very weak, even in the literature of wind engineering (Willemsen and Wiss, 2007). In addition, a few studies have been conducted in this filed with technical characteristics and/or technologies which are useless for designer. Urban planners require simple guidelines and designing tools to understand the wind flows in urban environment (Reiter, 2010: 3). Also, in urban architecture and planning, these tools are never used in the first designing phase while the decisions taken at the first stage (volumes and placements) are important in the distribution of wind around the buildings (Reiter, 2010: 4). Studies on wind are not often performed until a thematic design close to the end of design is achieved, so, decision-making is possible only in the minor dimensions. Operating Principles are treatment-seeking measures with the lowest impact and simple graphic tools are the only form by which specialized issues of wind environment can be used in the first stage of design (Reiter, 2010: 4).

An important note in climate planning is the need for management decision. For example, how the benefits of probable comfort of a construction project in a season should be balanced with its negative consequences in other times of a year. Developing operating standards for the comfort in outside environment is a complex process and it is still the subject of research (Bosselman et al, 1995: 238). This decision should be based on local climate conditions (based on bioclimatic charts of thermal comfort, in what proportions the need for sunlight, wind and shade are set), performance considerations of each space and economic and aesthetic considerations. Another important note is the use of design solutions. Designing according to creation of different climates, creation of different microclimates and also creation of climate flexibility, plays an important role in the balance. In this field, the use of suitable vegetation is especially very effective. For example, the trees greening in warm season, provide the shade in warm season and the possibility of sunlight penetration in cold season. Also, designing according to the direction of prevailing winds of each season is important in order to balance the influence of the wind in the warm and cold seasons.

Aesthetics

According to John Land, in the dimension of formal aesthetics, the concepts driven from Gestalt Theory are still governing the thought off environment design. These concepts like artistic endeavor (Lang, 2002: 224). In this context, the recent studies have emphasized on “the relationships between complexity, simplicity and enjoyable values of an environment” (Lang, 2002: 221). “Complexity can be measured in several ways. The number of element in a system, novelty and being surprise, context patterns and levels of discipline are some of these ways” (Lang, 2002: 223). According to Arnheim (1977, as Lang, 202: 216 quoted), when the order is established, it makes the basics of organizing the components of a composition essential. Regulatory principles may not be understandable to all. Irregular environment is an environment in which the relationship between the main components is poor and the overall principle is not governing it (Lang, 2002: 216). According to the definition provided by John Lang, “complex structure is a structure which has numerous components and many regulatory principles are involved in it. The composition is regular (if these definitions are accepted) when the principles of composition support each other and it is irregular when there is no such a support and coordination” (Lang, 2002: 216). Von Meiss (1990), based on Gestalt theory, argues that: part of the fun and difficulties that we experience in relation to the built environment, can be explained through easiness or difficulty of mental grouping of various elements of visual field into the synoptic units. A number of basic parameters of continuity or the principles of grouping are specified as follows:

- The principle of similarity which helps us to recognize the similar elements from others.
- The principle of proximity by which the elements that are spatially close together are detected as a group and they are distinguished from other elements which are placed further.
- The principle of common field or shared enclosure, wherever a closure or a ground defines a field or a group. Those elements are in the field are distinguished from those are out of it.
- The principle of orientation, wherever the elements are placed in a group due to shared orientation, alignment (being parallel) or convergence.
- The principle of dependency by which partial or minor elements are recognized as a whole.
- The principle of extension that creates the possibility of pattern recognition that may not be formed based on such intention (Von Meiss, 1990: 32).

“Gestalt theory has affected theoretical foundations of designing more the other theories of perception” (Lang, 2002: 97). Also, it should be understood that “many of the combination principles used by designers have no direct relation with Gestalt theory and have formed independently over the long run" (Lang, 2002: 216). In urban design studies, different criteria have been introduced for the design of urban form in terms of aesthetics. Kaplan (1982) points to the macro criteria of order, complexity, legibility and being mysterious (81). Moughtin (1992) presents the criteria of order, harmony, contrast, rhythm, proportion, scale, symmetry, balance and equivalence (25-59). Nowadays, complexity is particularly important in urban areas. According to Caspirin (2011), urban space is a multi-dimensional reality that its dimensions are placed in a continuous dialogue with each other (147). And Madanipour believes (2000) that in any urban space, we simultaneously experience three mental, social and physical spaces which have dialectic relationships and influence each other (22 and 23). According to Caspirin (2011), urban space has semantic, functional and spatial dimensions in itself which have continuous relationship with each other and the change in one of them causes the change in another one (147). In contemporary era, urban designer's task is to correctly translate the meaning and function of the place to spatial dimension and "creation of form" (Caspirin, 2011: 147). In this field, urban designer should study and investigate the cultural, social, historical, economic and ecological areas and recognize features and existing patterns and design patterns and form relationships according to it (Caspirin, 2011: 194 & 147). In today's world, we are witnessing growing widespread and complexity of meaning and function and its corresponding spatial dimensions is a complex form including a variety of patterns and spatial relationships. With the increase in complexity of urban contents (meaning and function), design potential and creativity capacity are develop not reduced or limited (Caspirin, 2011: 195).

Method

Measurement of thermal comfort

In order to design with a climate approach, understanding the effects of environmental factors is essential for increased comfort. Measuring the level of comfort requires some parameters to compare with climatic conditions which a person is in (Heidsari and Mena'am, 2013: 198). To measure thermal comfort in open space, different indicators including PET[1], PMV[2], Out-SET[3], SET[4], ET[5] and UTCI[6] are used. Different studies have shown the higher correlation between PET and individuals' thermal sensation in open space than other indicators (Heidsari and Mena'am, 2013: 212). In a walkway in a certain place, the changes of climatic variables can be predicted at different times of the year through weather reports and computer modeling and according this data, one can predict whether the walkway space will be in comfort conditions on specified day and time or not (Bosselman, Arens, Dunker and Wright, 1995: 231).

"Olgyay bioclimatic chart is an interesting measurement method which pays attention to thermal comfort of external environment and it is based on the studies on external environment not internal environment experiences" (olgyay 1963 as cited in Reiter and Di Herde, 2003: 1004). Combining different climatic factors affecting human energy balance, only in a formula is essential (Reiter & De Herde, 2003: 1004). Olgyay bioclimatic chart covers a range of levels of temperature, humidity, wind speed and solar radiation (Reiter & De Herde, 2003: 1004). The advantage of Olgyay bioclimatic chart is that it combines analytical and diagnostic tools. This chart shows that how uncontrollable changes in a factor can be offset by various other controlled factors (Reiter & De Herde, 2003: 1004). "Among the four main microclimatic factors affecting body energy balance, only radiation (solar or earth elements) and wind could be modified with smart design" (Borwn and Gillesp as cited in Reiter & Di Herde, 2003: 1004). "The main benefit of bioclimatic charts compared to single-parameter comfort indicators is that despite the combined effects of four factors in terms of environmental comfort, it provides a dynamic control of them" (Reiter and De Herde, 2003: 1005).

[1] Physiological Equivalent Temperature
[2] Predicted Mean Vote
[3] Outdoor Standard Effective Temperature
[4] Standard Effective Temperature
[5] Effective Temperature
[6] Universal Thermal Climate Index

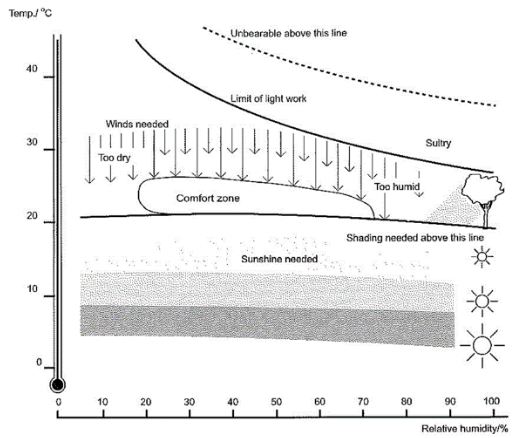


Figure1. Olgyay bioclimatic chart

Designing building according to wind management

Reviewing literature of urbanism, it is seen that there is a lack of operating principles in order to be used as design guidelines to enhance wind comfort. Given the gap in the literature of urbanism compared to significant achievements made in the field of climatology, now it is needed to bridge between the two field through transferring and translating specialized achievements of climatology which are usable in urban space to simple operating principles which are understandable and usable to architecture and urban design communities. The studies based on wind flow simulation show that the distribution of buildings to each other and according to the direction of wind is a major factor that cab be the basis for classification (Razjouyan, 2007: 103). It is useful that design guiding principles of building complexes are classifies based on it:

- Central courtyard (network effect): a building network creates an enclosed area that is protected against wind (Reiter, 2010: 27).
- High-rise buildings: these are buildings whose heights are at least twice the average height of the surrounding buildings (Reiter, 2010: 29).
- Column buildings: these refers to buildings which are placed behind each other in a row (Razjouyan, 2007: 105). Given the importance of building height on the one hand and position of their sides in relation to each other on the other hand, four small groups are specified in column type: 1- the buildings with the same height and common side; 2- the buildings with the same height and different sides; 3- the buildings with common side and different heights and 4- the buildings with different heights and different sides (Razjouyan, 2007: 105).
- Row buildings: in this type, the buildings with the same, narrow and less than 30 meters height and about 10 meters and less width and a length equivalent to eight times more than the height are separately placed adjacent to each other (Razjouyan, 1993: 105).
- Orthogonal buildings: in this type, the longitudinal axes of buildings are perpendicular to each other so that a space like square is established in front of them and two big sides of buildings overlook to it (Razjouyan, 1993).
- Street (cannel effect): a group of building form a channel with relatively small width (less than three times the height of buildings) and it can create a strong flow affecting the pedestrians' comfort (Klemm and Jablonski, 2004: 2).
- Funnel (venturi effect): two separate building groups forming an oblique angle create a funnel-like phenomenon known as venture effect (Klemm and Jablonski, 2004: 2).
- Stairway: this type refers to a set of buildings which are connected to each other in a short to tall (or vice versa) order and create a view of one-sided stairs (Razjouyan, 1993).

– Ziggurat: in this type, the stories of buildings and especially their lower floors are placed in stepped arrangement from all sides and the volume of buildings evokes the picture of Ziggurat (Razjouyan, 1993).

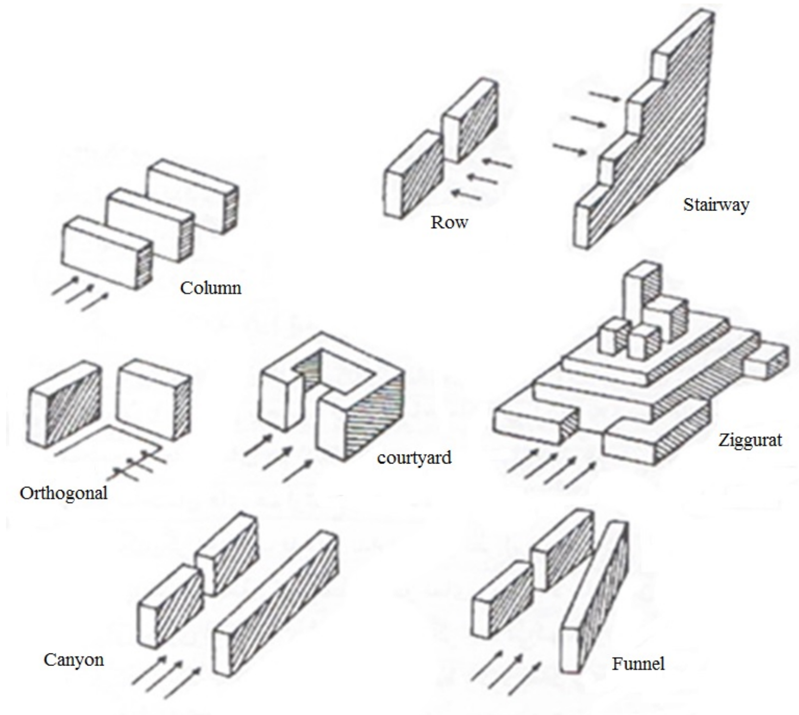


Figure2. Types of building complexes (Razjouyan, 2007: 103)

Table1. Aerodynamic considerations in building complexes design

type	Aerodynamic considerations in design
courtyard (network effect)	If the wind direction is perpendicular or parallel to the span surface of central courtyard complex, consider the wind speed in the courtyard less than the free wind speed in the region (Razjouyan, 2007: 211). if the wind direction and the span surface of central courtyard complex form a 45 degree angle, the wind speed in the courtyard will fluctuate and if it is perpendicular or parallel to the span surface of central courtyard complex, the wind speed in the courtyard will be less than the free wind speed in the region (Lawswon, 1980: 226) (Razjouyan, 2007: 145). If the central courtyard complex is not higher than 4-floor building and the width of yard is not greater than 50-60 m, consider the wind speed in the courtyard less than the free wind speed in the region (Razjouyan, 2007: 211).
High-rise building	The average wind speed at the sidewalk level depends on the height of higher building to average height of surrounding building ratio (H/h). The presence of high-rise buildings completely changes the flow of the wind in the surrounding streets. Key areas includes a circle with a radius of tall buildings (Reiter, 2010: 29). In general, don't design tall buildings perpendicular to the fast winds in the region (Razjouyan, 2007: 211). With rounding the windward sides of the tall building, you can prevent an increase in wind speed (Razjouyan, 2007: 212). If the wind speed may disturb the area, limit the building height to less than 25

	meters or eight floors (Razjouyan, 2007: 212). To avoid annoying wind speed, design the façade of tall building in a stepped mode (Razjouyan, 2007: 212). To avoid annoying wind speed at the sidewalk level, design the lower floors of the tall building wider than the upper floors so that the building is built on platform higher than surrounding buildings (Razjouyan, 2007: 212).
Column	You can create a sense of shelter among the buildings with the same height and common side if the distance between buildings is equal or less than their height (Razjouyan, 2007: 205) In the building complexes with the same height and different sides and of column type, consider the increase in the velocity of cross flow among the buildings compared to natural wind in the region (Razjouyan, 2007: 205) If reducing the velocity of cross flow among the buildings of column type with the same height and different sides is necessary, do following measures: 1. Reduce the protrusions of the buildings, 2. Increase the distances between the buildings. 3. Create appendage in the façade of rear buildings (Razjouyan, 2007: 206) A place in which creating thermal comfort is difficult in winter, in column type, the height of high-rise building of building complex with different sides and the same height must be twice the distance between the two buildings (Razjouyan, 2007: 207).
Row	In this type, the beginning of the span of passage is a special point because the wind speed exceeds the speed of free wind in the region and it becomes maximum (Razjouyan, 2007: 208). In this type, if the length of buildings adjacent to the passage doesn't exceed 40 m, consider direct correlation between the height of buildings and wind speed at the span of the passage (Razjouyan, 2007: 207). In this type, the wind speed in the passage may become twice the speed of free wind in the region (Razjouyan, 2007: 209), in order to reduce it, design the distance between the buildings less than the half of their height or twice greater than their height (Razjouyan, 2007: 209). If the wind is blowing with 45 degree angle to the row type, the wind speed may be maximized at the back of the building and in the middle of the row and consider its value in short row greater than it in long row (Razjouyan, 2007: 209). If the wind is blowing with 45 degree angle to the central axis of row type and reducing its speed in the passage is required, create jut in the façade of buildings (Razjouyan, 2007: 209).
Orthogonal building	Taking into account that the wind speed in the passage in this type become twice the free wind speed in the region. If the wind disturbs the complex, limit the height of building surrounding the passage (Razjouyan, 2007: 209). In this type, if it is required to reduce the wind speed, increase the width of passage (Razjouyan, 2007: 210). In this type, if the wind angle to the axis of passage passing among buildings taller than four floors, is 40 degrees, the wind speed exceeds the free wind speed in the region and reaches its maximum value. If the wind disturbs the complex, limit the height of buildings to less than 4 floors (Razjouyan, 2007: 210).
Canyon (channel effect)	To reduce wind speed and problems arising from it can be used the following solutions. - "buildings are separated from each other, and there is a sufficient distance between them (the length of free empty space is about 75% of the length of buildings and more) (Lawswon, 1980: 224-225) (Razjouyan, 2007: 143) . - With tall and short buildings make the skyline on both sides of the street non-uniform (Razjouyan, 2007: 144). - With the angles close to the right angle, create twists and turns in the street

	(Gandemer, 1977: 430) (Razjouyan, 2007: 144).
Funnel (venture effect)	In this type, wind speed greatly increases in the tight space between the buildings. The width of narrow span of street (w) is not less than the half of the average height of buildings on both sides of the complex (H) and also it is not greater than four times of it. No building or barrier is designed on the way of wind, up about 100 meters after and before the mouth of the funnel. If the increased wind speed is disturbing: a. reduce the height of buildings so that their average height doesn't exceed 5 floors. B. Make the both sides of the complex asymmetric to the central axis of street
Stairway	In this arrangement, behind each building, a negative pressure region (suction) is formed proportional to the height of it and finally, due to the pressure difference between the areas, cross flow will be established from the region with less suction to the region with greater suction. Cross-flow velocity depends on the height difference between the buildings (Razjouyan, 2007: 145).
Ziggurat	In this type of complex, wind speed reduces in many parts of the complex due to uneven façade (stepped floors and terraces) so that the wind speed in the most areas near the ground surface will be less than the free wind speed in the region (Gandemer, 1977: 430) (Razjouyan, 2007: 147). But in this type, there are critical points where wind speed around the complex will exceed the free wind speed in the region. The most important points are as follows: 1- windward corner of the complex near the ground surface, 2- windward corner of the complex at an altitude of forty meters (about thirteen floors) and 3- windward balconies near the corner, from the ninth floor to upper floors (Razjouyan, 2007: 148).

Designing building according to solar radiation management

Solar envelop is a structure of time and space: the physical boundaries of the surrounding property and the period of their guaranteed access to sunlight. The state of these measurements determines the ultimate size and shape of the envelope. Solar envelop prevents the creation of shadows beyond the borders determined on the limitation of neighboring property. These borders can be referred as "borders of shadow" (Knowles, 2003: 16). Also, their height can be determined according to surrounding land uses, for example residential land use needs lower borders of shadow compared to commercial or industrial land uses. Different heights of border of shadow affect the shape and size of solar envelope (Knowles, 2003: 16). The envelope provides the largest volume in the time zones called "cut time". The envelope does it by theoretically introducing the largest container of space which doesn't overshadow on prohibited limitation between certain times of the day. The longer timeframe of guaranteed access to sunlight limits the solar envelope further (Knowles, 2003: 16). The longer the time frame is, the less, the potential of development and thereby urban density are (Caputelo and Shaviv, 2001: 277).

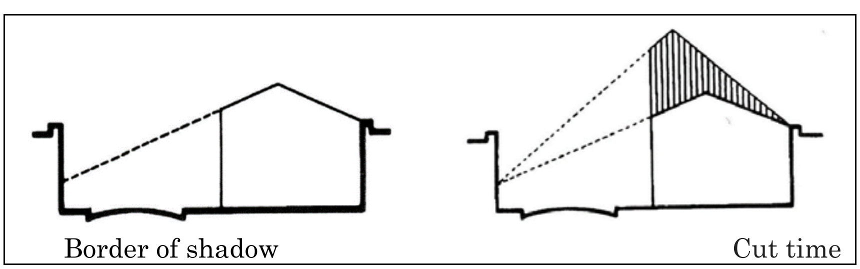


Figure3. The cut time and the border of shadow

Regulation of radiation

Choosing cut time (dimension of time) and the border of shadow (dimension of space) is a tool to control the solar envelope. Knowles (2003) has named this selection depending on the conditions of place, as selection of solar envelope regulations (Knowles, 2003: 17). In fact, selecting regulations is the planner's policy-making in shaping the solar envelope. Choosing the border of shadow (dimension of space) has different modes depending on conditions. At this stage, the objective is to identify the surfaces that should be placed under the guaranteed radiation. It must be determined that what open spaces and building are considered. Maybe only specific areas of a particular field or specific sides of buildings are considered. Different types of solar envelope may be formed as a result of this decision-making. This decision specifies that solar envelop will descend in what direction and also, accordingly, solar envelope may ascent and descent along the block in each building or it may be continuous. A common envelope was considered for the entire block and even a common envelope may be created for several blocks (Knowles, 2003: 19).

As mentioned, thermal comfort is achieved as a result of balancing temperature, humidity, wind speed and solar radiation. So, for this purpose, above factors must be considered in relation to each other. Therefore, solar radiation should be determined based on other climatic factors mentioned above. For example, a place where the temperature in winter can be greatly reduced, access to sunlight is required most of the day time. Also, solar envelope regulations are set in accordance with the development of the area. The development plan includes the density and type and severity of function intended for the area. At this point, in policy-making, it is important that solar envelopes are formed in accordance with the development needed. For example, in the high-density areas compared to low-density areas, it is possible that the period of guaranteed access to solar radiation and the boundaries of the shadow are reduced and increased, respectively. Land use must be considered in developing solar envelope regulations. In this regard, the severity of function as well as special functional considerations must be taken into consideration. Some land uses such as residential, green space, sport, recreation land uses, etc. require more solar radiation compared to other land uses due to functional considerations. "Residential land use needs lower borders of shadow compared to commercial or industrial land uses" (Knowles, 2003: 19). Each residential units in multi-unit residential buildings requires at least four hours of direct exposure to daylight and winter heating (Knowles, 2003: 17). Urban spaces, in terms of function, require different considerations. "Public centers" including public parks, game lands hyperplasia need constant access to sunshine during the day (Headman and Yazoski, 1984: 198). While there is no such necessity for streets. According to Headman and Yazoski (1984), a variety of access approaches to solar radiation over street network enriches the experience of city and this positively affect passer-byes (Headman and Yazoski, 1984: 198). Another point is that to protect the public space from shadows, limiting only the first layer of adjacent building block is not enough and depending on its importance, the next layers of building should also be considered. In this case, the important issue is to protect public spaces from the shadow of other high-rise buildings in the region.

Case study

In July and August, daily temperature turns around 30°C and at night, the temperature is about 7° C less than daily temperature so that it will be in the range of temperature moderation and if there is a gentle breeze, bioclimatic and thermal comfort will be provided for summer nights. The probability of frost in winter is low. 20-year average of forest days is about 2 days a year. But the indicator of winter temperature is low and average of maximum daily temperature is less than 14°C. High relative humidity in this area leads the occurrence of sultry phenomena in summer. The lowest daily relative humidity (about 76.6%) and the highest daily relative humidity (about 83.5%) are related to July and March, respectively. In most months, the prevailing wind direction is northeast and from mid-May to October, the prevailing wind direction is northwest. Secondary prevailing winds direction, with 45 degrees difference between them and the main prevailing wind, is west or east. The strongest winds with average speed of 18.8 knots per hours and the smoothest winds with average speed of 5.2 knots per hours are reported in July and December, respectively.

According to Olgyay chart, Mahmoudabad city, in most months of a year, requires heat of sun to achieve thermal comfort and in part of a year in warm season, it needs wind and a few part of a year, it requires shadows.

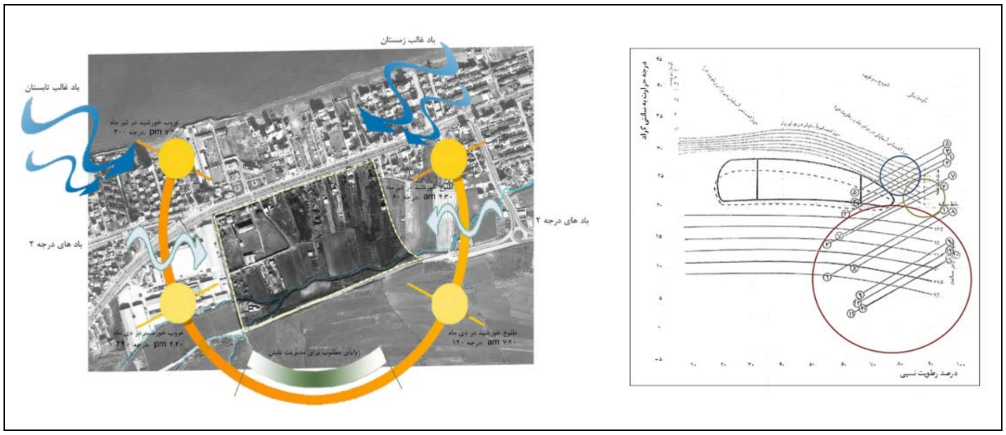


Figure 4. Climate analysis of the case study

Design procedures

1. Two-dimensional design:

In comprehensive plan of Mahmoudabad City, its western part is designated for residential neighborhoods, its eastern part is designated for recreation and tourism area with regional function and its southern part and the areas adjacent to the river are considered as urban green spaces.

In the two-dimensional design, following items were taken into consideration:

- Directing the main passages in a way that the possibility of sea breeze penetration in to the spaces of the area is provided.
- Orienting the passages in the oblique direction towards the North – South and East – West orientation so that public spaces would have more exposure to the sun. (Knowles, 2003: 4.6-4)
- Establishing most of the residential parts in Northeast – Southwest direction that they would have the greatest exposure to the sun.
- Creation of a visual corridor
- The use of desirable central courtyard type in order to control the wind
- Creating openings and openness along the street building complexes in order to control the wind

2. The proposed land use:

Designing the land uses in the case study was performed according to comprehensive plan of Mahmoudabad city:

- East core, as open mall for tourists and citizens. It includes buildings with mixed land use and residential spaces
- West core, residential neighborhood with required service land uses
- South core, green and natural area along the watercourse

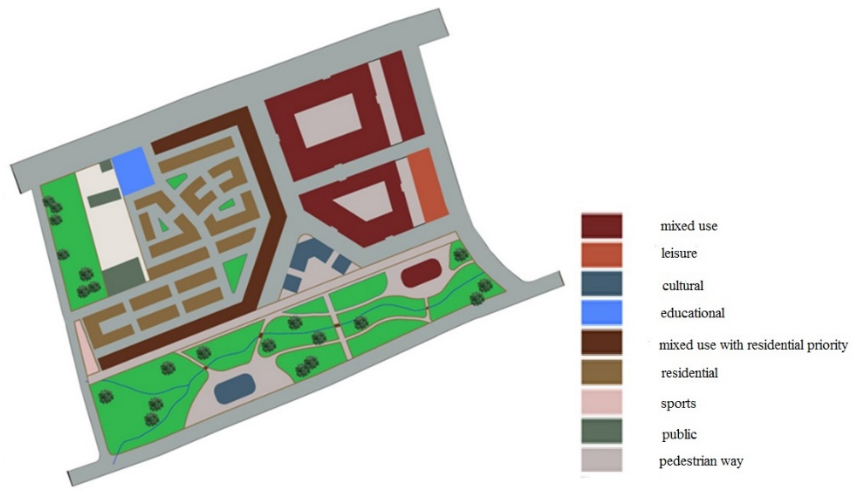


Figure5. The proposed land uses

3- Regulations of radiation

At this step, access to solar radiation was planned for the spaces of the case study. In this regard, local public spaces were divided into three parts:

1. The spaces for which during the day, 8-h guaranteed access to sunlight in winter is considered; these spaces include main natural spaces and public open spaces which require the maximum guaranteed access to sunlight.
2. The spaces for which during the day, 6-h guaranteed access to sunlight in winter is considered; these spaces include secondary natural spaces and public open spaces which are placed in the second priority.
3. The spaces for which during the day, 4-h guaranteed access to sunlight in winter is considered; these spaces include the main commercial center, walkways and all residential axes.

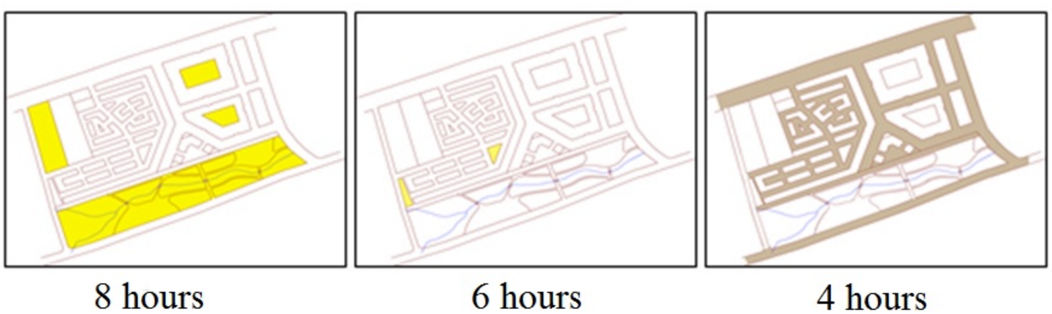


Figure6. Regulations of radiation

4- Construction of solar envelop

At this step, the borders of shadow were determined as 2 meters parallel to wall side. Then, given the cut time determined for each space these borders are extended at the angles tailored to the solar radiation during the day in January that the sun is at the lowest altitude and therefore, some pages were generated in different directions. Then the height of building blocks was determined. Finally, the generated pages were interrupted by buildings and the solar envelope was created by cutting the buildings.

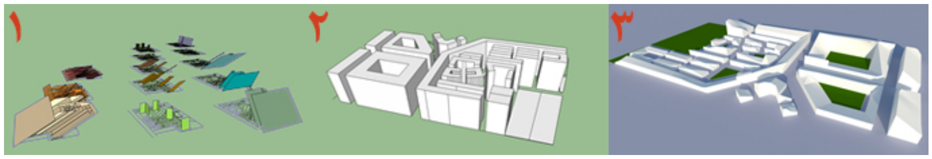
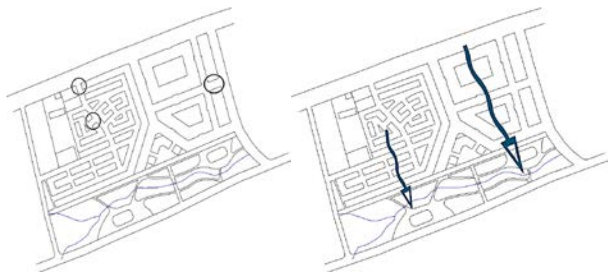


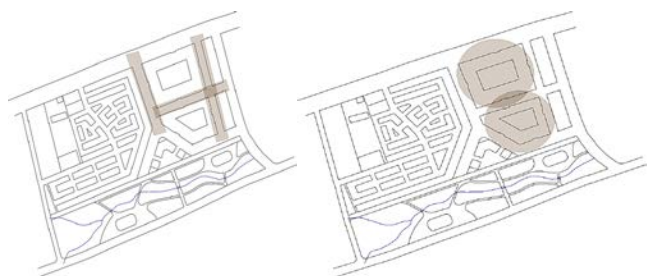
Figure7. Construction of solar envelope

5- Aerodynamic strategies

In the wind management part, aerodynamic strategies were provided for different types of building complexes. At this stage, mentioned types were identified in the area. The volume design of these types must be performed according to provided notes.



Row column



Canyon courtyard

Figure8. Aerodynamic strategies

6- The strategy of natural landscapes view

In height structure design, the main strategy is to use piece, open and discontinuous pattern instead of long and continuous masses. This structure, because of being open and presence of openings between masses, provides the most possibility of seeing the surrounding natural areas and also the influence of more light and air flow to public spaces is provided.

Figure9. The strategy of natural landscape view

7- Massing design in the spaces of envelope

In this part, the volumes were designed in the area of solar envelopes according to aerodynamic, aesthetic and functional strategies.

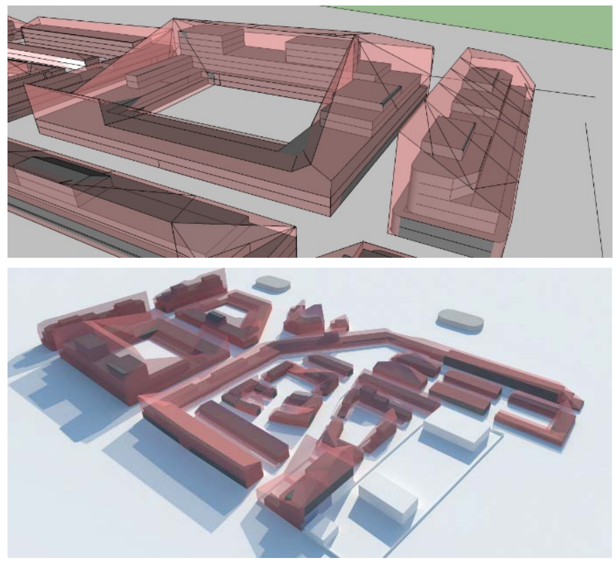
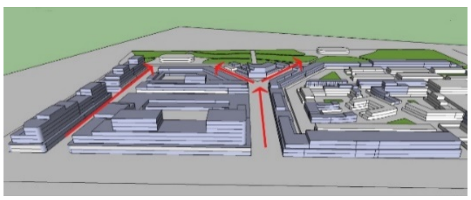


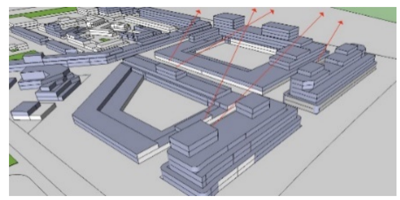
Figure10. Massing design in the spaces of envelope

Results

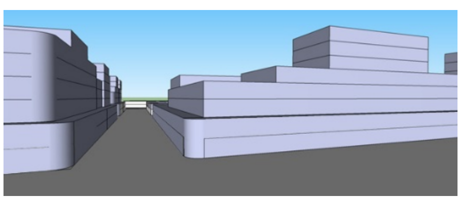
According to what presented in method, the case study was designed. According to the direction of favorable wind (in summer) from the northwest wind and unfavorable wind (in winter) from the northeast as well as denser development plan on the East of the field, the strategy of construction of solar envelop was taken in order to create shorter height and more open mass in the western part of the case study in order to receive proper air flow in warm season and also, to create taller height in the eastern part of the case study in order to block the unfavorable air flow in cold season. Based on the overall analysis of temperate climate of Caspian Sea, in most times of the year, proper solar radiation is required to achieve climate comfort in the external space. In design and development of solar envelope strategy, the main emphasis is to ensure a desired level of radiation in the spaces. According to what mentioned and solar envelop regulation in accordance with the functions and types of public spaces, solar envelope was created and then according to aerodynamic, aesthetics considerations and functional considerations of land uses and provision of maximum view to surrounding natural zones, the building mass was designed in the limitation of solar envelope. In the dimension of aesthetics, visual complexity, form diversity, the relationship between various forms, creation of visual corridors, creation of symbolic masses in proper spaces and human scale were taken into consideration. Also, the massing was design by considering aerodynamic considerations of different types of building complexes.

Figure 11. Final plan

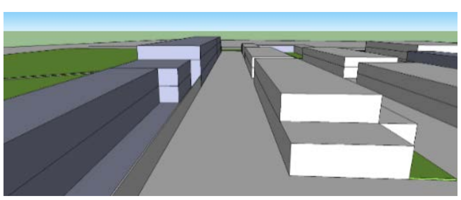


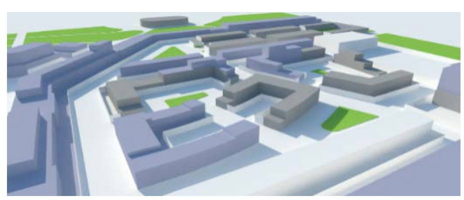


Visual corridors toward the sculptural structure height open structure creates an appropriate view to surrounding natural areas.



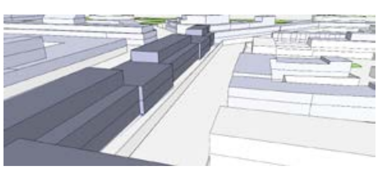
Rhythms, gradual change, control, coordination recess of buildings after the second floor strengthens the human scale

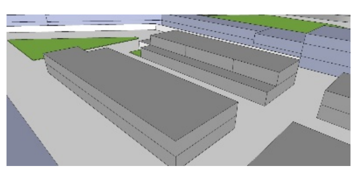




Gradual change in forms variety of forms and heights

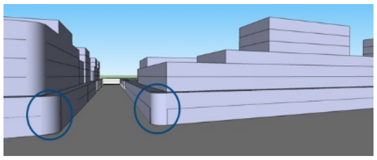
Figure12. Design policies in terms of aesthetics

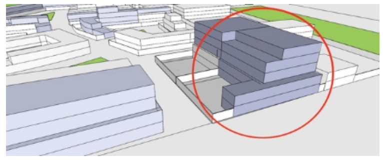




Short and tall buildings and the protrusions and recesses in the streets body, in addition to reducing the channel effect and the severity of the wind, result in the form diversity and richness.

Creating appendages in the façade of rear building in the column type in order to reduce the cross flow velocity





Designing critical points in terms of aerodynamics

In designing massing, the ziggurat type is mostly used and it is the most proper form to be used in order to prevent bothering winds.

Figure13. Design policies in terms of air flow management

Conclusion and suggestions

In the present study, it was tried to review the extensive design considerations of scale element and to extract operating principles and to use them in design process. The next step was to use specialized software in design process that in simulated environment, the objectives and hypotheses can be assessed. The design approaches used in the present study were to avoid annoying wind, convenient access of spaces to solar radiation, to combine buildings according to aesthetic principles with approach to greater diversity and complexity, height structure design in order to

In this regard, in the present study, in the form of comprehensive process, designing the scale of urban form in the case study of coastal Mahmoudabad City has been performed regarding different dimensions, especially aesthetic quality and thermal comfort. In the present study, form and height mixture, instead of segregation and zoning, was considered and used in order to increase the diversity and complexity of form and enhance the aesthetic quality and climatic comfort. The following points are suggested for further research:

- Considering different tastes and species in the composition of urban massing
- Paying attention to other factors of urban forms affecting the quality of thermal comfort of public space, such as kind and color of wall and floor materials, natural factors and 2D structure
- CFD empirical research on urban structure in order to obtain usable design principles for urban planners.
- To use simple software with the ability to automatically create large-scale solar envelop
- To pay attention to operational aspects and to coordinate with municipal regulations.
- To study and compare the effects of different scenarios of solar envelop on thermal comfort in urban space in different seasons and to determine the optimal scenario for different climatic zones

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