Assessment of insolation at a playground

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Abstract. This article reviews insolation characteristics, favourable effect and harmful impact. Insolation requirements adopted in the Russian Federation make the basis for the examination of insolation. The methods used to analyze insolation in the “City’s Solaris” program are described. The authors share their calculations and analysis results of insolation at a Tyumen playground.

1 Introduction

Present-day urban development, increasing density of population and heightening while reconstructing areas demand to make living conditions comfortable and safe. One of the most important ecological and hygienic factors in town planning studied in [1] is insolation. It improves environment and makes urban space and accommodations comfortable. According to [2] compliance for the requirements of light conditions and insolation is an index of housing quality. Compliance for sanitary norms is obligatory for citizens, independent businessmen and legal entities dealing with planning, construction, restoring and upkeep of objects.

According to the Federal Statistics Service, the urban population of the Russian Federation is 74% of the total population of the Russian Federation and for the last 5 years (from 2010 to 2015) increases by 0.30-0.41% per year. Over the last five-year period, 216.5-306.4 thousand of buildings are annually introduced, incl. Residential use - from 201.7-286.1 thousand, non-residential purpose - from 14.8 to 20.3 thousand.

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Fig.1. Commissioning of residential buildings per 1000 people population m² total area.

In recent years, significantly increased the area of housing, however, this is not enough for Russia, which inherited the still difficult housing crisis of the Soviet era. Thus, the existing rates of development of residential areas of urban areas will continue, which entails the consolidation of existing buildings, increasing the number of storeys of reconstructed and new buildings, increasing the level of congestion in urban transport roads and expanding the street-road network.

Construction of new buildings should not do any harm to built-up areas in terms of illumination. Spacing of buildings is determined by the standards of insolation, illumination and fire safety rules. Thus, it is quite necessary to observe sanitary norms and rules, building requirements as well as territory building norms setting standards for insolation and natural light. Insolation is considered to be an important health factor and should be used in all dwellings and public buildings and in the residential areas. Optimum insolation efficiency, its health, psychological and physiological, bacterial and thermal activities are achieved through everyday 3-4 hour continuous direct sunlight treatment of accommodations and territories.

Local building regulations can be laid out by the authorities of the subjects of the Russian Federation. Approved in one subject of the Russian Federation such documents are not legally binding and can be considered as recommendations. The examples are “Natural, artificial and combined light. MSSN 2. 06-99” and “The standards of outside illumination in urban and rural settlements. LBR 23-330-2002 KhMAD”.

2 Methodology

Learning of regulation and standard technical documentation makes it possible to sum up the main insolation requirements:

- buildings should be designed so as to provide sufficient duration of insolation aiming at creating safe living conditions regardless of term (Federal Act №384);
- standard duration of continuous insolation for accommodations is set for certain calendar periods depending on types of dwellings, functional specification of buildings and latitude;
- standard duration of insolation should be ensured in one room in one- or two-bedroom apartments, and in at least two rooms in three and more-bedroom apartments (SRaN 54.13330.2011);

- standard duration of insolation on the territories of playgrounds, recreation grounds, playgrounds of pre-school facilities should be no less than 3 hours on the 50% of the lot independent of latitude (SRaN 2.2.1/2.1.1.1076-01)

So, providing standard insolation of constructions is realized through the following:

1. Location and orientation of dwellings and public buildings should provide continuous insolation required by sanitary standards.
2. Spacing of buildings is determined by the light conditions and according to number of stories in the opposite building but no less than 2.5 of the height.
3. Insolation routing does not take into consideration some raised parts of buildings.

Location and orientation of dwellings and public buildings (excluding pre-school institutions, comprehensive schools, boarding schools) should provide continuous insolation of accommodations and areas: to the north of 58° of latitude north of the equator – no less than 3 hours a day for the period from the 22nd of April till the 22nd of August; to the south of 58° of latitude north of the equator – no less than 2 hours a day for the period from the 22nd of March till the 22nd of September.

The insolation regime of territories and premises mainly depends on the climatic region of the locality of the locality and can vary according to the regulated insolation time both in the large and in the smaller direction. This is due to the assessment of the effect of the established time of action of the sun's rays on the microclimate of the premises. So, when the established norm is exceeded, the overheating of premises is often observed, which in turn creates discomfort to the population. Most often this occurs in one- and two-bedroom apartments with the arrangement of windows on one side of the building. However, such layouts of apartments in the greater part suffer from a lack of sunlight. Such a violation of the insolation rate is observed in windows directed to the north, north-west, north-east and west directions. In such directions, insolation of living quarters is much lower than the established norm or it is intermittent, which can not have the desired health-improving effect for the microclimate of the room.

Year-round shadowing of facades of buildings and residential areas is not allowed. Semiannual shades (from the 22nd of September till the 22nd of March) should not exceed in general 10% of undeveloped residential areas, healthcare centers in localities to the south of 58° of latitude north of the equator, and 20% to the north of 58° of latitude north of the equator

Single intermittency of insolation in domestic premises is permissible while housing with 9 and more-storied blocks. However, this can be conditioned only by half an hour increase of overall length of insolation during the daytime for each zone correspondingly.

Favorable effect of insolation on sanitary and hygienic atmosphere in rooms is achieved through a bacterial and biological quality of UV light to kill microorganisms or to slow down their multiplication. Hygienic effect of insolation is important for the purpose of letting in some certain daily amount of UV sunlight during some continuous period of time. biological quality of UV light to kill microorganisms or to slow down their multiplication. Hygienic effect of insolation is important for the purpose of letting in some certain daily amount of UV sunlight during some continuous period of time. Getting inside solar radiation forms some sanitary and hygienic conditions which can be either favorable or unfavorable [2,3].

Unfavorable effect is connected with overheating of rooms in summertime. The heat getting inside the rooms with solar radiation through light transmissive and lightproof screens causes air temperature rise inside.

Actual insolation is always different from the theoretical (presumable) one and can be defined only while observing it. Actual insolation depends on housing orientation and layout, aperture of windows, location of rooms, balconies and recessed balconies.

Duration of permanent and interruptive insolation of buildings and territories can be calculated with the help of program complex “City’s Solaris”. It allows to make calculations for any geographic values and for a given date. The program provides opportunities to create, edit, copy objects, change their spatial altitude, and present objects as 3D models.

Calculations of insolation examination can be visualized in diagrams, display of shadows, as well as in drafts with design parameters of insolation of constructions and areas.

3 Results

Tyumen and its green zone are situated in the southern part of West Siberian lowland plain. The climate in Tyumen is not quite favorable for air pollutants dispersion. It is characterized by low annual total insolation. Accumulated temperatures are also relatively low above 10°C. More detailed information can be found in [4].

The city of Tyumen is a dynamically developing city with an area of 698.48 sq. Km. And the population for 2014 697 thousand people. Housing construction in Tyumen is characterized by extremely high growth rates. The forecast of housing construction in the city and its immediate surroundings during the estimated period of the master plan (2025) is based on the expected increase in the rate of housing construction from 400 to 500 thousand square meters. M / year and taking into account the existing demand for the territory for multi-family and individual development in a ratio of 60/40. Such intensive development of the city entails not only an increase in the area of built-up areas, but also a consolidation of the existing urban development, an increase in the number of storeys of the building, and the expansion of the city's road network with increasing traffic congestion.

There has been done a research of a playground situated within the complex of various multistorey blocks of apartments which are common for the city [4]. The examined playground is situated in the western part of Tyumen and occupies an area of 2154 sq.m. The examined area is represented with apartment blocks of different numbers of stories and nonrectangular facades.

Calculations of insolation were conducted with the help of “City’s Solaris” program during the normative dates (March 22, June 22, September 22) on the days of solstice. Calculation time was chosen according to the function of the object, namely, children’s walk hours – in the morning and in the afternoon (Figures 2,3).

Also, insolation in residential units was calculated. Residential units compose a dwelling complex around the playground. The results allow to conclude that not all examined residential units have comfortable light conditions. Many windows of the apartments situated below the fourth storey are shadowed for most part of the daytime. This situation has a negative impact on the layout design of the given apartments. It can be supported by the data in [5,6].

Fig. 2. The model of the playground shade on the 22nd of September at 11 a.m.

Fig. 3. The model of the playground shade on the 22nd of September at 4 p.m.

4 Discussion

House insolation requirements are not the same in different climatic zones. In southern regions where long lasting heat provokes an abundance of solar irradiation, house insolation in summertime is a negative factor. It can be favorable in relatively cold periods. In the central part of Russia insolation of residential units, childcare and healthcare facilities from March to September is considered obligatory [4]. As for the rest period, insolation is advisable. In northern regions which lack solar irradiation it is necessary to use a favorable effect of house insolation to a full degree.

Conditions of year-round shadowing are calculated proceeding from the day of summer solstice (June 22). Conditions of semi-year shadowing depend on the days of the vernal equinox and the autumnal equinox (March 22, September 22).

Insolation and natural light are important elements of comfortable environment of the apartment.

Good natural light and house insolation demand a calculation procedure which allows to determine spacing of buildings conditioned by natural light. That is especially topical in Tyumen region in terms of dynamic development of towns and settlements. Thus, correct calculations of insolation are important for development plans of the territories.

5 Conclusion

Insolation analysis of the playground in one of the developing Tyumen districts has revealed that insolation regime at the playground is observed only in the afternoon. That is proved by the models of shadowing of the examined lot in the mentioned periods. The models were formed in the program “City’s Solaris”.

Thus, similar territory observations at the outset of the project make it necessary to recommend to limit number of storeys in designed structures, and to change the functional purpose of the area. .

Taking into account the factor of insolation in developed areas will have a positive effect on health and workability of population. It may reduce sick-leave costs and costs on medical treatment of children and grown-us.

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