

Architectural and Compositional Concepts of Environmentally Safe Urban Arrangement

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Abstract The architectural and composition concepts of the environment arrangement play an important role in environmentally safe urban formation. In the modern era, there are some actual environmental problems in many of world's great metropolises. The aim of the study is to identify the existing environmental problems on the example of the city of Almaty and to make conceptual proposals for solving these problems. The article deals with the problems of architectural and compositional methods of solving environmental problems associated with the natural and climatic features of the urban environment. Also, the problems of insolation of residential houses and yard spaces that have appeared as a result of new high-altitude facilities construction close existing buildings are considered. In the study of this problem, the experimental method of the architectural and composition solutions study is proposed. As a result of the study, design models and theoretical concepts are proposed for the reconstruction of existing urban spaces, taking into account environmental safety and natural and climatic features that form the identity of the urban environment. The key conclusion of the study is the expansion of conceptual methods of conducting research activities in educational programs in the training of architects and designers. The main goal of conceptual methods should be: mindset formation and professional training of designers from the standpoint of moderators of human behavior in space. The

mindset and professional education of designers is a driving force in solving problems related to improving the quality of life of people in an urban environment.

Keywords Ecology, Architecture, Safety, Urban Environment, Composition, Space

1. Introduction

The environmental safety is one of principal markers for comfortable environment and high quality of people living in cities. Investigation of the issue on ecological problems and ways of their solution are of multifaceted pattern. Review and study of research works have enabled to determine the following trends. In the opinion of Polish researchers, the landscape reflects all the changes that occur in individual elements of the environment as a result of urban development. Knowledge of the dynamics and magnitude of these transformations can improve environmental design and technology [1]. "The principle of visibility to others" is based on the findings of Jacobs, Newman, and White [2,3,4]. He argues that people feel safer in cities when they are not isolated from contact with a larger urban space. The possibility to be seen allows observation by others who can neutralize or help in

threatening situations. This principle is related to Appleton's principle, the concept of a refuge, where the wider public sphere functions as an effective refuge from real and perceived dangers. In this aspect, the ecology of human behavior and the study of spatial methods as a tool for preventing criminal and antisocial behavior in a residential environment are noted, the main goal of which is to reduce crime, delinquency and vandalism in the residential environment with the help of an architectural organization.

Social design is considered as a specific scenario for the development of a comfortable, environmentally safe urban environment. A new natural habitat is being created, smoothly shaping the modern world view and world perception [5,6,7]. The importance of studying the influence of the surrounding urban space on people, regulation of the level of comfortable living by analyzing the ecological state of the environment and the quality of buildings being erected is substantiated. The role of culture as a source of modern environmental education and the place of environmental education in the culture of modern society are considered. The perspectives of a cultural approach to ecological education of youth are formulated [8]. The interaction of literature and science, as well as public participation, can contribute to a broader and more comprehensive understanding of the importance of environmental literature as a means of raising awareness about climate [9].

In connection with the tasks of this research in hand, the analysis of current ecological problems of the largest city of Kazakhstan – Almaty is held. Everyday observations and living in this environment allowed to form several basic problems associated with the ecological state of the city. For instance, urban streets flooding in period of *spring snow melting in mountain peaks*, a heavy rainfall, have been submitted for studying the states of such irrigation systems as - Malaya Almatinka, Bolshaya Almatinka river, irrigation ditches (aryks) flowing in the city. Transport facilities expansion has become the basic reason of the air pollution in the city. Active construction of high-rise residential and public buildings close houses in post-Soviet period have resulted in researching the insolation of yard spaces and premises inside of existing buildings. Considering that the specified parts of residential facilities of Almaty city comprise the buildings erected in the post-Soviet period, in this piece of work are analyzed the quality of emotional comfort of districts. In the city, there is the trend that the most part of rental housing is accounted for the facilities erected in 1992 (before the Republic of Kazakhstan has got its sovereignty). As per information data, the most part of negative statistics concerned with the people's behavior occur in these districts. In this connection appears the applicability of architectural and composition solutions for residential facilities erected in the post-Soviet period.

The natural and climatic features of the Almaty city's location have become the main prerequisites for the

emergence of unique irrigation systems in the city. These are irrigation ditches, Malaya Almatinka river and the Big Almaty Canal (hereinafter referred to as the BAC), irrigation ditches (aryks) that are located parallel to urban streets. Picturesque mountains are fraught with a formidable danger of avalanches, mudflows, earthquakes. In the history of Alma-Ata, geological disasters are known that occurred on May 28, 1887 and December 22, 1910 (old style), devastating mudflows in 1921, 1956 and 1973, which significantly influenced the development of architecture and urban planning. City waterways have always created a special atmosphere in the metropolis. Ditches are still unique engineering structures, the historical identity of the city of Almaty. But, in connection with transformation of urban spaces, construction of new facilities and streets led to considerable destruction of the irrigation ditch system. At the present stage, various discussions are being held among architects, urban authorities and public groups about the future life of the irrigation ditches. Many city residents, representatives of public groups, architects are of the opinion that irrigation ditches should be restored while preserving their historical appearance. The uniqueness of the irrigation systems – ditches, also lies in the fact that they are the main irrigation systems for parks, squares, street landscaping in the city of Almaty. Currently, the city of Almaty, like many modern cities, is experiencing air pollution. Active measures are being taken on the part of the city authorities to solve these problems. For example, measures to reduce the number of vehicles in the city. This process has found its manifestation in reconstruction of transport roads with segregation for public transport and private vehicles. Closing of some of the road lines and their transformation to bicycle and pedestrian ones, to some extent, excessive enthusiasm for the construction of bicycle roads leads to destruction of green lawns inside many parks and squares. Nevertheless, the problem of air pollution remains relevant for the city of Almaty. One of the main reasons is violation of the irrigation system, which provided the irrigation function. Currently, the embankment of the BAC Malaya Almatinka river, which flows through the city, has a good landscaped area, taking into account the principles of inclusion and universal design. The architectural and compositional solutions of the BAC and the irrigation ditch system are enriched with a large number of small architectural forms: unique fountains and pools, cast-iron water intake columns, green fences made of elm. All these objects are actively involved in shaping the image of the city and in forming its identity. But, notwithstanding all above mentioned positive changes, the spaces under bridges of Malaya Almatinka and BAC remained non-improved and belong to the space which evokes negative sensations. The urgency of this problem is enhanced with that the route of urban residents when rambling or at running the tracks along the riverside passes through the space under bridges.

At the present stage, in the cities of Kazakhstan, there is

a process of active infill development of a large number of residential buildings and whole new districts. The relevance of this issue is justified by the need to provide housing for the growing population in the city of Almaty. But, in the urban environment, you can see quite a few negative examples, especially with the point introduction of new buildings into the existing urban structure. Within the framework of this study, we will consider an example of a violation of insolation and videoecology of a newly built 16-storey and existing 9-storey residential buildings.

At present in Almaty city the significant part of residential facilities comprise the buildings erected in the post-Soviet period. Mostly this 5-9-storey panel houses, the blind ends of 5-9-storey residential buildings do not find their qualitative application and very often create unfavorable, to some extent criminally dangerous sections of the city. According to the latest statistics from criminology, most crimes committed in the city occur in areas with blind ends of residential buildings. Large city squares are occupied by 9-storey panel houses, urban planning and compositional solutions have a ray-like shape in three directions. In the center of the ray-like shape, *dark wells* are formed to the width of a 9-storey building and to a height equal to a 9-storey building. It should be noted that there are narrow pedestrian walkways between these three 9-storey buildings, which are used by residents of this area. These areas of the district are not illuminated, not asphalted and create criminally dangerous areas of the district, especially at night [10,11,12,13].

2. Methodology

The methodology of this study uses the conceptual method of constructing a spatial body used in previous studies conducted at the Academy (hereinafter KazGASA, Almaty, Kazakhstan). This method has shown methodological efficiency in the study of the compositional aspects of the organization of the urban environment. In the previous study, using a three-dimensional model of the spatial body of open (void) spaces, the building density, architectural and compositional arrangement of residential and public facilities in the districts of Almaty were determined. The authors conducted a sociological survey of city residents, took videos and photographs, carried out field surveys. The main task was to study the imaginative solution of the urban environment and the problems that affect the aesthetic perception of the urban environment. As a result, the authors put forward a number of proposals for the creation of a functional classification of roads; reconstruction of building facades, in some cases the demolition of dilapidated buildings and the construction of new types in their place, as well as the transformation of courtyards and public spaces in accordance with the concept of ecological design [14] (Figure 1).

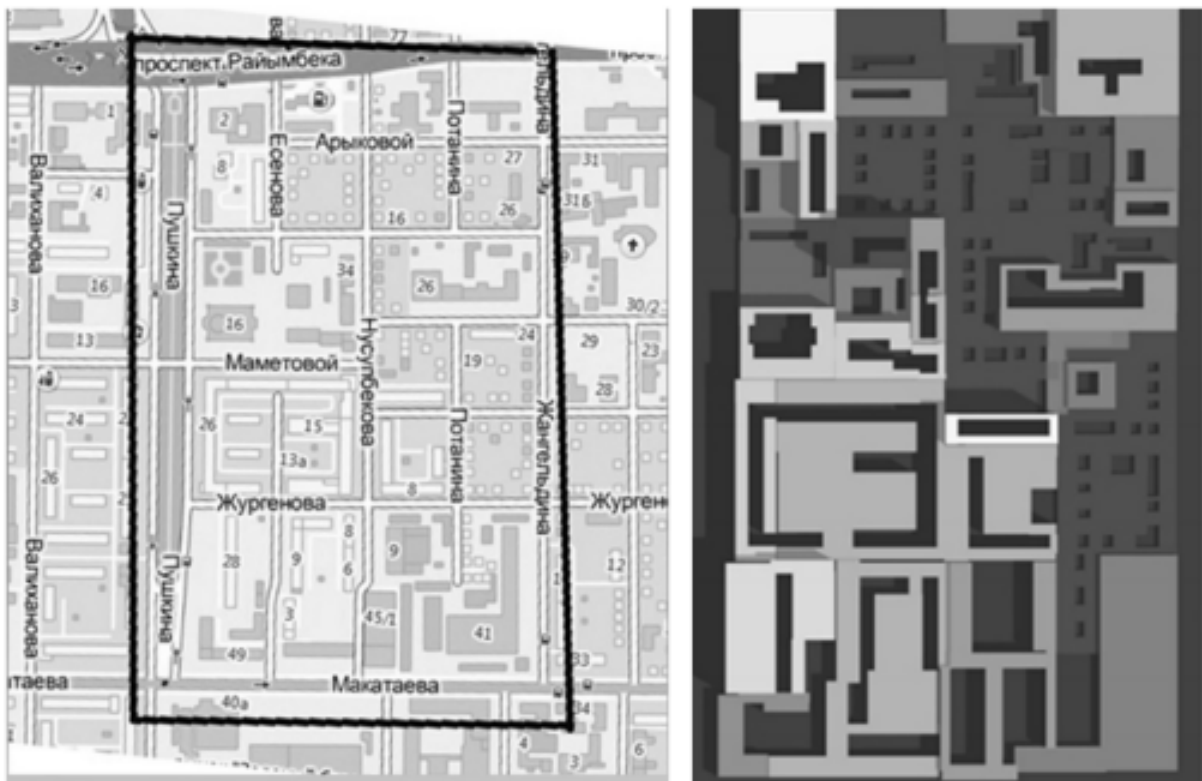


Photo by D. A. Amandykova (D.B. Kabylov, 2017)

Figure 1. An example of using a spatial body of the void space (*experimental method*)

The main characteristics of the methodology of this study is building of three-dimensional models of a spatial body to analyze problems concerned with mudflow danger, residential houses insulation, air pollution, effect of surroundings on human expression of negatively emotional sensations. The principle of building of three-dimensional models of a spatial body is performed in the following way: on the selected map of district (city), there are designated the contours of buildings and borders of void space. The height of the void space is equal to the height of the building around which the spatial body is erecting and the width is limited on the boundary of the studied facility. In this case, a designer immediately receives information on high-altitude correlation of existing context, on configuration of void space areas. In the three-dimensional models of a spatial body researchers may designate negative, unimproved areas of urban environment. As a result, it is possible to get a unique map requiring transformations. By result of the map received researchers conduct on-site studies of areas, perform the photo fixation, if necessary then they carry out measuring works for comparative analysis with data of three-dimension model.

Environmental safety analysis uses the concept – “territoriality”, “natural observability” and “social control”. Developed by American architect Oscar Newman and described in the “Protecting space” book. Material collection and analytical studies also include: field method, study of internet resources, innovative objects, literature sources, photo fixation, to sketch and conduct face-to-face interviews, usage of deductive methodology on development of reconstruction proposals and strategic development.

On basis of current problems photo fixation related to the environmental safety, the district map is analyzed. On the map, the contour of buildings is designated and according to the accepted experimental technique for building of a spatial body of void, the three-dimensional volumes free of buildings of urban area are determined. During the spatial body building with red color are marked the negative areas which do not conform to the environmental safety criteria, as researchers think. As a result, the researchers receive a map with volumetric parameters of negative areas. Further on, to confirm supposals, the researchers hold the on-site studies in order to analyze the locality with the help of visual observation, empirical data, and photo fixation. If necessary, the measuring works, residents’ opinion poll are performed.

On basis of the results obtained, the desk job on transformation of architectural and compositional solutions for three-dimensional models of negative spaces are held. Searches for the architectural and compositional solutions for three-dimensional models may be carried out via computer programs, modelling or by graphical manual sketching.

3. Results

3.1. Analysis of Irrigation Systems Breaches

Studies of environmental problems concerned with natural and climatic conditions are conducted via analysis of the irrigation systems mentioned above. The length of Big Almaty Canal is 168 km, of Malaya Almatinka river is 125 km, and total length of irrigation ditch (aryk) network is 1525 km. Most part of BAC length is located outside of Almaty city. Along the whole length of BAC and Malaya Almatinka, more than 100 bridge facilities are located there, 20 of which are located on the territory of Almaty city. As a result of on-site observations, it is also revealed that under Al-Farabi avenue, the works on development and making comfortable space under the bridge are started. This process points to the positive dynamics for level increase of the riverside comfortability. Thus, 19 out of 20 spaces remain in status of “negative” ones and require the problem solution. As a result of the study there are obtained the three-dimensional models of negative space under the bridge. The three-dimensional configuration of the three-dimensional models is similar, having the difference in the height from 10 to 50 cm. The accepted in Almaty practice of development of the space under the bridge with the help of small architectural forms, in researchers’ opinion, is positive. Within this work, it is proposed to implement these practices in all the rest 19 spaces. By analysis of irrigation ditch (aryk) network, there is also the map of breaches made. Areas designated as negative ones require to attract for this work either practicing architects-designers or students of higher and secondary educational institutions of this specialization. It is necessary to organize competitions and include results of this study in the list of project disciplines subjects (Figure 2).

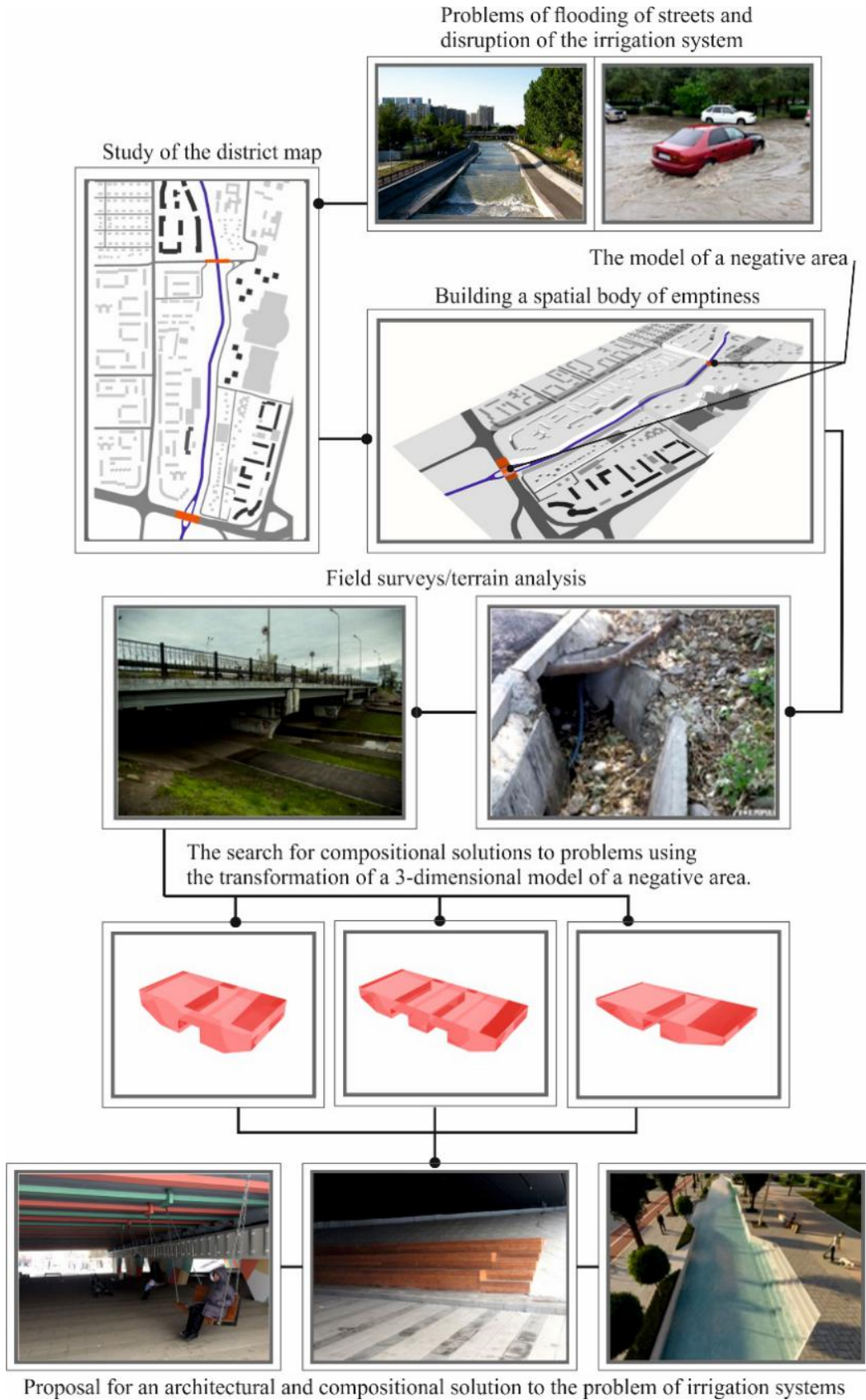


Figure 2. Analysis of violations of irrigation systems

3.2. Air Pollution Problems

Within the framework of this study, solving the air pollution problem is proposed based on two concepts. The first concept is based on the experience of Superkilen Park in Copenhagen. The project is based on the concept of public participation as a driving force in the development of space design. Another proposal is the Antismog airship, represented by Kazakhstani architect L. Rakhimzhanova (Figure 3). The invention of the Antismog sailboat or airship sprouts from aerodynamics laws. “To understand the principle of Antismog one has to understand what causes the unpleasant natural phenomenon. Streams of warm air meet the cold air layer at around 200-300 meters above the ground. The cold air does not let the warm streams through and works as an inversion layer. It not only hinders smog dispersion, but also serves as a screen reflecting all the hazardous emissions generated by the city back to the ground, thus increasing their concentration. The Antismog airship is called to make a hole in the inversion layer and provide a surge of fresh air for our lungs,” the architect explains. The invention’s mechanism is based on the difference in wind speed in different atmospheric layers: the speed is greater in the upper layers than in those close to the ground. The pipe-like construction is capable of ‘sucking out’ the smog and bringing it outside the inversion layer. However, it is not possible to simply install a vertical pipe to make things work, because it would be too bulky and would threaten to suck people in.

Therefore, a self-opening airship was proposed that would easily go up in the air thanks to inflatable elements filled with helium: horizontal rings or vertical arcs. Cone-shape rings have to be gradually filled with helium starting from the top one. According to the architect, the aerodynamic pipe could look like a vertical unmanned airship that would fly above the city. The Antismog airship can be equipped with additional functions, the author says: “If we apply titanium dioxide inside the airship, it, together with natural light, will be able to destroy poisonous substances.

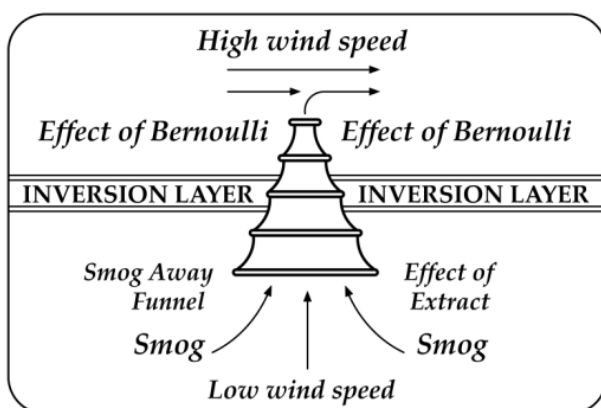


Figure 3. “Antismog”, architect L. Rakhimzhanova. Illustration from the site megapolis.kz

And if this pneumatic device is complemented with a generator in the upper part of the funnel where the air stream is most intense because of the sucking effect, it will be able to generate wind and solar energy. Finally, Antismog could become a good screen for different signs, video and laser shows and light effects. And the city, selling space to advertisers, would recoup the cost of their installation” [15].

3.3. Analysis of Insolation Breaches in Residential Buildings

Under the assumptions on insolation breaches in relation with construction of new high-altitude facilities, several residential facilities overlooking the picturesque mountains were analyzed. The residential facilities are located along Al-Farabi main thoroughfare. In construction of residential facilities in Almaty, the insolation standards for residential houses no less than 2,5 and 3 hours are adopted. In documents of legal regulation of architectural and spatial urban development, the requirements to population density in residential districts and micro-districts as well as the minimal value of spacing between long sides of multi-apartment buildings are determined. In the case with 3-5-storey buildings, it is no less than 20 m; at 10-16 storeys, it is no less than 48 m, and at 17 storeys and higher the distance is rising up to 80 m.

In the course of analysis, the insolation breaches were revealed at infill construction of residential or public buildings. On basis of horizontal map is obtained the geometric configuration of negative space the height of which is equal to the height of 9-storey residential house. *As part of this study, in order to improve insolation in the premises of a 9-storey residential building, it is proposed to modernize window openings. Modernization of window openings can be carried out by changing the angle of inclination, window openings relative to the plane of the facade. It is proposed to turn the window openings towards the west, where the solstice remains most of the time of the day. Taking into account the existing location of the 9-storey building (almost 90 degrees) to the west, the width of the window openings can increase to the east. Such a technique will improve insolation in all apartments, will not shade adjacent windows, and will also improve the facade plastics (Figure 4).*

Currently, there are no landscaping and small architectural forms in the territory of the 9-storey building. The territory of the residential building is fenced with a metal fence. It is proposed to replace the fence with green spaces, using the safety principles – visibility of the space. Ensuring the visibility of the space is achieved by adjusting the height and distance between green spaces.

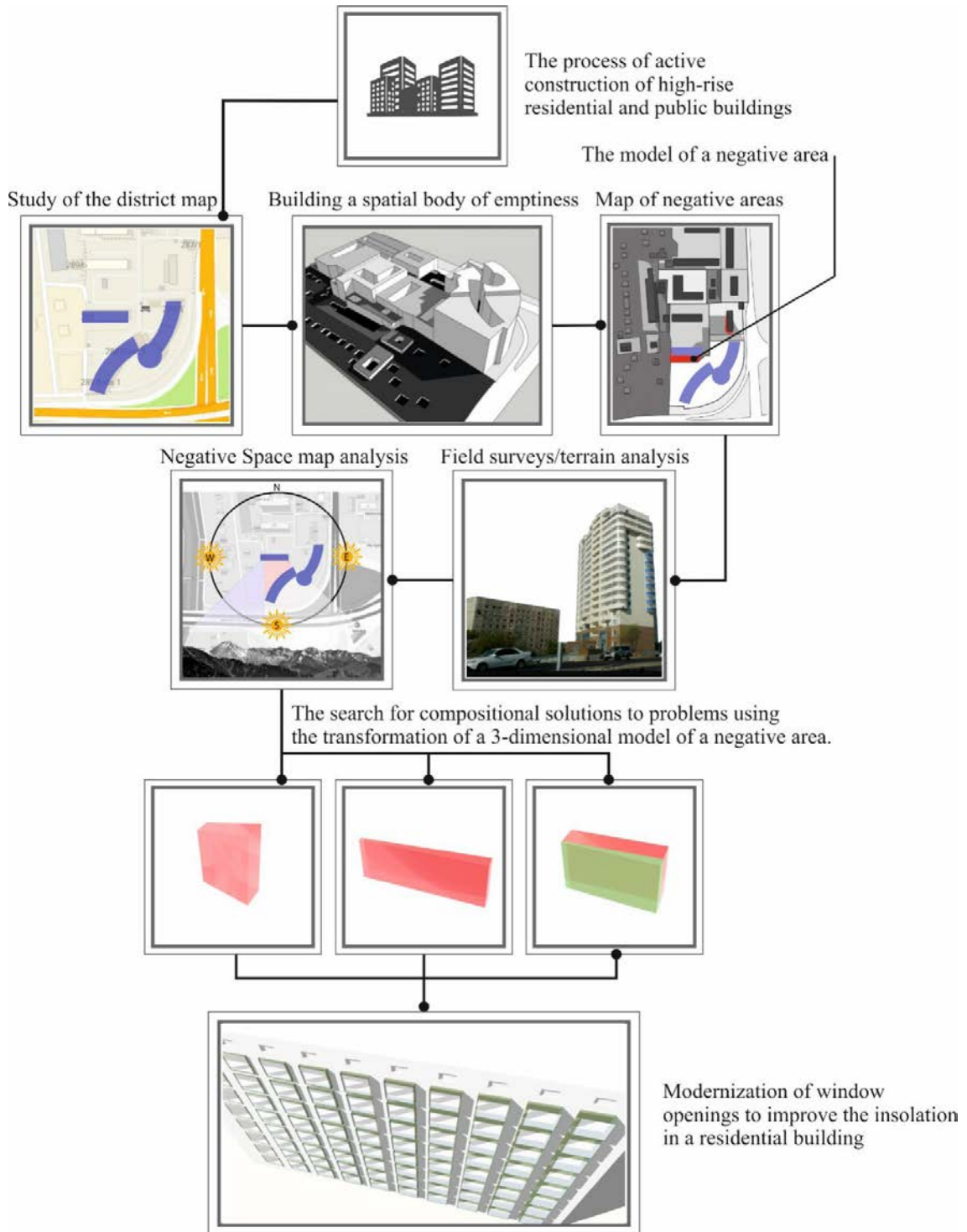


Figure 4. Analysis of insolation violations in residential buildings

3.4. Analysis of Architectural and Composition Solutions of Residential Facilities Erected in the Post-Soviet Period

The obtained results of three-dimensional model of negative space have a closed triangular and semi-open “r”-shaped form under 90% having the height equal to 5th and 9-1-storeyed panel houses. These areas are not

illuminated, not asphalted. But, they have passages with 1,20 cm wide which are actively used by dwellers of these districts. To improve the comfort conditions in this district, we propose to make public spaces relevant to principles of environmental safety. This may be temporary facilities of art objects, vertical farms, etc (Figure 5). The vertical farms may grace not only urban residents’ leisure but also be new workplaces for many dwellers [16,17,18, 19].

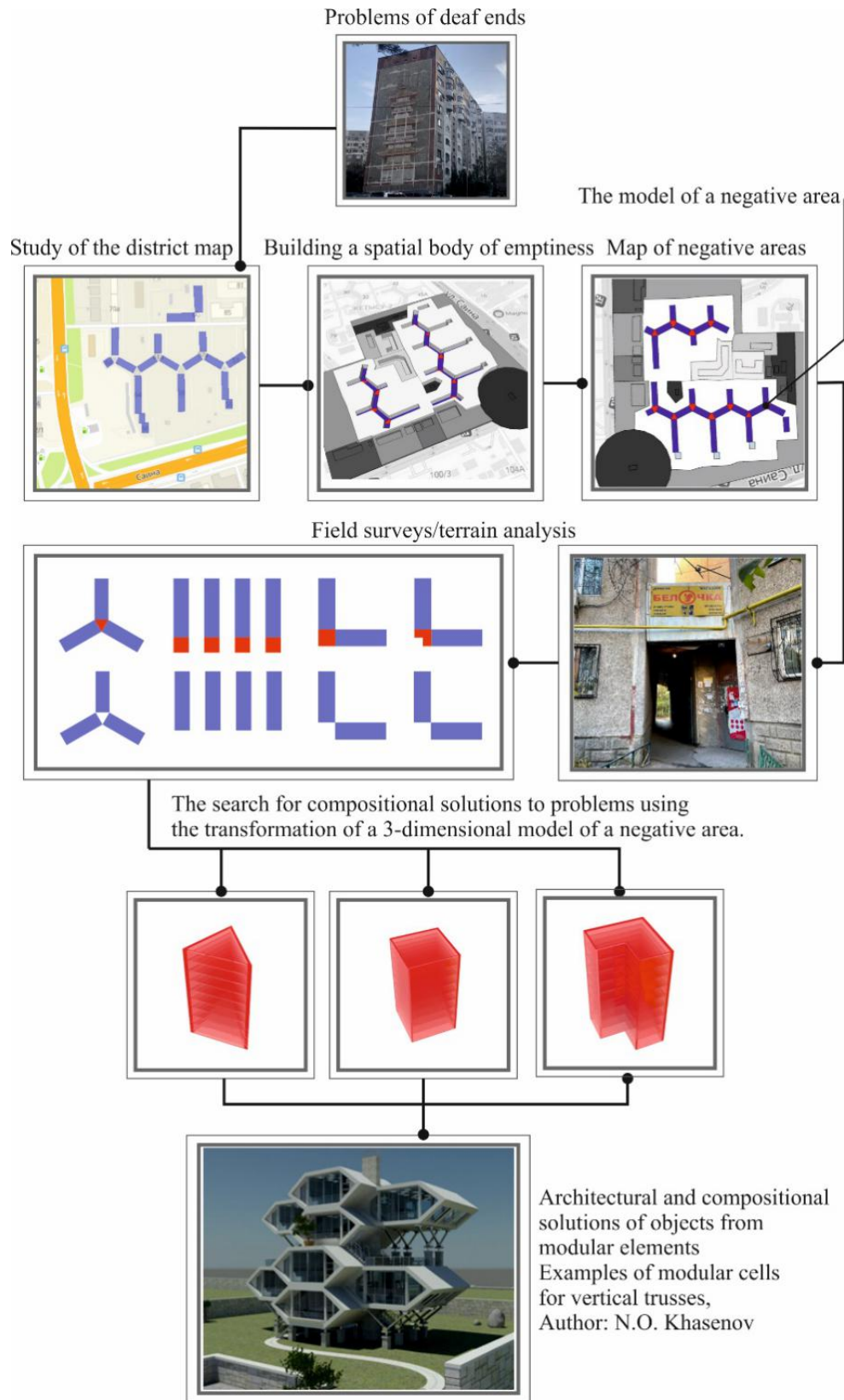


Figure 5. Analysis of architectural and compositional solutions of residential buildings built in the post-Soviet period.

4. Discussion

Historical facts bear evidence that the water from the ditches was potable. «There were special decrees that prohibited clogging of those irrigation canals. It was not allowed to dump garbage and water the cattle. It was decided that the cattle can be watered only by taking water in a bucket, for example, and at a distance of one meter from the irrigation ditch. Almaty residents not only bathed or washed clothes on the main irrigation ditch, but also drank water from its irrigation ditches, and organized picnics on the banks. All processes were given special time. Strict rules were thought out for the regulation and use of water for certain needs, especially for watering gardens and vegetable lots in the evening. Sluice gates were installed along the irrigation ditches, and specially appointed elders, mirabs, supervised the water supply. The urban authorities plan to expand public spaces in the city along the irrigation ditch system by expanding pedestrian roads. According to other opinions, there are proposals to partially close the irrigation ditch network and preserve only a small part of it in the center of the city as a historical object that forms the identity of the city. Residents of the city come out against such proposals; the urban dwellers also show their negative opinion regarding replacement of irrigation canals with deaf asbestos pipes. Unfortunately, most of the irrigation ditch system has now been replaced by pipes» [11]. These actions are explained by the constant flooding of the streets during the rain. The successful way for solutions for these problems may be construction of various architectural forms. This may be fountains, towers with various functional purposes. The proposed architectural forms will not only enrich the figurative solution of urban environment and solve most of utilitarian issues. As an example, we may consider Kuwait Towers. This project is one of laureates of first cycle of Aga Khan Award in the field of architecture in 1980 which symbolizes Kuwait modernization. Known because of its form as “Mushroom towers” are one of the best examples of improvement of the population quality of life in the city [20]. The history of construction of the BAC and Malaya Almatinka is associated with the shortage of irrigation water in the vicinity of the city. The richest land, capable of feeding millions of people, regularly suffered from a shortage of irrigation water. In addition, the absence of in-house water systems did not allow an increase in the area of irrigated lands. The numerical growth of the population of the Almaty region, for the most part lived in rural areas and were engaged in agriculture. In the absence of new lands in the countryside, unemployment began to grow; the exhausted lands yielded less and less crops. That whole tangle of economic and social problems was solved with the construction of the BAC and Malaya Almatinka. An efficient system of collection and accumulation of melt water from glaciers and their rational use for the needs of irrigation in agriculture was created. That measure made it possible to increase the area of irrigated land by two and a

half times. Forty new state farms were created on the new lands in the Almaty region, hundreds of thousands of people got jobs. Orchards, vineyards bloomed on the new lands, vegetable plantations, melons, wheat and corn fields spread out.

Taking into account all the available aspects: annual increase in the population of the city, ethnic diversity, concentration of large educational facilities in the city, business structures, etc., it is necessary to develop conceptual proposals for solving the air pollution problem, it is proposed to learn from the experience of Superkilen Park. The experience of Superkilen Park in Copenhagen was enabling not only as per the air purification but it has given a pulse on criminality decrease in the city. This type of participation aims to develop a sense of ownership of the park among the residents of the area. Many of the properties offered by residents are related to their home cities and countries. As a result, trees appeared in the city, used in the park, are also designed to denote the different geographic regions and nationalities represented by the park. For example, the Lebanese Cedar is associated with Lebanon, the Atlas Cedar is associated with the Atlas Mountains between Morocco and Algeria, and the Windmill Palm is associated with eastern China. In addition, even a dedicated mobile phone app has been developed to provide more detailed information about these sites and their history. This park has become one of the most popular destinations for Copenhagen residents and visitors [21].

In Almaty, the construction of residential buildings in the post-Soviet period was carried out according to the principle of micro-districts or infill construction on free areas of the city in separate spots. This is how the urban subdivisions arose, which also used the development of infrastructure according to the microdistrict principle. In the center of the urban subdivisions, there were schools, sports stadiums, kindergartens, administrative buildings, etc. The distance between residential buildings was 30-50 meters, which ensured an optimal level of insolation and contributed to the creation of a comfortable space between buildings. In Almaty, the microdistrict building principle continues to be largely used when creating new social districts – for example, in Algas, Zhas Kanat and many others that have arisen within the framework of state orders over the past few years. Residential buildings of a higher class are built on a block and infill basis.

The nine-storey house is located near the main road with a mountain panorama from the south. The construction of a new housing complex with 16-storey buildings has disturbed the insolation in residential buildings and the courtyard space of the existing 9-storey building. It is also possible to note the videoecology violation, instead of a mountain landscape, residents of a 9-storey building are forced to look through the windows of a neighboring residential building. Within the framework of this study, a conceptual solution to the problems of insolation is proposed by modernizing the facade of a 9-storey building

and landscaping.

Within the framework of this study, a conceptual proposal is offered to eliminate the negative areas of the city with the introduction of vertical farms. This conceptual proposal is based on the high demand in Kazakhstan and around the world for the production of organic agricultural products. The development of the industry of organic products is a very important strategic direction responsible for the growth of the well-being of the people and the health of the younger generation of our country. One of the well-known methods in the development of organic agriculture in urban environments is the use of vertical farms. The possibility of the cells to be arranged in different ways and to adapt to any area is of great interest. Urban farming can become a new market niche, a new direction of economic growth. Introduction to methods of involving residents in design and planning activities into the practice of self-management of residential areas will create an environment capable of adapting to new and changing requirements of residents. In the process of informal planning, people obtain an understanding of urban space, an interest in real improvement of the conditions of their environment, including the development of environmental education, the formation of traditions in a certain territory [11,12].

Thus, it is possible to realize the idea of human ecology by providing communication between city dwellers through architecture, including communication between neighbors in homes, within blocks, in comfortable well-manicured courtyards.

5. Conclusions

The theme of interspace, pause, void space occupies a special place in architectural theory and practice. Quite traditionally, void space is imagined as a space surrounding an architectural object, which is taken into account in the urban planning of territories. Competently organized squares, green squares and parks, pauses in street development become part of architectural ensembles. In modern design and construction practice, in addition to the necessary infrastructure, the building environment contains expressive figurative and semantic content: improvement elements, landscaping, land art. In the article "Void space is an important building material" the architect D. Perrault points out the integration role of void spaces: "... void space ... has become for me the main building material for creating connections between the widely differing elements constituting the architecture" [21]. The technique of building the spatial body of void proposed in this study is implanted in the training process in "composition" discipline as experiment.

This study confirms that architects and designers play an important role in improving the quality of life of urban dwellers and in creating a comfortable environment. Architectural and compositional techniques based on

landscape and natural and climatic features of the environment are able to generate the identity of the urban space. The landscape is an indicator reflecting all the changes that occur in individual elements of the environment as a result of urban development. Awareness of these changes by students and practicing design professionals, involving them in the search for conceptual ideas, can improve the ecological design of the urban environment. The concept of the transition to a climate-resilient city must be studied in all urban settings. The findings of this study confirm the view of researchers that socio-ecological modelling can provide guidance in adjusting the human-land interaction and climate-resilient city development from the perspective of macro policy [22, 23, 24, 25].

The architectural and compositional principles of organizing an ecologically safe urban environment can affect: the ecological state of the environment, buildings, human ecology. Compositional techniques are based on the methods of social design, on the scenario of the development of a comfortable, environmentally safe urban realm. The architectural and compositional principles of organizing a safe urban environment are capable of shaping the modern worldview and world perception of urban dwellers.

Further research can be focused on the way in which the work of architects and urbanists can improve people's lives in the field of restoration or change of economic, social, cultural systems using architectural and compositional techniques.

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