May 2011, Volume 5, No. 5 (Serial No. 42), pp. 421-439
Journal of Civil Engineering and Architecture, ISSN 1934-7359, USA

Modelling of Baku Residential Structures on a Complex of Climatic Factors

Kahramanova Shahla

Department of Architecture and Town-planning, Azerbaijan Architecture & Construction University, Baku, Az1073, Azerbaijan

Abstract: Growth of an anthropogenic load on an environment in the second half of XXth centuries has led to an exacerbation of many ecological problems. Today ecological risk scales cover territories of large regions. In this respect the territory of Azerbaijan is not exception, within which Baku is noted by very adverse ecological conditions. Complex natural conditions (presence of strong winds, high air temperature and solar radiation) complicate the city ecological situation even greater. In modern conditions a construction boom relates to the factors aggravating the ecological situation of Baku. Last 10 years the city is rapidly built on by multistoried buildings which deform it, hinder visual contacts to the environment and obstruct the natural aeration of Baku amphitheater. The modern multistoried buildings erected ignoring town-planning norms do not correspond with regional climatic conditions, essentially modify the territory wind regime, hamper in surrounding buildings insolation, neglect a territory temperature-humidity conditions. As a result, it is necessary to use energy overly for their adaptation to Baku conditions and creation comfortable microclimate in them that leads to the city environmental pollution. The planning decisions and construction materials applied in these buildings are also alien to Baku climatic conditions. For qualitative transformation of Baku environment and improvement of ecological characteristics of the residential areas the author has carried out the estimation of the city territory on a complex of climatic factors (aeration, insolation and thermal-humidity regimes). For these purposes the multidimensional statistical method is used. As a result the investigated territory of Baku is divided into 5 typological areas on climatic conditions. The brief characteristic and the general recommendations on transformation are worked out by the author for each of these typological units. Results of the research can be a basis for revealing of methods and principles of town-planning and architectural-planning organization of Baku residential areas.

Key words: Residential structures of Baku, ecological situation, typological zoning, climatic parameters.

1. Introduction

Cities as people habitat cause great anxiety today. The amassed economic and social problems are aggravated with more and more worsening ecological situation. In this respect the territory of Azerbaijan is not exception, within which Baku is noted by very adverse ecological conditions. All elements of the nature are negatively changed here: an atmosphere, a hydrosphere, a lithosphere. Uncomfortable natural-climatic conditions (presence of strong winds, high air temperature and solar radiation, complex geo-ecological situation) complicate the city ecological situation even greater.

One of the basic directions for acceptance of long-term decisions on improvement of Baku eco-environment and providing for sustainable development of the city residential structures is transition to more energy-and resource-saving living standard. First of all it is necessary to acquaint with the basic climatic factors influencing on Baku residential structures eco-system, with microclimatic features of the city and traditional construction methods of the residential areas. All this will promote to carry out the complex climatic modelling of Baku city environment providing sustainable development of the urban ecosystem, to develop a complex of principles and well-founded recommendations on formation of town-planning and architectural-construction decisions of the residential structures directed on rehabilitation of the city environment.

Corresponding author: Kahramanova Shahla, PhD, assistant professor, research fields: urban planning, urban ecology, heritage, sustainable development. E-mail: kapitel2006@yandex.ru.

2. Methodology

Baku has specific climatic parameters that impose the specific responsibility on architects and town-planners at designing sustainable residential and public structures. The basic factors influencing on town-planning and architectural-planning decision of residential structures in conditions of Baku are solar radiation, wind and thermal-humidity regimes.

2.1 Building Aeration Regime

The wind regime of Baku is the most typical feature of the city climate [7]. The city is known for a long time under the name of Badu-kuba–the city of winds, and it is situated on Apsheron peninsula which occupies one of the first places on wind energy potential in post-Soviet countries space [4]. During all year dominant winds are northern and northwest, and also southern which speed exceeds admissible comfortable norms in several times, sometimes achieving up to 40 m/sec. Wind and buildings are impact on each other: wind changes the speed and direction under building influence, and at the same time a strong wind dictates specific methods of building and territory planning.

Baku wind mode depends on its orography and natural landscape features. The city descents from edges of Baku amphitheater toward to Caspian Sea and there are 11 terraces traced here. The city height varies from 28 up to 150 m above the sea level and breaks by abrupt slopes to surrounding it valleys with height difference in 140-220 m in the west and 20-8 m in the north and in the east [1]. The highest city points are Patamdar height and Zikh ridges, the lowest ones are in the coastal zone of Baku. Considering the relief features, literary data and on-site investigations the author worked out the scheme of Baku territory aeration (Fig. 1), where sites with the most wind speeds are located on the northern windward slopes and tops of Patamdar height (150.5 m), lateral and leeward slopes and top of Zykh ridges (166.5 m), abrupt Baladjar slope, the northwest (9 microdistrict) and western (Yasamal, Yeni Yasamal districts) ridge and western slopes of Baku amphitheater.

In one's time experts of Central Scientific Research Institute of town-planning decided to place wind barrier from lengthy high-rise buildings on some areas of Baku with strong winds for protection of the city

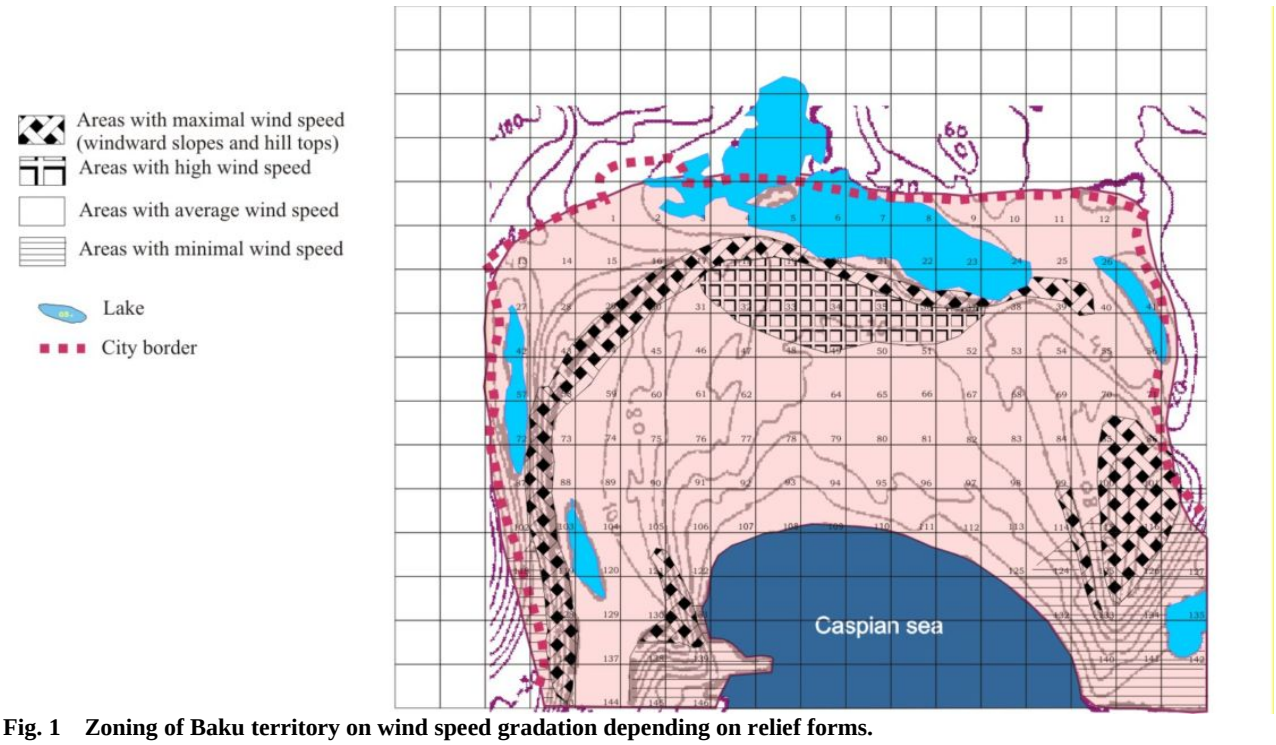

Fig. 1 Zoning of Baku territory on wind speed gradation depending on relief forms.

territory from strong northern winds. The 9th microdistrict building can serve as example of such areas, which is located in Northwest Housing Estate and faces Baku amphitheater edge, completing the city panorama in the north. Then rather abrupt Baladjar precipice is placed. This territory is opened to northern winds most of all therefore it has been built up by a wind-shelter barrier from blocked 9-storeyed apartment houses [6]. However in time it was revealed, that lengthy multistoried buildings do not protect from strong Baku winds, and quite the contrary they form strong whirlwinds in places of pass to court yards, between buildings placed close to each other.

Location of Baku as the amphitheater promoted natural aeration of the city, clearing it from air pollutions until recently. Today the town-planning infrastructure of Baku remind simple gathering of buildings. For last years unsystematic placing of residential high-rise buildings, in the city central part, and then on the periphery, has led to distortion of relief, and as consequence to change of Baku microclimate. As a result of high-rise building construction on windward slopes and uplands (Yasamal, Patamdar districts, etc.) pedestrians were blows off by gale-force wind at a building foot. It is possible to refer "Three crowns", "Elite", "Sea View", etc. to such buildings.

It is known that building depending on compactness, methods, number of storeys, building configurations, etc. significally change wind speed and direction. In conditions of Baku wind is one of the most negative factors for construction of high-rise buildings, so such buildings are not recommended for mass construction in Baku. After high-rise construction the city building aerodynamics changes and strong vortical streams arise, therefore at building planning it is required to research of their aerodynamics in view of adjoining city building.

Low-rise construction of Baku does not influence essentially on wind speed change (Rasulzadeh, Baladjar, Patamdar settlements, etc.), but these territories can have better climatic parameters than perimeter or line-perpendicular structures at suitable gardening. Therefore, it is recommended to improve the existing low-rise construction microclimate, basically, using gardening. In quarters of 4-5 storey buildings with court yards (1-3, 4, 5 microdistricts) the wind touches light on the surface of apartment house roofs and tree crones. Therefore, such court yard shined by the sun, differs more comfortable microclimate. The successful example of such construction is the housing estate in Mammadyarov settlement created in 1930s years. The 2-4-storey perimeter building of Baku central is also protected from a wind and a dust although protecting from strong winter winds, they do not allow penetration the weak summer winds for aeration of quarter spaces. This residential construction is characterized by complete lack of green plantings, design elements and needs reconstruction by disclosing the inside green spaces to the south or vertical aeration. Today reconstruction in such building is carried out by destruction of separate old buildings and construction of new high-rise building. However, when high-rise building is entered into this construction, the funnel effect is shown more contrast because of abrupt difference between low atmospheric pressure on the ground and on the roof level of high-rise building [17, 21].

5-9-storey residential construction is basically located in microdistricts (4,7,8,9) and in the East Housing Estate of Baku (Ahmedli, Gunashli, 8th kilometer). Created on free suburban territories of Baku this mainly linear, sometimes quarterly building is remarkable for territory accomplishment and gardening. However the areas were mainly built up by typical buildings, that's why this construction needs in reconstruction for adaptation to local climatic conditions, in particular providing of building territory wind protection and transformation of apartment houses planning structures. The practice has shown that multi-storey lengthy buildings are not applied in conditions of Baku because they assist to formation of strong turbulences in the court yards.

Planning decision of Baku residential areas will differ from each other depending on location on different slopes orientation, placing on terraces [10]. In such conditions it is necessary to construct Baku housing estates basically by low-rise buildings with courtyards (the bottom terraces) and quarter medium height buildings (middle terraces). The author on the basis of experimental and theoretical researches analysis worked out the basic schemes of low-rise buildings with courtyard and medium-rise block construction in view of Baku aeridynamics (Fig. 2). It is necessary to locate special developed buildings on tops and windward slopes and also narrow parts of valleys. It is recommended to use compact block constructions here in view of insolation and hygienic conditions. Building heights on low and average terraces of the amphitheater should be limited.

Tower building can be used in the coastal zone of Baku as accents in the transport units, etc.. Separate tower buildings will not break the field of view from the bay, however, continuous use of high-rise construction in this area will change shape of the bay and will break the direct and back city panorama. It is necessary to consider that the lower coastal city part is seismically active, there is high ground water level here and that is why it is not advisable to increase building height more than 14-16 storey without special antiseismic construction methods. Today high-rise building demands of new planning decisions the most adequating to the city climatic factors. The streamlined building can be applied as wind-adjustable ones, behind which a winter speed will not change [13].

It is necessary to enter boulevards, squares and green avenues into the historical city center, and on windward abrupt slopes, to create wind-proof plantings from special kinds of tracery and strengthening plantings, that on the one hand will protect slopes from northern winds, on the other hand will strengthen them from landslides. It is necessary to be applied on windward slopes and tops of Patamdar height and Zykh ridges, Baladjar slope and Yasamal valley slopes, placing in parallel to northern wind.

2.2 Insolation Regime of Residential Areas

Alongside with a wind regime high solar radiation also has determining value at planning and construction of Baku housing estate. The average yearly quantity of solar radiation makes 135 kcal, and in winter months is 46-65 kcal, and in summer ones is 3 times more [19] (Table 1).

At such high solar radiation both sun-protection and correct natural insolation of apartments become problems. There are some problems with the last criteria in condition of Baku. The building compactness increases due to multistory buildings. Aspiring to increase of the city building compactness in conditions of free areas deficit and high coast of the territory, builders frequently ignore insolation norms. The striking example is the 24-storey building on Gutgashenly street, constructed at 10 m distance from 9-storey apartment building. Unfortunately, there are about ten such examples only on this street. In the other city district there are 6 single-type multistory buildings ("White sail" complex) placed in two rows at 10-12 m distance from each other. The central zone of Baku also abounds in the similar construction (H. Hajiyev, N. Narimanov streets, etc.). The author has constructed the computer model of Baku building on relief for 1990 and 2007 years. On the schemes it is visible the negative influence of intensive construction by high-altitude buildings during 1990-2007 years on the city building insolation (Fig. 3). It refers, first of all, to high-rise buildings which number has abrupt increased in Baku for last years. Reaching 18-22 floors, they hamper in surrounding buildings insolation, not creating normal shading of residential areas at noon. Especially it refers to the flat city sites (gradient less than 5%) – the central zone of Baku, microdistricts, the coastal zone.

In some cases an insolation lack in Baku apartments has not been caused by surrounding building impact. In other words, inadequate insolation in Baku dwellings have been projected-in and defined by plan configuration and also by placing of living rooms and

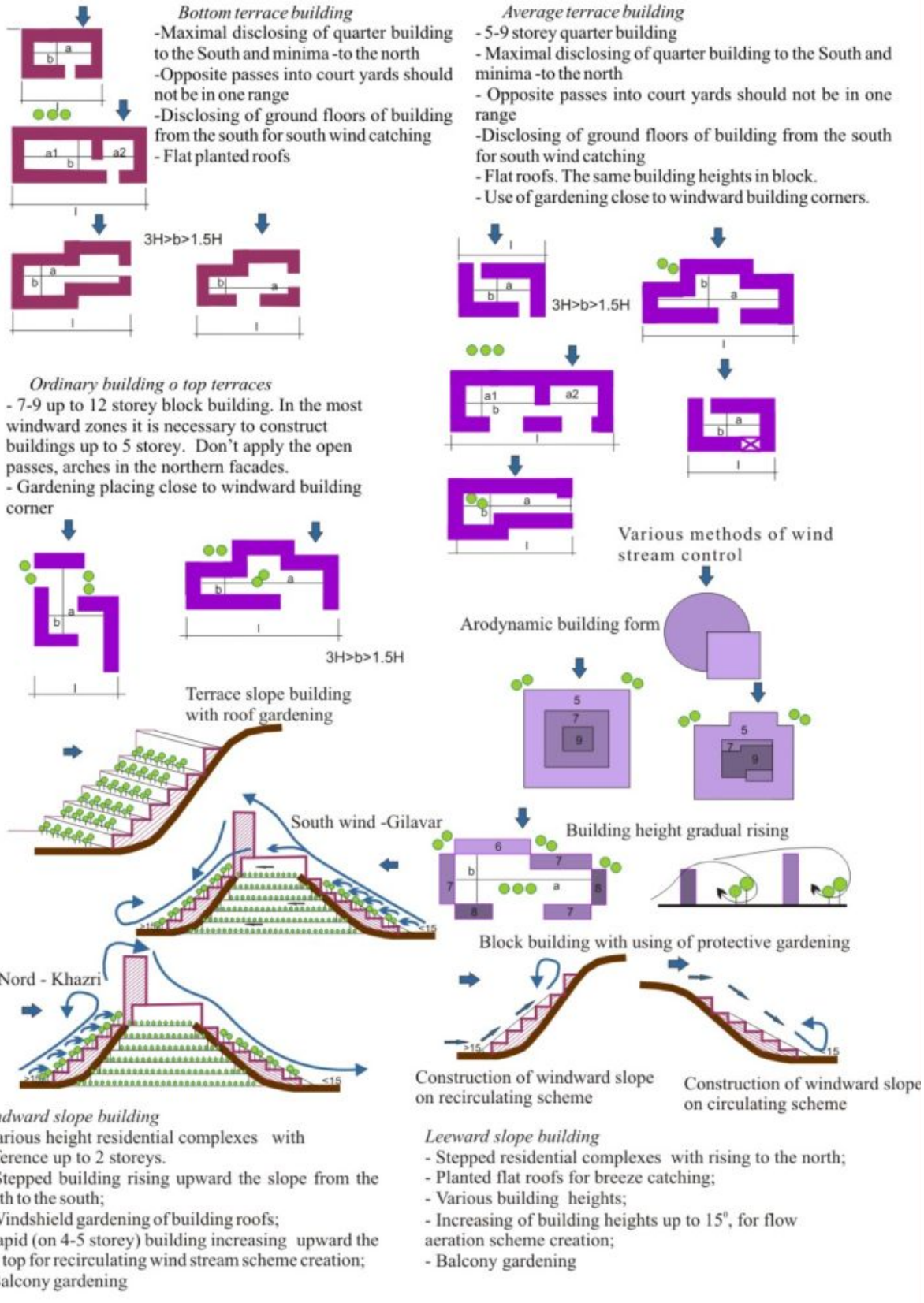

Fig. 2 Basic schemes of low-rise and medium-rise block construction in view of Baku aerodynamics.

Table 1 The average quantity of heat acting from total solar radiation on a horizontal surface (monthly, kcal).

I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
54	65	106	158	218	246	232	206	140	97	57	46

apartments in it [8]. It can be referred both to modern buildings, and the buildings constructed during the Soviet period, and also in the XXth century. For example, in pre-revolutionary Baku the insolation does not correspond to minimal sanitary norms in 43.9% of all working families houses (5774 rooms). 215 apartments (2.35%) didn't have windows at all, 56 apartments had ceiling apertures for insolation. The analysis of typical and experimental apartment buildings maintenance (SN&R, 1974) shown, that in 1-450-A (10%) and 1-400-AN (33%) typical series buildings, built in 1960, had one-side orientation, that is inadmissible in Baku climatic condition.

Today, in conditions of intensive territory construction and rigorous competition of building companies in Baku many owners aspire to draw customer attention by unusual building form and decoration, innovation technique. In turn it results in subservience of plan decision to volumetric one, ignoring of insolation and other project norms. In such conditions more than 80% of all constructed buildings have hastily built and insufficiently insolated apartments. In many cases new apartment owners are compelled to re-plan it before moving to the flat.

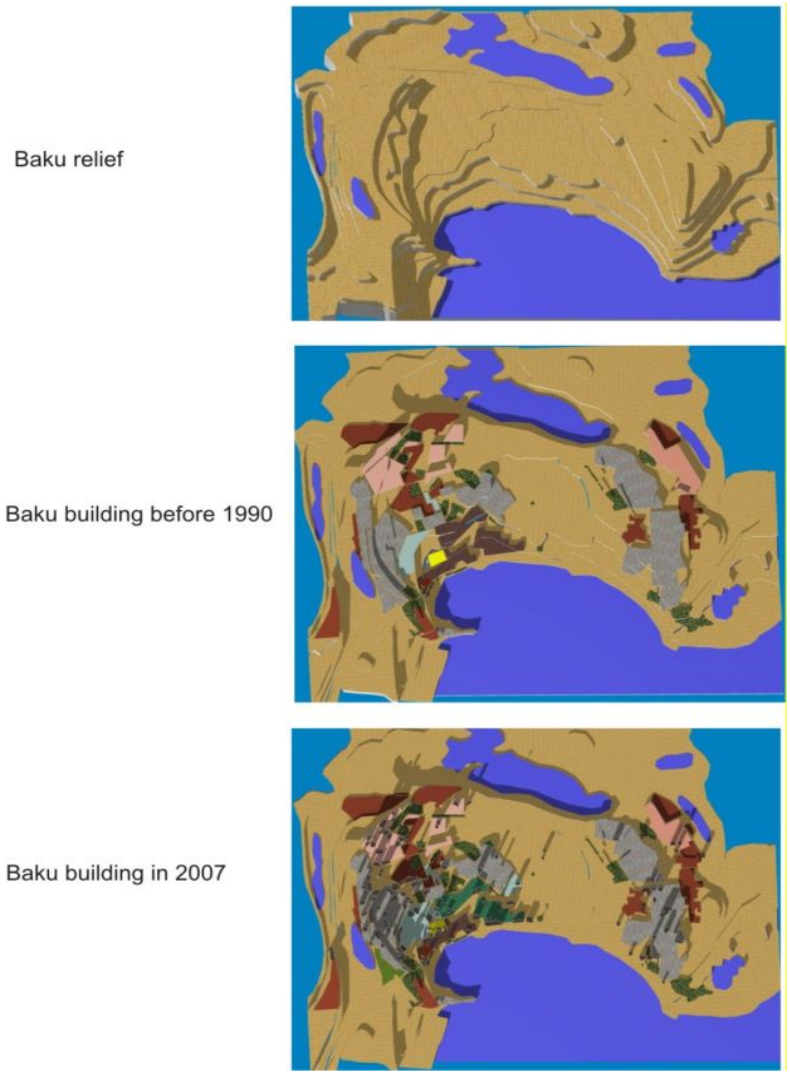

Fig. 3 Impact of intensive construction of Baku by high-rise building on the city territories insolation.

High thermal conditions of Baku set also the problem of overheating protection in Baku residential areas in summer period. For overheating protection it is necessary to achieve the greater shading during the daytime when overheating reaches its maximum. For Baku overheating in June-August lasts approximately from 12: 00 till 16: 00 (on the average for the period). Therefore, it is necessary to make the shadows schedule for construction site for this daytime.

As a whole, for Baku residential areas subject to summer overheating, microclimate difference degree in leeward and wardside courtyards vary according to area gradient and building storeys.

The radiating regime of building of Baku essentially depends on orientation of Baku amphitheater slopes. 3-D modeling of slopes insolation of the Baku amphitheater executed by the author has allowed establishing optimum sites for construction of residential areas in territory of Baku from insolation point of view (Fig. 4). So, the optimum territories are east and southeast slopes of Patamdar plateau, Yasamal valleys, Zykh ridges, and also Garachuhur sett., southwest part of Baku coastal zone, territory of the 1-9 microdistricts, the central zone of Baku because they are positioned on Baku amphitheater slopes shadow.

Therefore, it is expediently to construct buildings of small frontage length (against the height) with breaks or shifting of blocks ring by using multiroom sections (more than 3 apartments) in residential areas of Baku. In 5-storeyed building the optimum length corresponds with 4-6 sections, in 9-storey-3 sections.

Buildings length shortening essentially reduces summer overheating, balances microclimate contrast in leeward and wardside sites. In this connection during building stage of abrupt slopes in Baku more favorable microclimate, applying either 4-5-storeyed buildings with orientation restriction and well differentiation of leeward and wardside in functional territory zoning of block or microdistrict can be received.

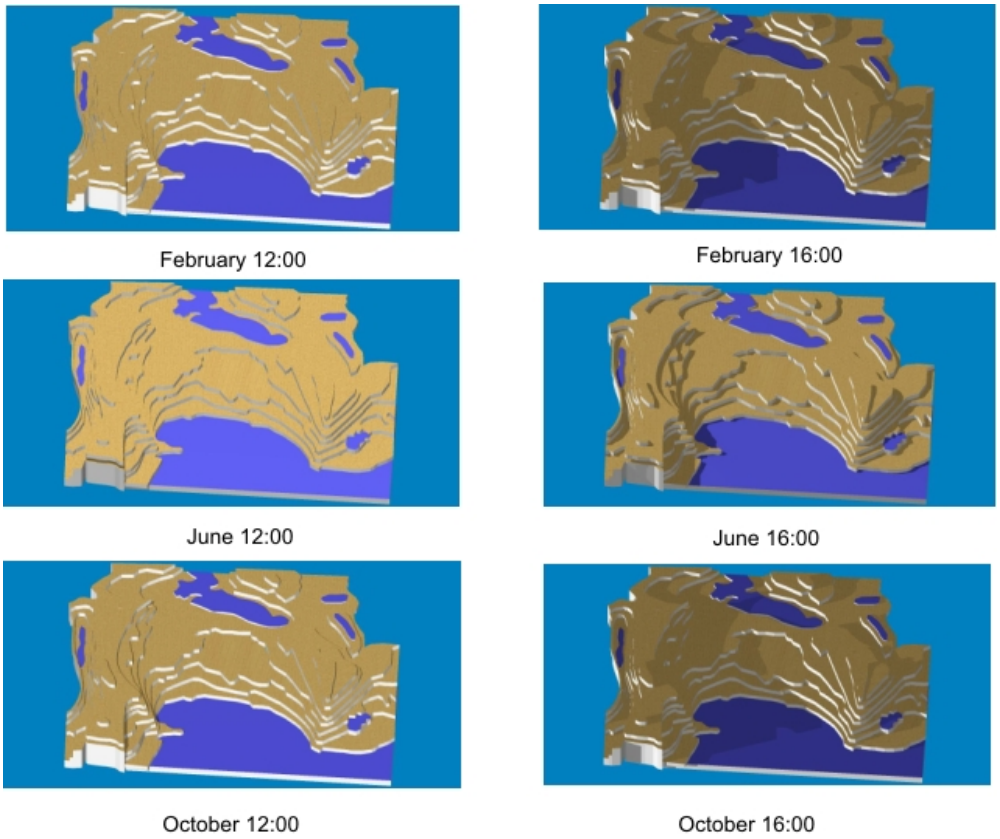

Fig. 4 Insolation of Baku amphitheatre slopes in calculation period 22 February-22 October.

Building type also has a great impact. The author has simulated insolation pattern of various types of Baku residential areas: line (3 microdistrict), regular (7 microdistrict, Ahmedli sett.), gridiron (Mammadyarov sett.), low-rise carpet with inclusion of high-rise buildings (on H.Javid pros.), ribbon, compact with a various configuration of quarters (meridian-on the Fountains square, latitudinal–area of Nizami and H.Hajiyev strs.). Construction of insolation models was made for 12:00 and 16:00 o'clock in the afternoon. As a result of modeling it has been noted that the greatest shadow is created by ribbon quarters with compact planning of meridian directions with narrow streets between them (Fig. 5).

The analysis of simulation of various building type (linear, quarter, etc.) territories insolation on an abrupt and flat relief carried out by the author has shown that only the distance between facades of north-south orientation (Fig. 6) has determining value. However from Baku aeration mode, building functional purpose and insolation point of view, the most favourable building orientation is the west-east direction. Therefore, in conditions of Baku residential structures are advisable to project as closed or semi-closed complexes with different numbers of storeys and shifting of flanks.

The optimum orientation of Absheron and Baku houses is towards the sea, and also to the east, north-east and south. In conditions of Baku during planning of residential areas the great role, except building orientation, plays an internal apartment planning and availability of summer premises. In this way rooms should be supported through or angular aeration. Buildings should be compact and massive. Compactness of buildings was traditionally shown in courtyard availability which served as cooling pond. Heavy building materials allowed balancing an external and internal climate temperature. The main features of similar architecture are inherent in many Islamic cities.

Characteristic features of Baku architecture are also balconies, loggias, terraces, verandahs which are called to play a role of summer premises during summer period. However, 1.2-1.8 m width balconies used in modern construction, are not full-fledged summer premises. In spite of the sufficient area of balconies and loggias (20% from a total apartment area), they are inconvenient in exploration because of insufficient width, lack of visual isolation, etc. [14]. Free standing balconies are served mainly as sun protection shades and also for storage of household things. Loggias essentially do not differ from balconies and have the same imperfections.

In conditions of hot Baku climate it is necessary to use a green planting for solar radiation protection. planes, elms, maples are the most suitable deciduous largeness trees for their planting close to buildings, in the gardens and parks.

2.3 Thermal-Humidity Regime of Residential Structures

One of the components of the city ecology is temperature-humidity conditions of Baku residential areas. An air temperature and humidity and surfaces temperature are the main parameters defining a comfortable human state.

On long-term observations data the annual average air temperature in Baku makes 14.4°C. In spite of great wind speed air temperature in January is +3.8°C, whereas in July-August (annual average is 25.7-25.6°C) it often rises up to + 40°C.

Macro-and local (radiation conditions, wind regime, form meso-and microrelief, soils, building, etc.) climatoforming factors influence on thermal regime of Baku building [2, 24]. Owing to their impact the temperature difference comes up to 1-1.5°C in different districts of the city. For example, in July monthly average temperature in Azerbaijan Economic University court yard is higher in comparison with Bailovo settlement on 0.8°C. Approximately the same difference exists between the city centre and H.Javid

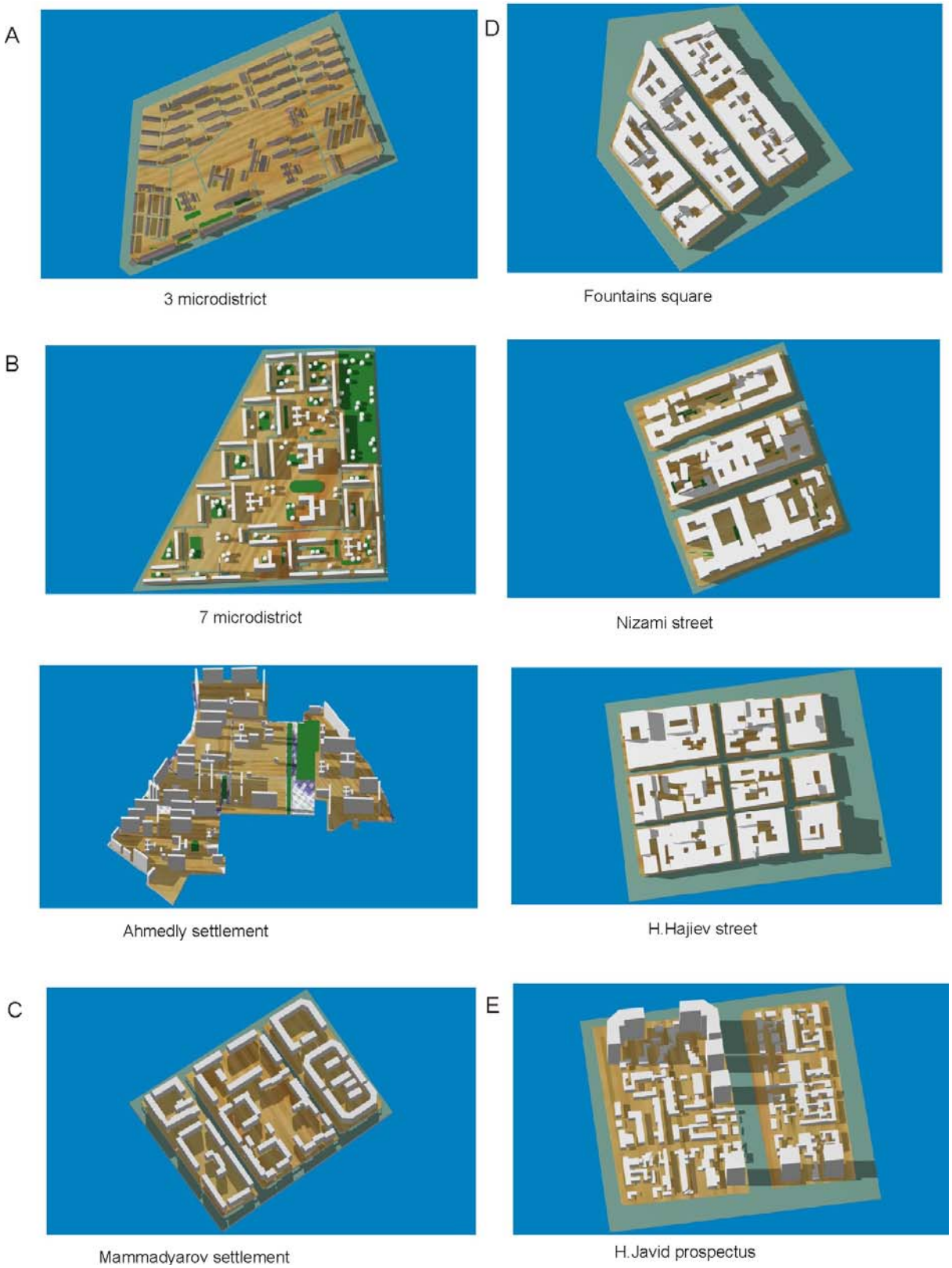

Fig. 5 3-D modelling of insolation pattern of various types of Baku apartment blocks: A-line; B-regular; C-block; D-ribbon, compact with various configuration of quarters (meridian, latitudinal, and square); E-low-rise carpet with inclusion of high-rise buildings.

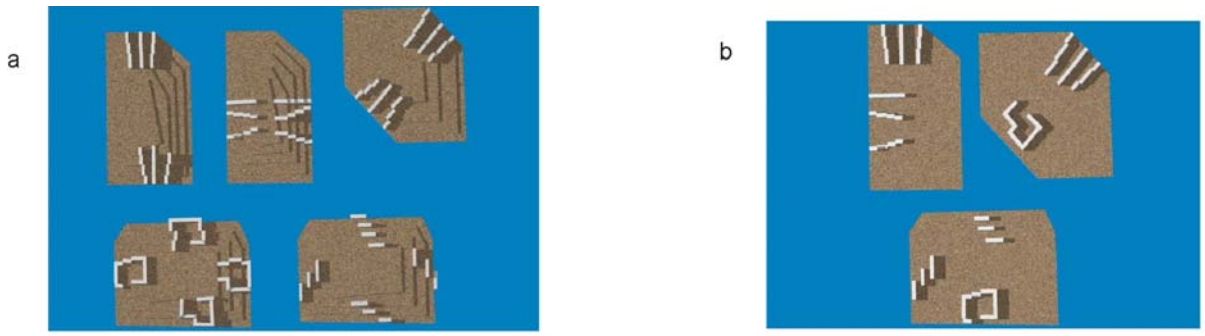

Fig. 6 Construction on abrupt slopes in hot climate condition. Shadow zones of various building types: a- on abrupt relief (on wardside and leeward slopes).

prospectus [7]. It partly occurs because a various temperature regime is created above different exposed Baku amphitheatre slopes.

The author worked out the scheme of Baku territory zoning on thermal conditions (Fig. 7) on the basis of orographic scheme, Baku territory aeration scheme, and also the meteorological stations data. According to this scheme territories with the highest temperature parameters are located in central (industrial zone) part of the city, and Binagadi district, and territories with lowest temperature parameters are located on high points of the city, and also on windward shade slopes-on southeast and east slopes of Patamdar, Zykh ridges, Yasamal valley, and also northern edge of Baku amphitheater. It is shown on the scheme, the western slopes of Baku amphitheater protect the city central zone from overheating, shading it from sun rays. Besides the northern wind, and also the city location as amphitheater (that allows northern wind to climb down form the city slopes, cooling them) play the certain role in summer temperature reduction.

In spite of poor rainfall (on the average 217 mm during the year, which greatest quantity falls out during the autumn and winter periods), and also high air temperature and strong northern winds, there is high humidity here. The Caspian sea plays the certain role in this situation. Average annual relative air humidity for Baku makes 70% [1]. About 80 days in the year relative air humidity in Baku makes more than 80%. It means that air humidity exceeds optimum levels for a human health.

Air humidity has essential value for characteristic of district climate, and also for estimation climate impact on person, for projecting of protecting designs and support of comfortable microclimate in apartments. Relative humidity in various areas of Baku depends on closeness to the sea, soil and plant cover, rainfall and kind of precipitations, temperature and wind regime of the district, and also grade and exposition of Baku amphitheater slopes. Data comparison of the meteorological stations in territory of Baku show, that relative humidity has the greatest value in the coastal area [7].

In comparison with Bailovo settlement the air relative humidity is lower on 3-8% in the city centre, and lower on 4-10% in N.Narimanov street [1]. Thereby, the relative humidity is lower if you move inside the city from the sea. These data as a whole coincide with the scheme of territory zoning on humidity conditions worked out by the author (Fig. 8). According to the scheme of territory zoning on humidity conditions worked by the author the sites with highest humidity are located in the coastal part of the city, on leeward shadow slopes, and also close to Beyuk-Shor, Haji-hasan, Zykh and Bulbula lakes. The areas with the lowest humidity are located in the central part of the city, on the highest points of the amphitheater, and also on windward city slopes-western slopes of Yasamal valley, Patamdar heights, Zykh ridges.

The widespread modern high-rise buildings erected in the Northwest and East Housing Estates of Baku last

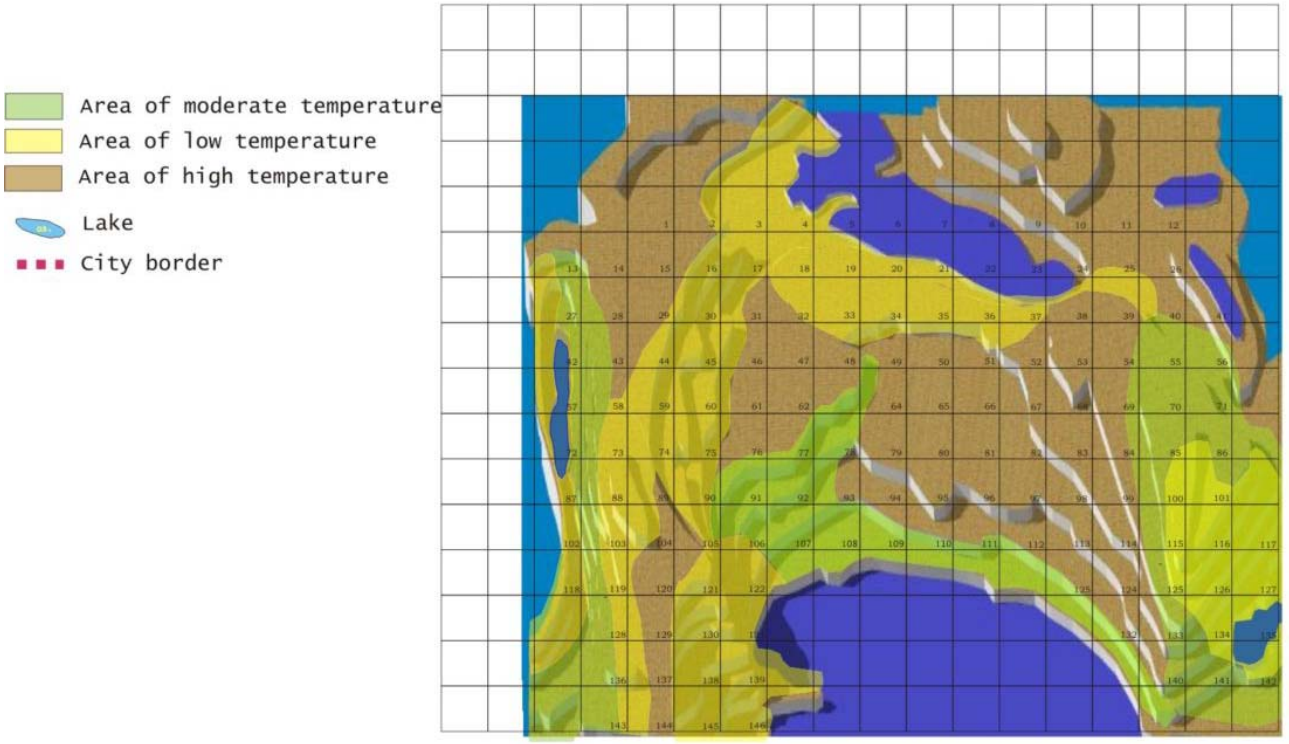

Fig. 7 Zoning of territory of Baku on thermal conditions.

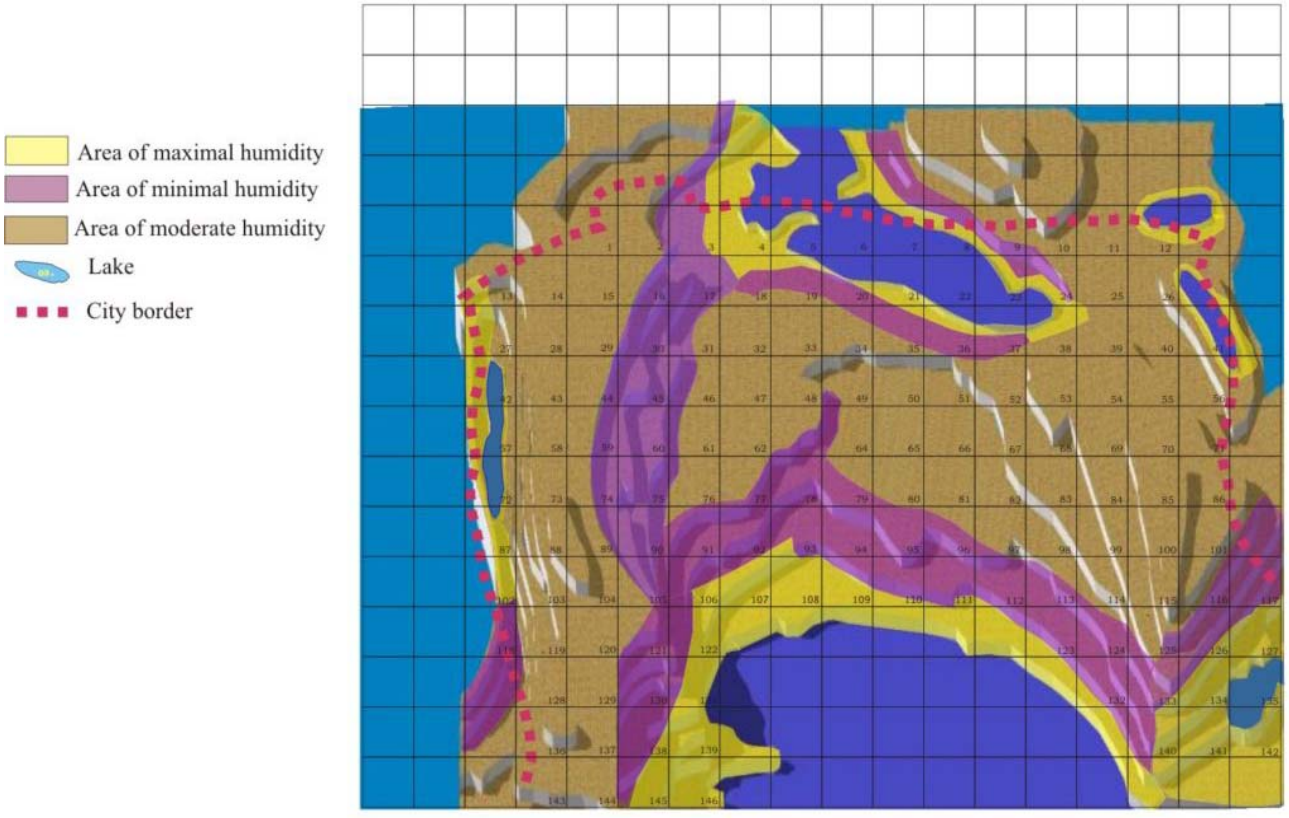

Fig. 8 Zoning of Baku territory on degree of humidity.

year are "concrete boxes" not corresponding with regional climatic conditions and their positive influence on human health is questionable (Figs. 9 and 10). Correct application of construction materials, designing of exposed structures and their shading, natural cooling, passive solar heating and accurate use of predominating winds for ventilation-the important elements of comfortable microclimate support in Baku housing estates and creation of sustainable residential structures.

It is known that the territory and apartment building planning with good aeration and insolation is the most effective methods of humidity control. However in a hot Baku climate it is necessary to protect buildings and territory from overheating and insolation. From this position it is necessary to draw attention to traditional methods of climate mitigation in this zone. The narrow deflected side street of medieval Ichery Sheher on the one hand shade the streets and drop a temperature in them, on the other hand change the wind speed, but do not interfere with the ventilation and insolation (Fig. 10). However, narrow, deflected streets will promote creation the traffic jams and congestions on the roads in modern cities and this method is inadmissible for Baku. In this case wide arterial roads and open spaces with suitable gardening can at the same time play a role of wind-shelter and shading structures. From this point of view wide main Baku streets in north-south direction paved after 1920 year, (Azadlig, Samed Vurgun prospectus, etc.) should be maximum planted by deciduous trees. The passages, arcades, canopies arrangement will promote free people movement in hot summer day.

High thermal conditions of Baku set the problem of overheating protection in summer period [18], but on the other hand, they create an opportunity of long stay on the open air during the warm time constituting about 6 months. Centuries-old experience of national housing construction has chosen local sustainable types of dwelling with various types of summer devices, combinations of open courtyard spaces with semi-exposed balcony spaces and closed living rooms

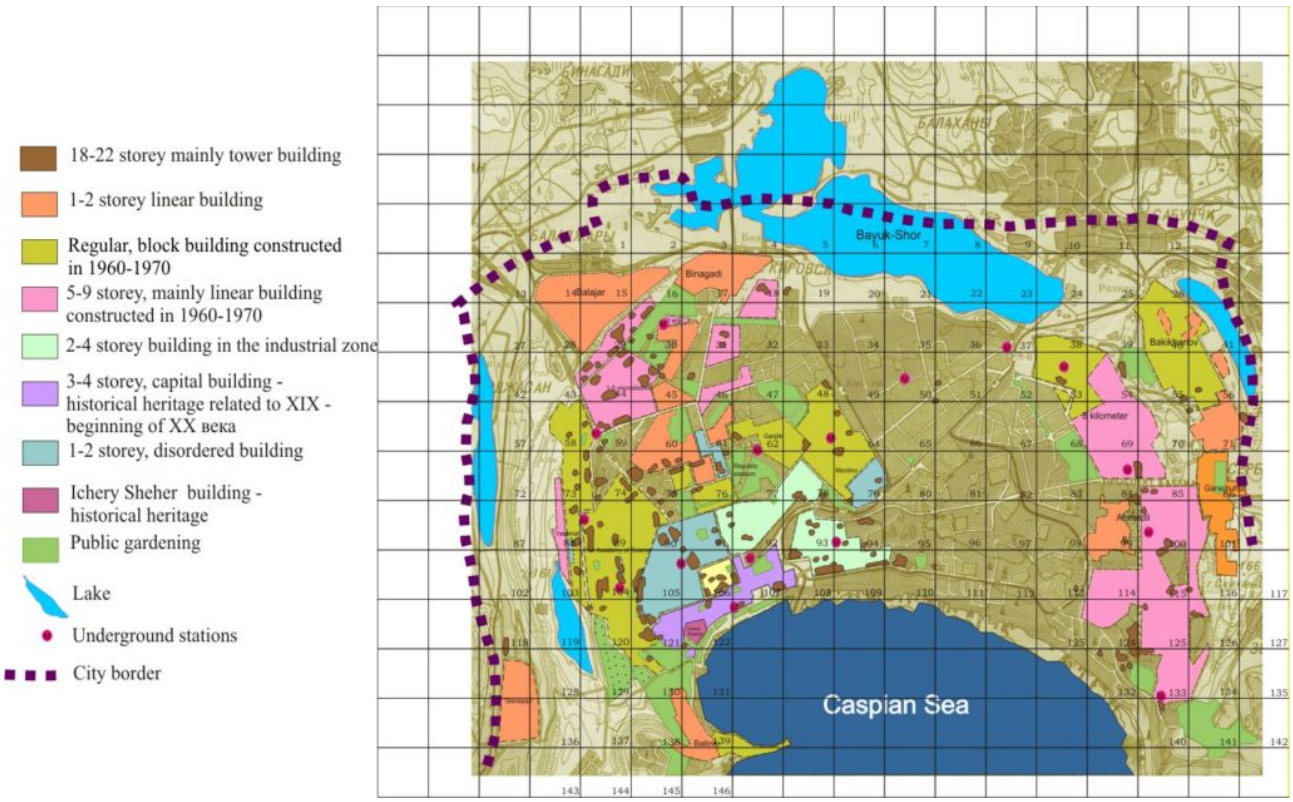

Fig. 9 Zoning of Baku territory on basic building type.

Fig. 10 Residential construction of Baku: A-modelling of existing construction on a relief; B-space shooting of city blocks.

[14]. From this point of view traditional city type dwellings of Baku (aul building in Nagornaya and N.Narimanova streets) with individual courtyards as the natural "conditioners" cooling inner rooms on 3°C are very interesting. Unfortunately, today this kind of dwellings is mercilessly pursued from investors. Similar building is unprofitable and is replaced by another faceless and not acclimatized to Baku high-rise buildings.

In conditions of a hot humidity Baku climate it is

necessary to adhere to the basic concepts of the traditional architecture, formed under the natural factors influence-closed, compactness, the importance of a blank wall in external building shape. Compact closed and semi-closed massive structures provide wind-shield of the building in winter, aeration and sun-protection of residential structures during the summer. A difference of day time and night temperatures should be balanced by heavy or composite construction materials with the big specific heat. At Baku residential structures planning the ventilation should be adjustable to protect from cold winter air and effectively to cool premises during the summer. The high summer temperature and cold winter winds dictates reduction of window apertures sizes whereas the humidity requires to enlarge their, to provide the maximal ventilation and air mobility in the rooms. That is why it is recommended to apply an average window apertures sizes with adjustable shading and sun-protection covering.

It is necessary to use the traditional Baku architecture experience for working out of interesting planning offers in Baku conditions. So, terrace-like buildings of the old city, using of flat roofs for a night dream, make possible to create the modern multistory stepped houses-cottages with court yards on the roofs of lower floors, to place the expanded summer premises in breaks between apartments. It is important to express also the regional features in modern housing architecture of Baku in various interpretations: from direct traditional forms iteration up to absolutely new forms executed in modern constructions and materials. The arch roof being very popular practically in all East countries owing to the unique and viable design can play the considerable role in it. Because of the raised blocks it always creates airflows that reduce a heat which the roof has collected [15].

One of the methods promoting reduction of dwelling heating and cooling expenses by reduction of a temperature range between an external and inner microclimate is use of thermal transitions in Baku residential construction at all stages of its forming. So, it is observed the following hierarchical space rising in Baku central zone dwelling structures relating to XIX-beginning of XX centuries (aul building in N. Narimanova street): street–blind alley–courtyard-gallery-an apartment. This multistage hierarchy of the spatial organization has been founded in medieval Ichery Sheher planning structure: street–side street–blind alley-courtyard-gallery-room. At construction of modern multistory buildings it is expedient to stick to the following space hierarchy: street-a court yard-garden-external structural elements (entrances, verandahs, etc.)-inner structural elements (tambours, etc.)-premises. Thermal transitions also promote fast acclimatization to temperature changes at transition from 38°C up to 23°C and to reduction of negative decompression impact on human body.

Low-rise compact building with courtyard widespread in Baku outlying districts is as convenient in a hot climate today as many centuries ago in the afternoon the family gets together in the shady cool rooms, and at night when it is stuffy in the rooms, people has a rest on the open air in the court yard protected from somebody's eyes.

In conditions of Baku at enclosure materials choice and their thickness it is necessary to focus attention on their physical properties which should be agreed with local climatic factors [20]. To reduce heat transfer from one wall side to another, the heat conductivity factor should be reduced by one of two ways: wall thickness increase or using of materials with lower heat conductivity and higher resistance. Almost all people in hot regions used the first method in ancient times. They built massive dirt or masonry walls. In modern town-planning use the second method–the walls are made from composite materials for providing of necessary thermal and aesthetic characteristics. Isolation reduces heat conductivity.

The ferroconcrete invention opened a new era in which traditional architectural forms and methods, and also construction materials have been forgotten very

soon. However, together with ease and speed of construction works, concrete has brought many problems from the point of view of comfortable microclimatic conditions creation. Ready concrete structures are inadmissible in conditions both hot and a cold climate as have small thermal resistance. Nevertheless, today the basic multistory buildings in Baku are constructed from concrete (external walling), and thus there are practically not used heat insulating, moisture-proofing and vapor sealing materials for external walls that leads to great energy consumption of buildings, and also to formation of a unhealthy microclimate. Besides at concrete preparation the technological processes are very often broken that leads to concrete strength retrogression, pore structures degradation, life reduction and etc..

Correct projecting and construction of Baku residential buildings external walls in the areas with the greatest humidity (the city coastal part, areas around the lakes) assist to reduce the risk and make their more stable to humidity. In this case the condensation control strategies include: air leak control, adequate thermal isolation using, cold patch minimization, and water vapor propagation control [12, 16, 22].

It is necessary to use composite materials in external walling, to make the most out of gardening as in building decoration (gardening of facades, balconies, roofs and terraces), and in the courtyard and city territories planning. Use of fountains, artificial pools and reservoirs in the city structure also promotes cooling of adjoining territories.

3. Typological Zoning of Baku Residential Areas on a Complex of Climatic Factors

For creation of comfortable living conditions both in the territory and apartment, sustainable development providing in Baku residential structures and an ecological situation improvement in them, it is necessary to carry out a complex microclimatic zoning of the city territory on climatic factors considered above for differentiated approach to the problem of urban environment rehabilitation. Maximal use of positive climatic factors and alignment of adverse influence as well as reduction of building exploitation costs become a basis for scientific prognostication of building compactness, height, and methods in the typological areas of the city revealed on the basis of the mathematical analysis.

The complex analysis results of the city territory climatic situation become a basis for revealing of typological areas in investigated territory and detecting of dwelling areas construction methods according to characteristics of each of them.

The territory of Baku has been divided into 146 equal sites. 7 basic parameters have been selected for the sites describing: territory relief, radiation mode, wind mode, temperature regime, humidity regime, gardening and building types coded in binary system: the presence of an attribute-1, the absence-0. In turn these parameters are characterized by 28 features.

For typological zoning of Baku territory the author applied the multidimentional statistical method-cluster-analysis, as this method previously was successfully applied in many fields of a science including town-planning [3, 5, 9, 11, 23]. In this case Euclidean distance is used as a coupling measure between object pairs [5]. As a result of the calculation these 146 sites is divided into 5 typological areas (Fig. 11). The brief characteristic and the general recommendations on transformation are worked out by the author for each of these typological units (Table 2).

The analysis of results of Baku territory zoning on a complex of climatic factors has allowed to conclude that construction on Baku amphitheatre slopes will demand more responsible approach with the view of visual communications to surrounding areas, and also for wind-shield in winter and sun-protection in summer. In a coastal area the greatest problem becomes protection against humidity by the organization of normal airing. Sun-protection is the most actual basically in former industrial area Baku (areas from Beyuk-Shor lake to the city coastal zone). The city

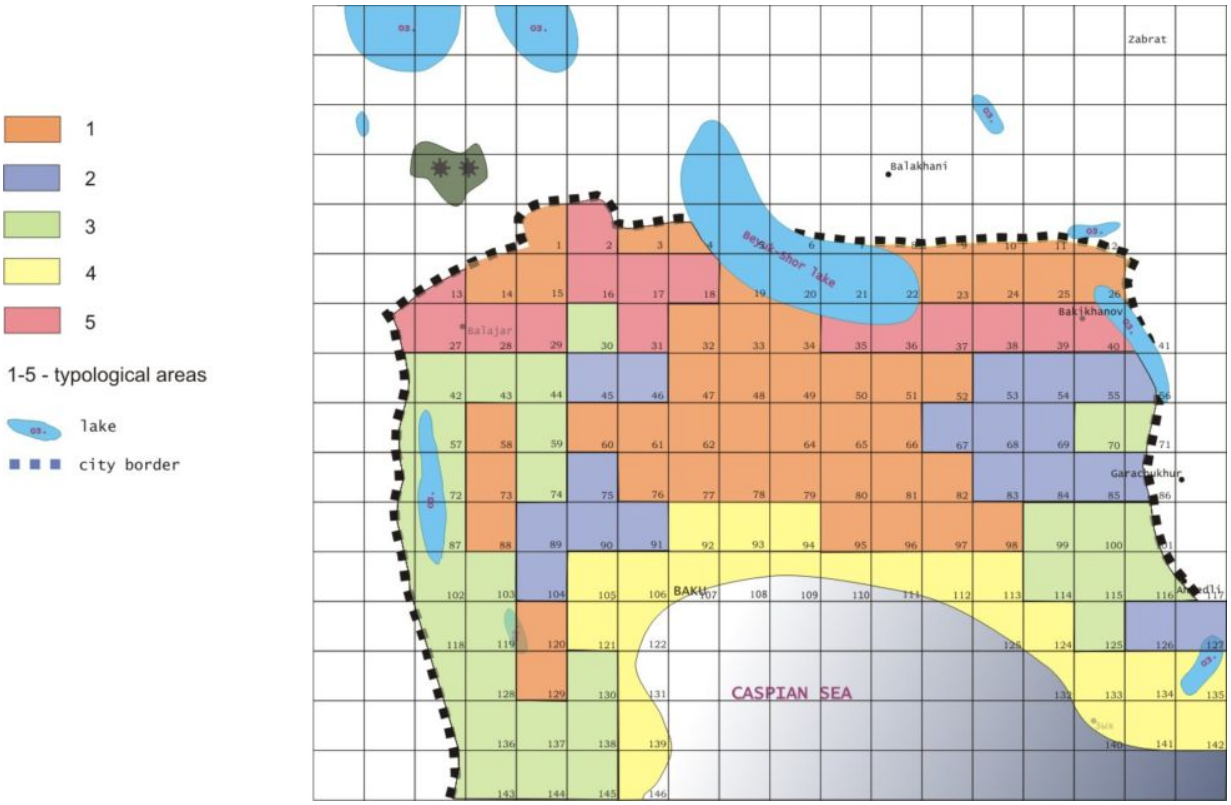

Fig. 11 Zoning of Baku territory on a complex of climatic conditions.

Table 2 The brief characteristic and recommendations on transformation of Baku typological areas on a complex of climatic factors.

Area number	The brief characteristic of typological area	Territory of spreading	The brief characteristic and recommendations on transformation of typological units
1	2	3	4
1	It is characterized by flat relief (gradient up to 10%), located on 2 and 3th terraces, with moderate, sometimes maximal humidity, high air temperature, in some places minimal and high wind speed, unshaded territory, small gardening, with various building types (high-rise, 1-2 storey low-rise, 4-5 storey regular quarter, 1-2 storey disordered)	It occupies vast territory from Bejuk-Shor lake up to the coastal part-all industrial zones of Baku, and also areas of Baladjar and Sabunchi and narrow vertical sites below Hojasan lake (at Shubany mountain) and in Nagorno park territory	Buildings of average number of storeys (5-8storey), gradual rise of building heights to north. It is necessary to carry out the wind-shelter measures in the northern part. It is prohibited to construct high-rise lengthy buildings in latitudinal direction (they create barriers for sea breezes) in the coastal part (the bottom terrace). It is recommended to construct compact 3-5 storey residential structures with courtyards for protection from wind and sun rays. The courtyard size is limited on the one hand by insolation, fire-prevention and sanitary-and-hygienic, on the other hand-by aerodynamic characteristics. The maximal disclosing of quarter building to the south and minimalto the north. To plant the northern passes by trees for protection against the northern winds. Opposite passes into a court yard should not be in one range. Using of ground floors in the southern part for breezes catching. Flat roofs. On the top terraces it is not provide a green planting close to linear multisection buildings shorter sides and tower type buildings. To use various types of laced windscreen from plants, stones, vertical green screens in the court yard. To cover dusty territories by hard surface and planting. Double-sided apartment orientation for providing of aeration and protection from overheat. High-rise buildings (18-22 storey) is not recommended as ordinary building. The small width of meridional quarters will promote rapid courtyard shading. The ideal street direction is northeast-a southeast. It is necessary to plant courtyard spaces by plane trees, elms, maples, etc. for their shading. It is necessary the presence of summer premises, application of constructive and technical sun-protection devices (antidazzling devices, canopies, jalousies, etc.). Average size window apertures with shading control. Application of passive solar architecture methods. Using of heat insulating, moisture-proofing and vapor sealing materials at construction of low-rise and especially high-rise residential buildings.

(to be continued)

2	Relief gradient is 20-30%), located on 2 and 3th terraces, basically moderate and maximal humidity, high average air temperature, average wind speed, 50% and more shaded territory, small gardening, various building types (high-rise, 1-2-storey low-rise, regular quarter)	It includes territory of Garachuhur settlement and reaches up to Bakikhanov settlement, and also cover Basin, N.Narimanov streets, and territory of 1-5 microdistricts	Terraced building accented relief forms, with increase building heights to the amphitheatre edges where it is necessary to provide special wind-shelter measures from northern and northwest winds. High-rise building systems placing on the relief contraflexure. 5-9 storey compact quarter building (on 2th terrace) and 7-12 storey terrace carpet building (on 3 terrace). It is necessary to construct up to 5-storey buildings on the windward slopes of the amphitheatre. The maximal disclosing to the south and minimal opening to the north (not in one range). To plant the northern passes by trees for protection against the northern winds. Opposite passes into a court yard should not be in one range. Using of ground floors in the southern part for breezes catching. Flat roofs. The building heights difference should be small in a quarter. On the top terraces it is not provide a green planting close to linear multisection buildings shorter sides and tower type buildings. To use various types of laced windscreen from plants, stones (30% lace), vertical green screens in the court yard. High-rise buildings (18-22 storey) is not recommended as ordinary building. Compact residential structures for protection from wind and sun rays. Providing of angular or direct airing. Small length buildings. It is necessary the presence of summer premises. Application of constructive and technical sun-protection devices (antidazzling devices, canopies, jalousies, etc.). East and western building facades protection by special shading devices. Using of heat insulating materials and heat-resisting glasses. Average size window apertures with shading control. Application of passive solar architecture elements at construction of Bakikhanov and Garachuhur settlements residential areas by 1-2 storey residential structures with courtyard. Using of local building materials (limestone, etc.) in low-rise construction and composite materials in high-rise buildings. Application of moisture-proofing and vapor sealing materials at residential buildings construction. An intensification of construction due to rising of number of storeys up to 5-7 floors.
3	Relief gradient is more than 30%, placed on 3th terrace, partially on 2th one, various humidity-from the minimal up to moderatel, various air temperature-from low up to high, basically average and in some areas maximal wind speed, minimal shading, basically small or lack of gardening, various building types: high-rise, 1-2 storey low-rise, regular quarter, 5-9 storey linear	It covers Akhmedli settlement territory and also big territory close to Hajihasan lake, Yasamal and Patamdar settlement and partially microdistricts territory	Carpet or terraced building accented relief forms, with increase building heights to the amphitheatre edges where it is necessary to provide special wind-shelter measures from northern and northwest winds. High-rise building systems placing on the relief contraflexure. Application of special measures of the residential construction functional organization. It is necessary to place the specially worked out residential complexes at hill tops and windward slopes, and also narrow parts of valleys. It is also necessary to apply specially developed residential structures for leeward slopes. It is necessary to create wind-shelter gardening perpendicularly to wind stream on the abrupt windward slopes (Yasamal, Patamdar, Zykh settlements). Compact low-rise structures for protection from strong winds, maximal disclosing to south winds for normal airing. Active use of gardening for sun-protection, wind-shield and humidity control. To avoid the high-rise and lengthy buildings-screens. Courtyard structures using. It is necessary to apply 4-5 storey buildings with restricted orientation and clear differentiation of lowlands and uplands for functional territory zoning on amphitheatre slopes. Similar height quarters with shorter facades shifting. Orientation of summer premises to the sea, on the southeast and the east. Using of heat insulating, moisture-proofing and vapor sealing materials. Staircases and entrances should be isolated from influence of strong northern winds and solar rays (tambours, vestibules). Application of passive solar architecture methods will assist to save electricity. To use antidazzling devices, eaves, canopies for protection from overheating.
4	Relief gradient is up to 10% and more than 30%, located on 1th terrace, the maximal and moderatehumidity, various air temperature-from low up to high, average, in some places minimal wind speed, shading and gardening varies	It occupies Baku coastal territory from Bailovo settlement up to Zykh settlement, from Beyuk-Shor lake up to railway station (industrial zone-Black	Preservation of town-planning structure and the basic part of the buildings in the city coastal area. New construction: compact 3-5 storey perimeter building not higher than existing building, it is possible to use tower dominants in meridional direction. It is prohibited to construct high-rise lengthy buildings in latitudinal direction (they create barriers for sea breezes) in Bailovo and Zykh settlements. The maximal disclosing of quarter building to the south and minimal-to the north. Construction by 3-4 storey terraced buildings, gradually rising of building heights on the slopes. Application of special measures residential construction functional organization and use of special apartment types buildings adapted for housing on abrupt leeward slopes. Flat roofs gardening for catching sea breezes. Re-organization, modernization and reconstruction of existing building. Prohibition of high-rise construction not fitting into the city architectural-planning structure. Use of green planting, pavilions, covered passages, canopies, etc. for overheating

	from small up to considerable, various building types: high-rise, 5-9 storey linear, 2-4 storey in the industrial areas, 3-4 storey architecture monuments, Ichery Sheher building	city)	prevention of court yards, streets, open spaces. The ideal building orientation is the south, southeast and the east. Providing of angular or direct airing. It is necessary the presence of summer premises, application of external sun-protection. Thus the distance between buildings should regulate by insolation and aeration norms. Big and average size window apertures with shading control and sun-protection devices. Use of ventilation methods in low-rise and high-rise construction. Using of heat insulating, moisture-proofing materials, mobile isolation, composite materials in construction. Application of basements and open planning structures.
5	Relief gradient is up to 10%, placed on 3th terrace, variouse humidity–from moderate up to maximal, basically high and low air temperature, high and average wind speed shading and gardening lack. Various building types-high-rise, 1-2 storey, low-rise, regular quarter, 5-9 storey linear	Small territories in the northern part of Baku amphitheater-in Balajar settlement, and on the western and the eastern sides of Beyuk-Shor lake	9-12 storey compact terraced quarter buildings on the edges. It is necessary to carry out the wind-shelter gardening in latitudinal direction protecting from northern and northwest winds. Gradual decrease of building heights to the sea. It is preferable to use of special kind of buildings for windward slopes application. It is necessary to construct up to 5-storey buildings on the windward slopes of the amphitheatre. There are not desirable to use the open ground floors, arches in the building northern part. Small quarters. It is not provide a green planting close to linear multisection buildings shorter sides and tower type buildings. To use various types of laced windscreen from plants and stones (30% lace), vertical green screens in the court yard. To cover dusty territories by hard surface and planting. Creation of a special kinds of strengthening plantings on windward slopes (Balajar slope and etc). Compact residential structures for protection from wind and sun rays, double-sided apartment orientation for providing of aeration and protection from overheat. Small length buildings. The ideal street and quarters direction is northeast-a southeast. It is necessary to plant courtyard spaces and streets by plane trees, elms, maples, etc. for their shading, wind and humidity control. Orientation of summer premises to the sea, on the southeast and the east. Use of gallery type houses. Closed and semi-closed perimeter complexes with the same height and shorter facades shifting. Low-rise houses should be compact and massive with a courtyard, application of heat insulating, moisture-proofing and vapor sealing materials is recommended. Use of thermal transitions and isolation of entrances from influence of strong northern winds and direct solar rays (tambours, vestibules). Application of passive solar architecture methods. Use of composite materials in high-rise construction. To use antidazzling devices, eaves, canopies for protection from overheating.

northern edges demand special attention for their protection from northern and northwest winds by compact building and wind-shelter gardening.

4. Conclusions

The climatic component of Baku urban ecosystem consists of several factors (aeration, insolation and thermal-humidity regimes) which purposes can contradict each other. Therefore the main problem at the residential structures planning is not optimum strategy search, but search of suitable strategy of city environment improvement in the given conditions, allowing to consider the separate climate subsystems purposes and to provide the complex rehabilitation of an environment as a whole. For this purpose the author has applied the multidimentional statistical method-cluster analysis therefore the territory of Baku has been divided into typological units with related characteristics. The author had been worked out the recommendations for reorganization of these typological units.

References

[1] V. Y. Akhundov, K. F. Akhundov, R. O. Amirov and I. M. Seyidov et al., Baku by 2000: Hygienic Aspects of Environment, Azerbaijan State Publishing House, Baku, 1981, p. 178.

[2] L. N. Avdotyin, I. G. Lezhava and I. M. Smolyar, Town-Planning Projecting, Stroyizdat, Moscow, 1989, p. 432.

[3] Sh. Babayeva, Typological zoning of Baku central zoning by application of mathematical methods, Journal of Bilgi 3 (2000).

[4] B. A. Budagov and G. B. Aliyev, Geography of Azerbaijan SSR, Maarif Publishing, Baku, 1983, p. 156.

[5] B. Duran and P. Odell, Cluster Analysis, Statistics, 1977, p. 128.

[6] R. M. Efendyzadeh, Architecture of Soviet Azerbaijan, Stroyizdat, Moscow, 1986, p. 319.

[7] A. J. Eyubov, Climate of Baku, Azerbaijan State Publishing House, Baku, 1999, p. 103.

[8] M. A. Gostintseva, Town-planning maneuverability of buildings and sections according to insolation conditions, in: Improvement of City Environment, CSRPI of Town-Planning, Moscow, 1973, pp. 109-113.

[9] Sh. Kahramanova, Geo-ecological Situation of Baku in Conditions of Intensive Construction of Residential Areas, El-Alliance Publishing Co. Baku, 2006, p. 133.

[10] Sh. Kahramanova, Climatized Residential Structures in Conditions of Baku, El-Alliance Publishing Co., Baku, 2008, p. 207.

[11] Sh. Kahramanova, Typological zoning of the central zone of Baku for preservation of historical heritage in modern conditions, in: Proceedings of EURA/UAA International Conference "City Futures in a Globalising World", Madrid, Spain, 4-6 June, 2009.

[12] American Hotel and Motel Association, Mold and Mildew in Hotels and Motels, 1990.

[13] A. N. Novruzy, Architecture and a wind, Journal of Architecture of USSR 12 (1989) 31-32.

[14] A. N. Novruzy, Formation of architectural-planning structures of house in conditions of a hot climate and active wind activity (on the example of Absheron), in: The Abstract of Candidate Dissertations, Moscow, 1981, p. 20.

[15] I. Pedram and Z. Hussein, Wind catchers: The cooling systems in traditional iranian architecture, The Circle of Ancient Iranian Studies (CAIS), 2006.

[16] National Concrete Masonry Association, Residential Concrete Masonry Basement Walls, TR 134, 1994.

[17] F. L. Serebrovsky, Aeration of Settlements, Stroyizdat, Moscow, 1985, p. 172.

[18] SN&R 2.01.01-89, Building climatology and geophysics, State Committee of USSR on Construction, 1990, p. 136.

[19] SN&R-1180-74, Providing an Insolation of Residential and Public Buildings and Territories of Cities and Other Settlements, Ministry of Health Publishing, Moscow, 1974, p. 43.

[20] SN&RII-3-96, Building heating technology, Construction Ministry of Russia, Stroyizdat, 1996, p. 44.

[21] Y. A. Tabunschikov and N. V. Shilkin, Aerodynamics of tower buildings, Journal of ABOK 8 (2004) 12-24.

[22] National Concrete Masonry Association, Thermal Bridges in Wall Construction, TEK 6-13A, 1996.

[23] V. S. Tikunov, Modelling in Cartography, Moscow State University Publishing, Moscow, 1997, p. 405.

[24] Z. N. Yargina, J. V. Kositsky, V.V. Vladimirov and A. E. Gutnov et al., The Bases of Town-Planning Theory, Stroyizdat, 1986, p. 326.