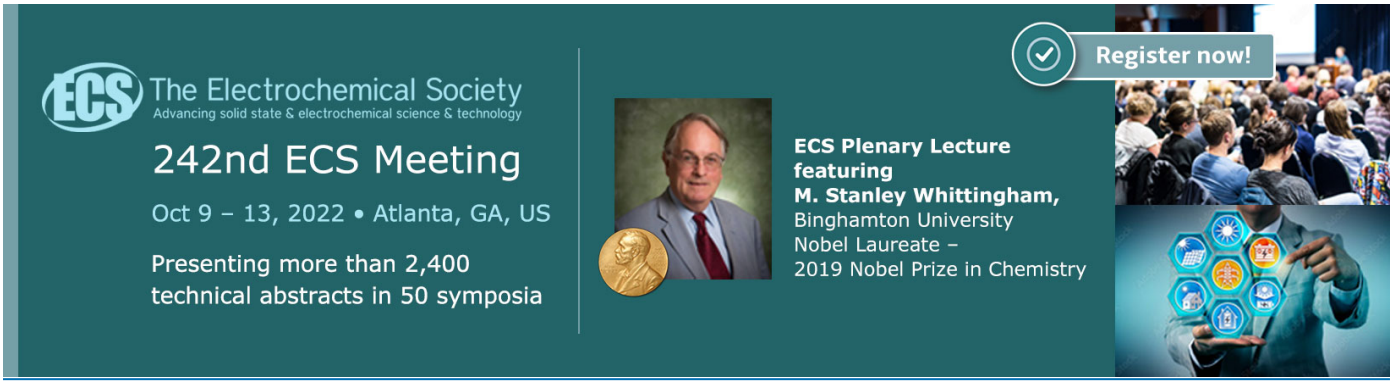
# Perspectives for using a three-beam space-planning structure in creating residential grid structure development





# Perspectives for using a three-beam space-planning structure in creating residential grid structure development

**Tagir Nureev** [1][0000-0001-7365-0061] **and Anton Popov**[2][0000-0003-2223-1654]

[1]LLC "Zodchestvo", Kazan, 420126, Russia
[2]Kazan State University of Architecture and Engineering, Kazan, 4200423, Russia
E-mail: ntm60@mail.ru, a.o.popov@yandex.ru

**Abstract.** *Problem statement.* The aim of the study is to reveal new urban planning possibilities in applying the three-beam architectural and planning structure under the changed sanitary regulations and standards (SanPiN 2017) in the central and southern zones of insolation in the Russian Federation.
*Results.* The main results of the study consist in the development of proposals for the central and southern zones of insolation in the Russian Federation, which allow achieving the maximum normative indicators of the building area density.
*Conclusion.* The significance of the results obtained for architecture is the geographical boundaries defined by the authors for the use of residential three-beam space-planning structure in modern conditions of housing development. The research is based on the analysis of urban planning indicators, including renovation of existing building area, and the typology on the basis of the rotation angles of the three sectors in different azimuth directions.
**Keywords:** urban planning, insolation, high-density residential development, residential grid development, three-beam space-planning structure, courtyard spaces, renovation.

## 1 Introduction

Architects of the world actively engaged in the use of a three-beam space-planning structure in housing development in the first half of the XX century. The first stimulus was the appearance of the first socially-oriented state on the world map – the USSR, with its housing development programs of a new socialist way of life. The next stimulus was the Athens Charter [1] (1933), which resulted in a revision of urban planning principles and goals, the key regulation was the implementation of insulation standards for residential premises in the Charter's member countries. By now the highest standards of insolation are taken in the Scandinavian countries of Europe [2]. The proposal set by the Athens Charter about insolation standards implementation was also accepted in Russia, which was quite popular until recently. However, in 2001 and 2017, with the implementation of a new SanPiN 2.2.1/2.1.1.1076-01 "Hygienic Requirements for Insolation and Sun Control for Residential and Public Occupancies and Premises Thereof" in Russia, the time of residential premises' insolation for each of the existing three zones of insolation (South, Central and North) was reduced by half an hour. The period of insolation was reduced by two months - March and September.

The relevance of returning to the investigated issue in Russia is caused not only by the latter fact but also social need to increase the availability of total area of housing per person in the country up to the European level, equal to 30,0 sq. m. To achieve this goal it is necessary to build in the country an additional one billion m2 of housing area going up to the number of 4.5 billion sq. m., up from the existing 3.7 billion sq. m. [3]. The implementation of this goal will have to be achieved in all settlements of our country not through the development of land adjacent to cities, but through the renovation of building areas within existing borders. The latter circumstance is particularly relevant for the use of residential three-beam space-planning structure due to its advantages not only in terms of urban planning flexibility but also in other qualities identified over the century-long historical period of its application both abroad and in our country.

## 2 Development of residential three-beam space-planning structure in the USSR

In the industrial housing construction of the USSR and Russia of the 20th century, the residential three-beam space-planning structure wasn't implemented purposefully, despite the existing projects based on it. Why?

Due to the fact that in the USSR private ownership of land was abolished and, accordingly, there was no ban on expanding the boundaries of settlements on public lands. Therefore, the state structures of urban development didn't face the current problem of creating high-density residential development in non-extended borders of settlements. In addition to this circumstance, there was state-level respect for any innovations, including urban planning, the land and excluding links with private property. Therefore, the state structures of urban development of the USSR decided to implement the Western new-fangled urban development type – housing estate (micro-district). It was not assumed that in the future of one or two generations, huge uncontrolled and free municipal spaces of micro-districts can lead to the formation of youth criminal groups. It happened in the USA in the 50s (Detroit) and in the USSR in the 90s (Naberezhnye Chelny) [4]. The micro-district type of development in the USSR was implemented with the help of urban planning standards, which imply the development of single-beam residential sections with names reflecting their relationship to the geodesic grid of the planet: meridional, latitudinal. Two-beam types of residential sections were designed in the form of rotary sections connecting meridional and latitudinal block sections at the corners of the block and micro-district buildings. But they were in no hurry to implement two-beam sections at construction industry plants, requiring the state structures of the industry to provide documents authorizing the conduct of research and practice experiment. Why?

The first reason: in the construction industry there were rules for saving strategic resources: metal, cement, etc.; and the criminal code provided for liability for overspending these resources. In this regard, the law approved the formula of examinations that prove the presence of criminal intent. The presence of a permit for the experiment relieved from criminal liability.

The second reason: the number of two-beam sections in a micro-district is usually no more than 10 %. And the financial profit of the construction industry appears only from a larger percentage of the use of technological equipment that goes to the production of reinforced concrete elements of sections. This inefficient economy of rotary sections has led to the fact that in most Russian settlements the implementation of two-beam sections is the exception rather than the rule. As well as in the projects of the standard series of the first five-year plans of the USSR [5].

In the Soviet period, despite the indicated economic inefficiency and indifference of the urban development state structures to the researched issue, the project design of residential three-beam space-planning structures was carried out by the leading design institutes of the country in the form of research and development (R&D) [6].

## 3 Development of residential three-beam space-planning structure in Russia

The return of the new Russia in the late 20th century to private ownership of the land and the possibility of acquiring it, as well as the collapse of the country's economy with legislative permission to privatize any real estate, led to the fact that at the end of the 20th century the land of Russian settlements no longer had state owners. In 1993 Federal laws appeared regulating relations in the field of real estate – the Land and Urban Planning Codes. And with them, the revision (updating) of all normative documents of the urban planning sphere approved during the Soviet period. New economic conditions have brought back the need for high-density residential development. It mentioned the existence of the three-beam space-planning structure in the form of (code of construction practice) SP 31-107-2004 - "Architectural and space-planning design of multi-apartment buildings" with a graphic image of two types of three-beam sections of multi-apartment buildings, differing only in the degree of angles between axes of three blank walls, which is assumed to be blocked the following sections one, two, or three-beam.

At the turn of the century, R&D projects developed during the Soviet period began to be implemented in a limited form - in several sections (Figure 1) [7].

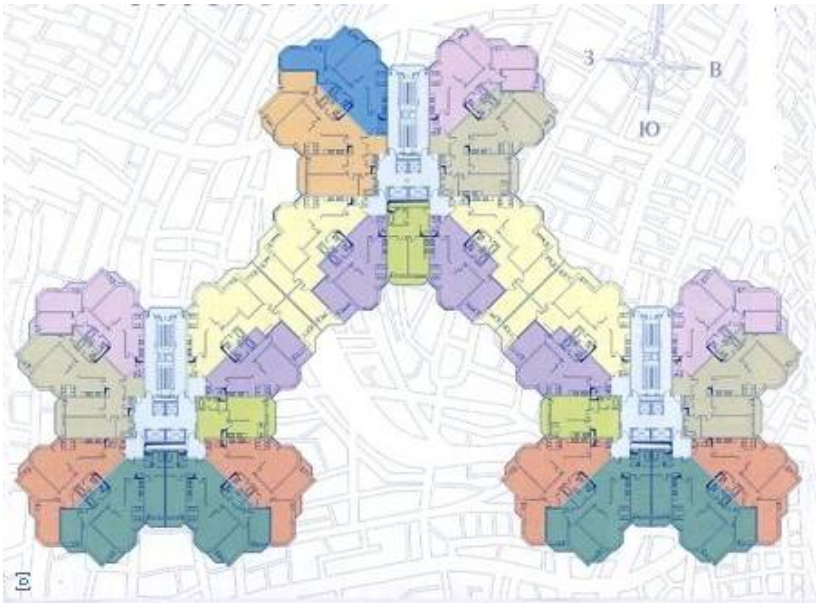



**Figure1.** RC (Residential complex) "Arcade house". Moscow, Ostrovityanova St., Yu. A. Makarov Architect et al [7].

Considering the plan of the residential complex "Arcade house "(Figure1), we recall the economically inefficient two-beam sections of industrial housing construction of the USSR, described at the beginning of this article [5].

Naturally, the reader will have a question about the cost-effectiveness of designing a three-beam space-planning structure. After all, it has many more angles. 4-beam structures are not considered due to their lack of insolation in the windows of one-way apartments facing to the North. The answer is the project of the residential complex "Arcade house". It is made only in the form of three sections. In this case, the outermost sections are the same central section, with the blank walls eliminated from the West and East. In connection with the above circumstance, one central section performs the functions of several types of sections: ordinary, rotary (corner) and end-type sections. In this case, the technological equipment of the construction industry will not be used by 10 %, as it was in the Soviet system of the diversity of block-section typologies, but by 100% with one type of block-section of a three-beam space-planning structure. For this reason, its economy cannot be negative initially.

Let's focus on the procedure for converting an increased number of blocked sections to a different quality. Blocking of already implemented three sections of the residential complex "Arcade house" to the ends of their own outermost sections, will lead to the creation of a new type of urban space - residential grid structure development (Figure 2) [7].

## 4 Three-beam space-planning structure in residential grid structure development

With the appearance in (code of construction practice) SP 31-107-2004 of two types of three-beam space-planning structure, in SP 42.13330.2016 - "Urban planning" the term "residential grid structure development" has not appeared. It can create some problems mainly with the use of the considered structure, which has its own morphology, principles of formation, methods and methodology of application.

Due to the absence of the term "residential grid structure development" in professional dictionaries, we will explain the generally accepted understanding of it in the professional environment. This is a residential development on a certain polygonal geometric grid that creates closed or semi-closed courtyard spaces, with the possibility of penetration of vehicles and pedestrians (Figure 2).

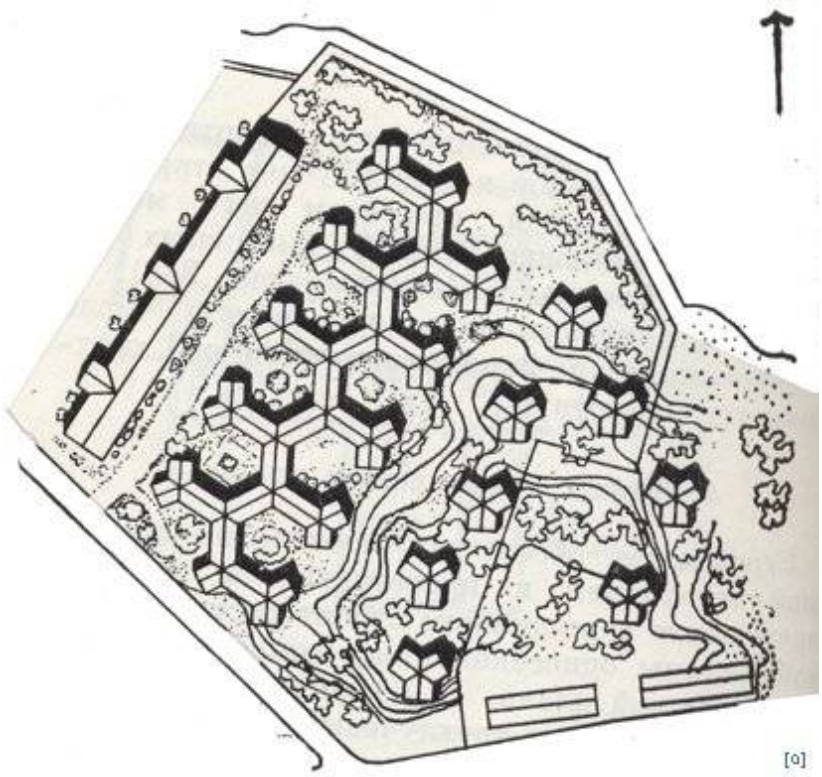


**Figure 2.** Stockholm. Sweden. Reismus Backstrem Architect. 1944-1946 General layout [7]

Let's look at attempts to create a residential grid structure development of the two types specified in SP 31-107-2004 three-beam spatial planning structure to understand their advantages and disadvantages. The first type is 90-degree three-beam sections, which are called "T-Shaped" in the professional environment. The second type is 120-degree three-beam sections, which are called "Shamrocks" in the professional environment.

In the case of forming a grid structure development with a latitudinal-meridian orientation only from T-shaped sections, with the types of apartments specified in SP 31-107-2004, we will get a rectangular grid structure development in the form of a single strip of courtyard territories. In this case, we will see that apartments with one-way orientation in the inner southern corners of the courtyard will not be insolated. Consequently, the T-shaped sections have mentioned disadvantage, which can be eliminated by the planning solution of apartments with a two-way orientation for the inner southern corners of residential courtyards.

In the case of forming a grid structure development only from 120-degree shamrock-sections, with the types of apartments specified in SP 31-107-2004, we will get a hexagonal residential grid structure development in the form of honeycombs (Figure 2). In the case of placement of 120-degree shamrock-sections in the central and southern zones of insolation in Russia, with 2 and 1.5 hour periods of insolation, respectively, there is a violation of SanPiN -the insolation of one-sided apartments in the northern sector of all three beams of the shamrock-sections will not be provided due to their shading by two neighboring beams placed from the southern sector.

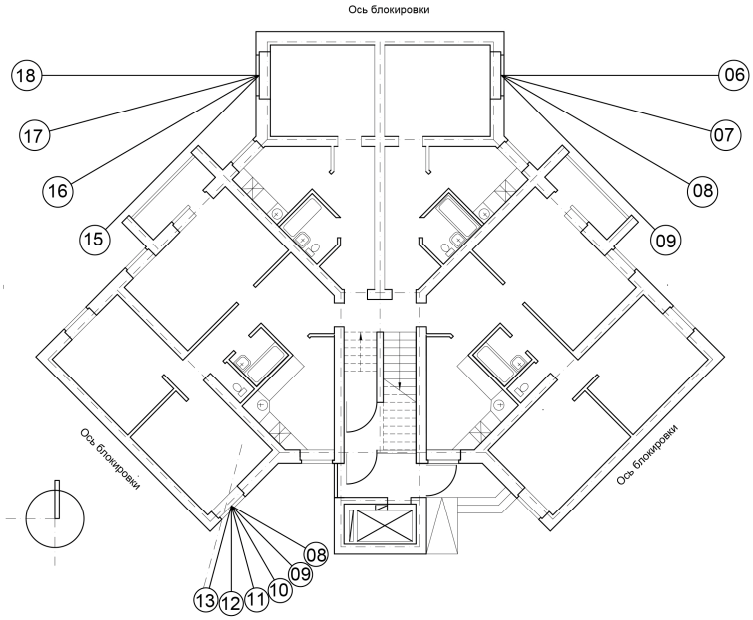



**Figure 3.** Shamrock-Section for the central and southern zones of insolation in Russia (Author's illustration).

The insolation diagram in Figure 3 shows: excluding on demand of SanPiN 2.2.1/2.1.1.1076-01 "Hygienic Requirements for Insolation and Sun Control for Residential and Public Occupancies and Premises Thereof" morning (from 06:00 to 07:00) and evening (from 17:00 to 18:00) non-insolable hour periods. The insolation of one-room apartments are provided for both the Central and southern zones of insolation in Russia. Therefore, reducing the 135-degree rotation of even one of the beams to 120 degrees will violate the regulatory requirement of the SanPiN of one-room apartments in the above-mentioned zones of insolation. The problem of insolation of the inner southern corners of residential courtyards of the hexagonal type of development should also be solved by using the two-way orientation of apartments.

The detected negative result of 120-degree shamrock-sections was taken into account in SP 31-107-2004 by adding one word to the second type of shamrock-sections - "and others". This refers to the degrees. Consider attempts to create a grid structure residential development from the third type of shamrock-sections: with 135-degree two sectors. The third sector between the remaining beams will have 90 degrees. In this case, residential grid structure development will have residential courtyards of two types of polygons: four and eight (Figure 4).

The principle of grid structure residential development from shamrock-sections, in proportion to the 135-degree rotation of one or two beams, was implemented in 2006 by the author of this article (architect T. M. Nureev) in the form of renovation of the residential block № 75 in the city of Menzelinsk, Republic of Tatarstan. The renovation was ordered by the non-budgetary housing Fund under the President of the Republic of Tatarstan (Figure 4). The principle creates urban planning flexibility in the form of transformation of the found correct residential grid structure into an irregular, but equally symmetrical one: squares into rectangles, regular octagons into irregular ones - elongated in any of the selected directions, due to additional inserts of block sections.

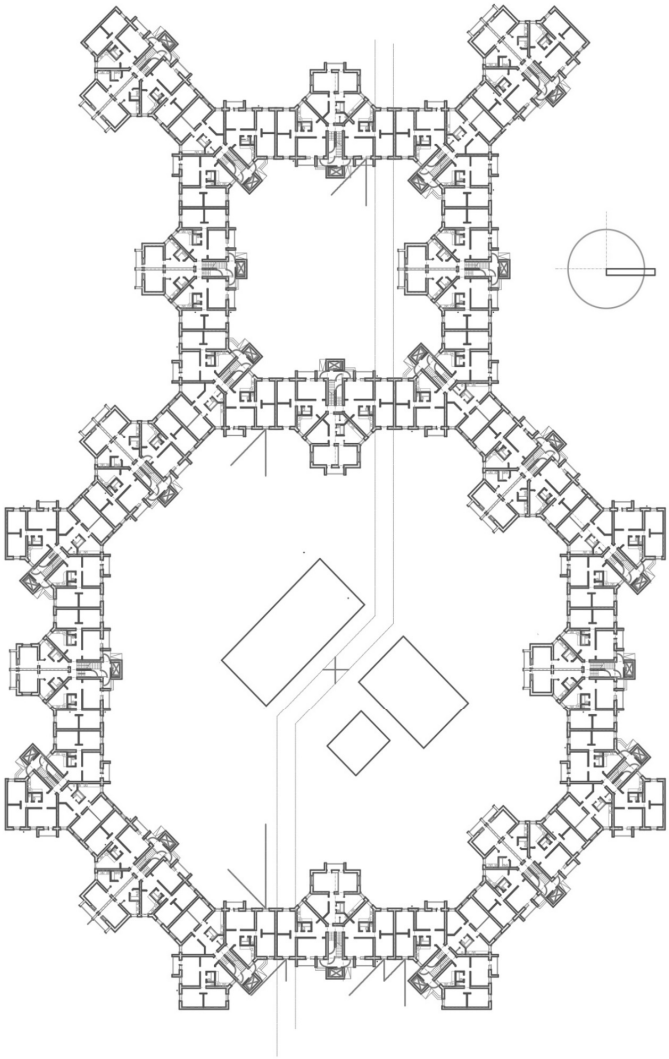


**Figure 4.** Residential grid structure development layout around existing buildings (Author's illustration).

## 5 Three-beam space-planning residential structure in foreign countries

One of the most remarkable foreign objects of the last decade that used a three-beam space-planning residential structure is the "Vertical village" in Singapore, implemented in 2013 by the German architect Ole Scheeren during his work in the OMA Company [8].

The concept of a multifunctional complex with a total area of 170,000 sq. m. and underground parking for 2,600 cars is formed from six hexagonal courtyard spaces that increase in height to the southern side of the courtyard, reducing the time of insolation of courtyard territories in a tropical climate, creating a cool microclimate in them. Innovation in the application of a residential three-beam space-planning structure for 1000 apartments located on active terrain, with an area of eight hectares, is that the architect places each beam of a hexagonal three-beam space-planning structure, turned into a 6-story two-entrance 70-meter block, places on the next similar block anticlockwise around a hexagonal courtyard. In this way, a staircase is formed from 6-storey residential blocks, in the direction of the sides of each of the six hexagonal courtyards. The number of storeys of stepped residential blocks is variable: from six to 24 floors.

At 120-degree corner intersections of 70-meter residential blocks, there is a staircase and elevator section, through which residents of each of the 6-story blocks have the opportunity to access their yard territory, located on the roof-step of the underlying similar 70-meter block. Due to the fact that each of the blocks is repeated on each side through six floors, the landscaped courtyard areas on the roofs of subsequent blocks are similarly repeated, doubling in area. And on the southern sides of the hexagonal courtyards they are tripled. Under the steps of six-storey residential blocks through rectangular openings are formed with a height of six-storey, creating the possibility of through-ventilation of courtyards.

## 6 Three-beam space-planning structure in the renovation of the existing development of depressive territories of Russian settlements

In addition to compliance with the rules of insolation, the three-beam space-planning structure allows diversifying urban planning solutions of courtyards, and forming various polygonal solutions with residential grid buildings in the form of any ornament. Even an Arabic ornament.

This possibility of a three-beam space-planning structure is particularly relevant in modern conditions of depressive territories renovation of Russian settlements, intended for housing construction by approved territorial development plan (TDP), which has passed public hearings of residents.

The three-beam space-planning structure makes it easy to find options for bypassing land plots, buildings and structures of owners, who couldn't agree to sell their real estate for the purpose of territory renovation in the first phase of the construction project.

The third beam in residential grid structure development provides additional space for apartments on the floor, compensating for the financial and economic costs of demolishing existing buildings, structures and engineering infrastructure.

The Ole Scheeren principle [8] for the formation of stepped low-storey residential blocks along the edges of residential grid polygonal structures is particularly appropriate in places of existing depressive development, provided for by the TDP (territorial development plan) for demolition. Due to the fact that the airspace is not classified as real estate, and therefore can't be encumbered in accordance with the current Land Code, it is possible to "jump" a 70-meter residential block through the "uncooperative" owner of existing real estate, planned for demolition. Real "overhead" urbanism in the form of residential development over the buildings and structures of another owner's land plot is not stipulated in the Land Code of our country today. It specifies a similar situation related only to engineering infrastructure objects (overpasses, power lines, pipelines, etc.) located in the airspace above buildings and structures of another owner's land plot.

This spatial innovation will have to be introduced into existing Federal laws in the form of two regulations. The first regulation: in the conditions of the renovation of an existing building with the use of a residential three-beam space-planning structure, intended for use in the airspace above buildings and structures of a land plot of another owner, whose real estate is supposed to be demolished by a legally approved urban planning document – the territorial development plan of renovation. The second regulation is the equivalent solution for areas of new construction.

## 7 Conclusion

This article considers the use of a three-beam space-planning structure only in two zones of insolation in Russia for several reasons.

The first reason is that the area of both zones – the central (2-hour insolation) and southern (1.5-hour insolation) of the country – is approximately 73% of the territory of Russia, equal to 16 995 850 sq. km. (about 17 million sq. km.).

The second reason: most of the megapolises, large cities and towns in Russia are located in these two zones.

The third reason: the global trend of rural population migration in agglomeration will stimulate housing construction in Russia in these two zones of insolation of the country, due to their comfort for living.

The fourth reason: the three-beam space-planning structure, providing two-hour insolation for the central zone of insolation in Russia, a priori provides 1.5-hour insolation in the southern zone, without requiring any architectural planning and structural changes of residential sections, proving the feasibility of its application in both zones of insolation in Russia for Federal housing programs for the construction of social (standard) housing [9].

Residential grid structure development of three-beam space-planning structure is formed from shamrock-sections with the sectors between the beams in the ratio of 135×135×90 degrees, with apartments one and two-sided orientation, ensure regulatory requirements of SanPiN 2.2.1/2.1.1.1076-01 insolation in the central and southern zones of Russia insolation (Figure 3). At the same time, it becomes possible to implement the insolation paradox: the placement of two one-room apartments of one-way orientation in the northern beam, insolated from the West and East, respectively.

In this case, the internal configuration of residential courtyards will be formed from two geometric grids that are interconnected. Namely, quadrangular and octagonal. The configuration of residential courtyards can be changed by multiplying the sides of the above polygons to eight and sixteen, respectively.

In terms of renovation of the existing building, three-beam architectural-planning structure allows to creating many different options bypass around existing buildings and structures, taking into account subsequent section replacement of the considered structure, making up the depressed area in high-density residential development with different typology of apartments and number of storeys in sections. This urban planning flexibility, along with the absolute use of construction industry products in residential grid structure development, indicates high economic feasibility of using a three-beam space-planning structure both in the conditions of the renovation of existing buildings and newly created in various climatic conditions [10].

A description of the methods and methodology for creating different types of three-beam block sections and their classification within three-beam space-planning structures of small, medium and high storeys is provided in the next article of the investigated issue.

## References

[1] *CIAM (Congres Internationaux d'architecture Moderne*) OPEN.EDU Homepage https://www.open.edu/openlearn/history-the-arts/history/heritage/ciam-congres-internationaux-darchitecture-moderne (last accessed 2019/11/01)

[2] Shmarov I A, Zemtsov V A and Korkina E V 2016 Insolation-practice of rationing and calculation *Housing construction* **7** pp 48-53

[3] *High-rise residential buildings are a toxic asset with a short life span* EXPERT.RU Homepage https://expert.ru/expert/2019/25/mnogoetazhki---eto-toksichnyij-aktiv-s-korotkim-srokom-zhizni/?fbclid=IwAR05-UInoqeJVQLqJIZUCcrDipFrnI4h60LpI2RGNuLPZRHi_VnucN4vWOw (last accessed 2019/11/01)

[4] Jacobs J 1961 *The Death and Life of Great American Cities* (New York: Random House)

[5] Belov A, Zadorin D, Koryakovskaya N, Levitskaya A, Meerovich M, Moizer F and Mukosey I 2016 Mass housing construction in Russia: history, criticism, prospects *Journal* **42**

[6] *NIOKR. DIC.ACADEMIC.RU* Homepage https://dic.academic.ru/dic.nsf/ruwiki/312460 (last accessed 2019/11/06)

[7] Dubynin N V 2007 Multi-beam high-rise buildings in housing construction *High-Rise buildings* **2** pp 78-81

[8] *The Interlace* BURO-OS.COM Homepage https://buro-os.com/projects/the-interlace (last accessed 2019/11/01)

[9] Zabruskova M Y 2016 To the modern vision of an urban home *Architecture and construction of Russia* **1-2** pp 32-37
[10] Sarvut T O 2018 Principles of the environment formation in the Arctic region *Vestnik MGSU* **2(113)** pp 130