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Basic Principles of the Formation of Solar Construction

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ABSTRACT: The article discusses the features of the formation of low-rise and multi-storey buildings with a different number of solar houses(from 50 to 80% of the total number of houses). The necessary distances between the facades of the solar houses are determined with an overestimated and underestimated insolation rate of helio-facades. The principles of the formation of solar structures of various planning structures are given.

KEYWORDS: Multi-storey and low-rise solar houses, helio-facade, insolation, solar collectors, distances between solar houses, facade shading graphics, building density, yard space, planning structure.

I.INTRODUCTION

Throughout the world, an increasing tendency to reduce the use of fossil fuels energy(oil, gas, coal), because they pollute the environment, in particular the atmosphere, increasing the greenhouse effect.
This leads to global warming, climate change and an imbalance in nature.
In this regard, the most urgent seems to expand the use of solar energy for heating of not only individual residential buildings and entire neighborhoods [1,10,11].

The use of solar energy for heat consumption of buildings, research shows, is promising and economically feasible in the first and second climatic zones of Uzbekistan, where there is a high probability of sunshine not only in summer (over 90%), but also in the heating season (more than 50%) [2].

The possibility and expediency of using helio-systems confirms the following fact: solar houses are built and function in countries such as England, Germany, Sweden, where cloudy days mostly prevail in winter; in the northeastern states of the United States, where the probability of sunshine is somewhat less, and the estimated winter temperature is lower than in Uzbekistan.

Nowadays, in the Republic have several built houses with a solar heat supply system (in Chirchik, Tashkent, etc.). The current level of development of solar technology allows us to begin the widespread introduction of solar heat supply systems into residential buildings of mass construction. This will require solving problems associated not only with the space-planning features of the solar houses, but also with the formation of helio-tuning (residential buildings dominated by solar houses). To do this, first of all, it is necessary to determine the necessary gaps between the solar houses, identify the building densities, and compare the obtained data with the corresponding norms regulated by the ShNK (regulatory document for designing houses).

II. SIGNIFICANCE OF THE SYSTEM

In low-rise solar houses - in most cases, and in high-rise ones - as a rule, to locate the required area of solar receivers for heating and hot water systems or for heat and cooling, it is necessary to use the area of both the roof and the southern facade of the building. Therefore, the necessary gap between the solar houses should be determined from the condition of ensuring complete insolation of the helio-facade throughout the day, regardless of the angle of inclination of the solar cell on the facade [3]. It is advisable to install solar receivers on a flat roof in separate sloping rows, which allows for large heat gains on their surface both in winter and in summer.

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Table 1

Necessarydistance	According to ShNK 2.07.01-03, (m)			By inflated normal insolation (m)		
	2-storey house	4-storey house	9-storey house	2-storey house	4-storey house	9-storey house
Between the long sides of high buildings	20	25	40	16.5	33	71
Between the long sides of the diagonal buildings	20	25	40	25.6	51	110
Between the long sides and the ends of the buildings	12	13.5	24	15	30	65

Table 2
Necessary distances (l) between the facades of four-storey solar houses at H = 13 m

The number of sections in the shading helio house	$L_н$-distance to shaded helio house (m) with the number of its sections			
	1	2	3	4
1	23.4	24.0	22.0	21.4
2	24.6	24.5	24.0	22.8
4	27.3	26.6	25.6	24.2
8	28.0	28.0	28.0	27.3

Table 3
The required distances (lн1) between the end of the four-storey helio house and the facade of the four-storey residential house, set meridionally, with the height of the house H = 13m

Carrying out the end of the shading building relative to the helio-facade - V, m	$L_н^1$-the distance to the end of the shaded solar houses (m) with the number its sections			
	1	2	3	4
B=H=13	8.4	5.6	2.5	0.5
B=1.5H=19.5	13.4	9.4	4.2	1.6
B=2.54H=33	19.0	13.6	6.6	2.1

To determine the gaps between the solar houses, it is proposed to calculate according to the coordinates of the sun in January (the coldest month), when the greatest area and time of insolation of solar receivers are needed.
In January, the lowest standing of the sun is observed in the year, which requires the establishment of the largest gaps between the solar houses.

Depending on the nature of the incorporation of the solar houses into the residential development, it is proposed to determine the gaps between the solar houses from the condition of ensuring an excessive or underestimated insolation rate of the helio-facade. An excessive rate of insolation is January 15, during hours of effective sunshine, insolation of the entire surface (100%) of solar receivers is necessary. The effective time of sunshine is from 8 h 30 min to 15 h 30 min, when the sun's height is more than 10^0 (here and in the future, the calculation is carried out for 40^0 N lat.,

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Since this is the average latitude for Uzbekistan) [4]. The first and last hours of sunshine, due to very low heat gains, are not taken into account.

To ensure an excessive insolation rate, the gap between houses should be determined by the lowest position of the sun during its effective heat supply. The average altitude and azimuth of the sun in the first and last hour of effective sunshine have been taken for calculation, i.e. at 9 (15) hours.

The height of the sun (hc) at 9 (15) h is 16^0, the azimuth (A) is 43^0, the profile angle (μ) is 21^0. Therefore, the necessary gap (Ln) between the latitudinal solar houses will be equal to: Ln = Hctg 21^0 = 2.55N (H - the height of the shading house). The latitude set by the solar houses should be at a distance of Ln = L^1tgA = 2.55H × 0.93 = 2.38H from the meridional house (Fig. 1). In the case of a diagonal installation of the solar houses, the necessary distances between the long facades are L^{11}_H =Hctg 16^0 = 3.94H. The planning structures of such solar housesare given by V.A. Akobjanyan [5].

Will the insolation rate be too high in other months of the heating season, as well as in other seasons of the year, the distances between the houses, determined by the coordinates of the sun in January? As shown by the results of our analysis, on December 22, when the lowest sun standing is noted, there is a slight (10-12%) shading of the helio-facade during the first and last insolation, which gives a decrease in the total daily heat gain of only 3%. In the remaining days of December, this figure is even smaller. It should be noted that December in Uzbekistan is warmer than January. Some shading of the area of solar receivers in December is offset by relatively less heat demand than in January. During the other months of the year, in particular, during the heating period, due to the higher standing of the sun than in January, the gaps between the solar houses, determined by January, fully ensure the elevated insolation rate of the helio-facade.

How do the proposed distances between solar houses agree with the corresponding ShNK norms - 2.07.01-03 (norms of town planning design) [6]. Table 1 shows the necessary distances between two, four, and nine-storey buildings at ShNK - 2.07.01-03 and the insolation obtained at an elevated rate. According to the table. 1 shows that only the distances between the latitudinal low-rise solar houses determined by the overestimated insolation criterion satisfy the norms of ShNK. The gaps between multi-storey solar houses significantly exceed the corresponding ShNK requirements.

The density of solar construction in case of ensuring the conditions of an excessive insolation rate turns out to be unsatisfactory, in low-rise solar construction - 1400 -1500m2 / ha, and in high-rise housing, the density of the housing stock drops to 2300-2700m2 / ha. It should be noted that the resulting gaps between the solar houses do not allow the creation of closed planning structures of heliobuildings that meet the conditions of deserts and semi-deserts.

Considering the aforesaid, the overestimated insolation rate and the corresponding shading schedule are recommended for use with single inclusions of solar houses in residential buildings

Due to the limited nature of the excessive rate of insolation, an underestimated rate of insolation is proposed for the formation of solar control - on January 15, at 9 (15) h, shading up to 15% of the solar facade is allowed, during the period of the greatest efficiency of sunshine (from 10h 30min to 13h30) should exceed 3%. If the low rate of insolation is observed, the average shading area of the solar facade from 8 hours 30 minutes to 10 hours 30 minutes and from 13 hours 30 minutes to 15 hours 30 minutes, i.e. in the first and last two hours of effective carotid radiance does not exceed 12%. The total daily heat gain from direct solar radiation per helio-facade is reduced by 188 kcal / m2, or 4%. In relation to the entire area of solar receivers (in multi-storey solar cells up to 40% of the area of solar receivers is located on the roof, which is insulated throughout the day) the decrease in total daily heat gain is only 2.5%. From 10 h 30 min to 13 h 30 min, i.e. within 3 hours, shading of up to 3% of the helio-facade area is allowed, which means that the latitudinal production building is shaded only by the heliohouse basement at a height of 40 cm - at four floors and at a height of 80 cm - at nine floors. The bottom of the ground floor window is usually at a level of 1.2 m and more. The distance from the helio-facade to the shading building of the meridional setting, determined by the conditions of the low insolation rate of the helio-facade, provides more than five-hour insolation of each light opening in January. Thus, each light opening on the helio-facade is provided with at least three-hour insolation in January. In March, due to the greater height of the sun and the duration of the insolation of the vertical surface of the southern orientation, even more insolation of each apartment is provided.

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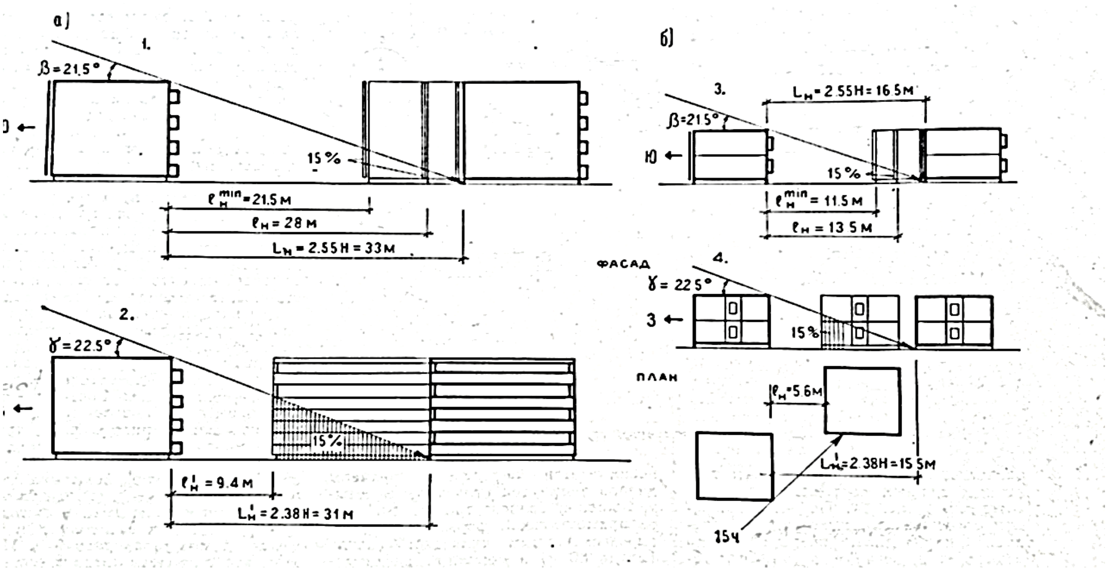
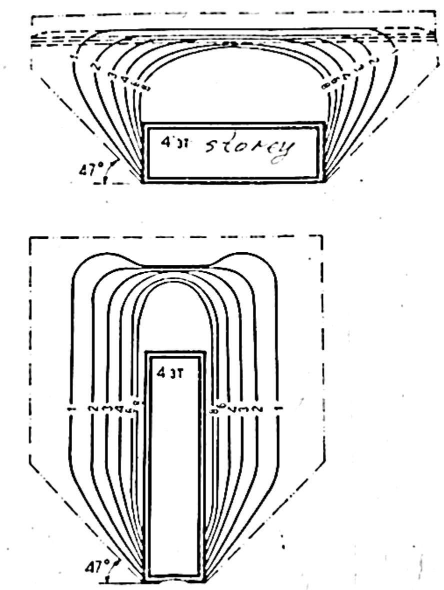


Fig.1. The scheme of determining the necessary breaks Ln and ln (providing respectively overestimated and underestimated criteria insolation helio-facade) between the solar houses in four-story (a) and two-storey (b) solar configuration 1 - between latitudinal houses; 2 - between the latitudinal solar house and the meridional house; 3 - between located on the same meridional axis; 4 - between the located along the diagonal.



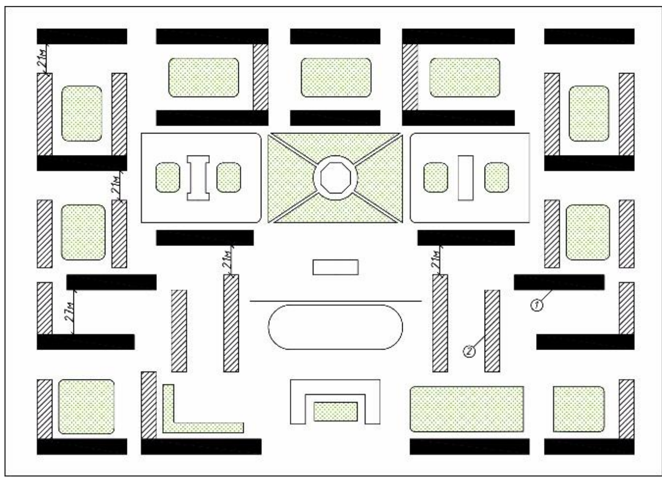


Fig.2. The shading graphs for four-storey
Fig. 3. Four-storey helio construction
helio-houses that provide an overestimated (- - -)1 - helio house; 2 - ordinary houses.
and underestimated (-----) criteria for insolation
of the helio-facade.

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III. LITERATURE SURVEY

The main role in determining the gaps between the facades of houses is played by the provision of standardized insolation of apartments according to sanitary and hygienic requirements. The need for a three-hour insolation was noted by Doctor of Architecture I.S. Sukhanov [4]. Why exactly 3-hour insolation? In the "Petri dish" placed on the window sill for double glazing, E. coli die within 2-3 hours. Therefore, it is so important that each living room in the apartment receives continuous insolation for 2.5 hours. Based on these considerations, the necessary gaps between the facades of residential buildings are established. This suggests that the entire surface of the facade of the house should be insolated for 2.5-3 hours. Since solar collectors for heating must be installed on almost the entire area of the solar facade, the gaps defined by the above criteria meet the requirements of the solar modules. An excessive increase in the gaps between the solar houses to improve the ventilation of the courtyard space and increase heat gains from the sun to the surface of the helio-facade leads to a decrease in the density of residential buildings [6]. The planning structure of the yard spaces (closed or open), depending on the climatic conditions, was considered by the wind regime G.K. Goldstein [7].

The optimal angles of inclination of the solar receiver, depending on the latitude of the construction site and the type of solar receiver, were determined by A.A. Saidov. [3]. For year-round helio-systems, they are recommended to take the angle of inclination ($\propto$) of the solar receiver equal to the latitude of the construction site (β), i.e. $\propto = \beta$. For solar systems operating only during the heating period, the angle of inclination of the solar receiver should be determined by the formula: $\propto = \beta + 20^0$.

For multi-storey solar houses Akopdzhanyan V.A. considers the most effective vertical solar receivers [5]. For low-rise solar houses, architect M. Zakhidov recommends passive solar heating systems with vertical solar collectors and a special home planning solution [8].

Helio-facades of houses should be oriented mainly to the south, deviation to the west is allowed up to 20^0in azimuth. The distance between the solar facade and the opposite northern facade should be taken in accordance with ShNK 2.07.01-03 "Urban Planning" [6].

IV. METHODOLOGY

The peculiarity of the low rate of insolation is that the necessary gap between the helio-houses is determined not only by the height of the sun and the building, but also by the area of the facade of the shaded and shading buildings. For example, between the facades of single-unit two-story solar houses (in plan of 8 x 8 m, the height of the house is 6.5 m) the distance (ln) must be at least 11.5 m. If the shading low-rise building consists of 5 block apartments and more, then ln = 13.5m. The standard value for ShNK for this case is 20 m. As shown by the results of our analysis, the gaps between low-rise buildings established by ShNK fully satisfy the underestimated insolation rate. The required distance (ln) between the latitudinal four-storey solar houses varies from 21.5 m to 28 m (with H = 13m) depending on the number of their sections (facade area). At the rate of ShNK ln for this case is 25 m.

In tab. 2 and 3 show the necessary distances (ln) between four-story solar houses with a certain number of their sections and relative positions. According to the results of tabular data, shading graphs were compiled (Fig. 2). According to these graphs, it is relatively easy to determine the necessary gaps between the four-storey solar houses, solar housesand ordinary residential buildings at their different relative positions.

V. EXPERIMENTAL RESULTS

The results of the analysis show that by observing certain ratios of the number of floors and the number of sections of the shaded and shading solar houses, normative and even smaller gaps between houses can be provided. Perhaps, for example, setting the latitudinal solar houses close to the meridional residential building.

Using the tables and shading graphs, we determined the size of the yards of a closed structure in a four-story solar system. In the courtyard of a rectangular shape between the four-section solar houses(the facade length is 60 m) and the meridional house the gap should be equal to half the height of the lady. If the helium has eight sections or more

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(the length of the facade is 120 m), it is possible to put these houses close. However, such a long house does not create a closed courtyard space. Therefore, to create a closed courtyard structure, a four-story solar houses should have a length of no more than 60 m (four sections). The meridional home can be placed close to such a solar houses if the left and right sides of the solar facade with a width of at least 7 m are free of solar receivers. In the courtyard of a closed structure, such zones of helio-facade are not sufficiently insolated. The missing area of the solar receivers can be reimbursed due to their location on the flat roof of the meridional houses. It is also possible to install solar receivers in the form of inclined bolts above the aisles in the courtyard space.

What densities are obtained in solar control in the case of the application of an underestimated insolation criterion. For this, a four-story building in the Chilanzar district of Tashkent was considered. The choice of this microdistrict is justified by the fact that latitudinal houses dominate here. Without essentially changing the layout of the building, this microdistrict can be reorganized into a helio-tuning, i.e. install solar receivers on the southern facade and roof of the latitudinal sectional houses. It is known that the helio house should be oriented by helio-facade to the south. The density of housing in the neighborhood Chilanzar district was quite high - 3300 m2 / ha. As a result of its reorganization into a helio-construction and the determination of gaps according to the understated insolation criterion, it became possible to increase the number of latitudinal houses, i.e., solar houses, to 20 (Fig. 3). The total number of houses increased by 8 and reached 39. As a result, the density of the housing stock increased by 15% and reached 3,800 m2 / ha. Consequently, in a four-story solar construction, it is possible to achieve a housing density that is not inferior to that of a conventional building.

VI.CONCLUSION AND FUTURE WORK

In the region of oases and foothills, solar construction should be a half-open structure. This requires the inclusion of meridional houses in the building structure. The courtyard space should be opened in the direction of favorable wind speeds (up to 3 m / s) of the warm period of the year. In the desert and semi-desert region, solar construction should have a closed structure. In this case, it is desirable to place meridional houses close to the latitudinal . However, the solution of functional elements, zones (driveways to houses, playgrounds, green areas) of the courtyard space in the desert zone remains little explored.

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My name is Saidov Abdumalik, I am from the city of Tashkent - the capital of Uzbekistan. After completing I studied at the Faculty of Architecture in TashPI in 1973, I began my career as an architect at the design workshop of the TashZNIIEP Institute. Upon completion of the postgraduate full-time and candidate of architecture thesis on the topic: "Features of the architecture of residential buildings with solar heating systems in the climatic conditions of Central Asia" became a senior researcher in the department of science "TashZNIIEP". I was the head of a number of research works in the field of architecture. From 2003 to the present, I am an associate professor at the Department of Landscape Design and Interior at the Tashkent Institute of Architecture and Civil Engineering.