Architectural and Urban Planning Microclimate Evaluation for Vladivostok City Area

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Abstract. Many factors are impacting our comfort feeling in the city, and in physical sense climate has a critical importance: the solar radiation and the wind are making serious adjustments to thermal acceptability perception. These particular vector climate factors can be controlled by the means of architecture and urban planning in the most effective way. Computer modelling of air flows and insolation allows to conduct the comprehensive aerial assessment and to differentiate territories with respect to climate comfort characteristics. In Vladivostok conditions with its complex terrain and strong winds this kind of analysis is very important as a potential basis for the city planning regulation standards regarding specific climatic features. The research was conducted for the space-planning regulations development (consulting bureau “Strelka”) under the order of foundation for the housing development sector elaboration in 2018.

1. Introduction
Vector climatic factors, as sun radiation and wind, are the most appropriate for the architectural and urban planning regulation. Different climatic zones vernacular architecture’s spatial features appeared as a result of direct regulation of air flows and sun rays for creating comfortable temperature-humidity conditions of open and inner spaces. Architectural materials and colors were the means for additional correction and creation of comfortable temperature-humidity regime.

So, the analysis of microclimatic changes of the wind and sunlight regime annual variation should underlie Vladivostok microclimate evaluation for architectural and urban planning goals [2, 4].

2. Methods
Among the diverse opinions, most specialists suppose that the wind speed higher than 4-5 m/s would be uncomfortable in the moderate climate zone (figure 1) [1, 3]. As the wind is the main discomfort factor, the mentioned wind speeds will demand special urban and spatial planning techniques to decrease them. In contrast, low wind speeds during the hot and humid weather are connected with the demand for creating such kind spatial situations, which will allow to save aerating effect. In the first case wind is a main discomfort cause, while in the second it’s a main factor for creating favorable temperature-humidity environmental conditions.

During the sunny winter, solar warming is an important element of creating comfortable regime in the built-up environment. In the climate conditions of Primorye region this factor can provide 50% and more of building demand for heating energy [4], and also correct the open spaces temperature regime,
in conversion to complex measurements for 5-15°C. This possibility is totally eliminated for shaded slopes. Summer overheating is also first of all adjusted with restriction of extra solar control. In the first case at wintertime solar radiation is favorable, while in the second it’s a main discomfort cause.

So, the terrain areas with permanent winds and still areas, sunny slopes and fully shaded even in summertime – all these location types are distinguished by contrast requirements for the spatial characteristics of the designed environment.

The evaluation method was developed in 1992 (Moscow, MArchI) and published in the scientific publications [2, 3]. It was approved while conducting the assessment of Peter the Great bay islands bioclimatic comfort for the Vladivostok masterplan pre-design works (2006, Pavel A. Kazantsev).

Figure 1. Summary diagrams of equivalent and radiation-equivalent temperatures; according to Yu. Gubernskyi, V. Litzkevich, G. Muravyova, V. Pivkin, N. Remizov, V. Scheleikhovskiy and A. Yakovlev.

3. Results
As a result, the wind regime features allowed to define the following area types (figure 2):

- Terrain areas, protected from the winds at any season, where either northern nor southern wind speed during the year is not raising higher than 4 m/s level (lowlands, hills bottoms, landforms hidden by higher uphill, not depending on the slope orientation)

- Terrain areas predominantly influenced by one of the monsoons – southern summer wind or northern winter wind (also not depending on the slope orientation)

- Terrain areas opened to both northern and southern winds with predominant speed 5m/c and higher during all the year (usually hilltops, watersheds and crests, not depending on the slope orientation)

The wind regime evaluation was fulfilled with the air flows computer modelling method using the Autodesk Flow design software and Murav’ev-Amursky peninsula terrain 3D-model (Yana V. Marus and Egor A. Van-Kho-Bin). The modelling results were revised with the data of Construction Climatology Laboratory of the Far-Eastern research institute [4].

The solar regime evaluation was intended for finding out the city areas with the lack of solar radiation at wintertime, where the possibilities of solar heating usage during the cold season are severely restricted. First of all, these areas are the northern slopes with the incline more than solar elevation between 9 and 15 o’clock in December and in 20th of November-January, and also differently oriented slopes shaded by the adjacent landforms.
For the overheating weathers evaluation was fulfilled by the direction of heliometric axis (sun azimuth in the moment of maximum daytime temperatures) for the 20th of July and August. Discomfortable overheating conditions in July-August will first of all take place on the terrain areas explored by the direction of heliometric axis, while shaded at the same time of day northern-eastern slopes will be the most climatically comfortable.

The insolation regime evaluation was also fulfilled with the computer modelling method using the Murav’ev-Amursky peninsula terrain 3D-model (Yana V. Marus and Egor A. Van-Kho-Bin). (figure 3).

Figure 2. The wind regime annual variation. Figure 3. The insolation regime annual variation.

4. Discussion
The schemes of wind and insolation regime seasonal changes show aerial binding of urban planning structure and architectural environment spatial characteristics requirements (figure 4 a), b); the seasons durations defined according to monsoon winds changing [1]).

During the winter season monsoon is definitely discomfort climate factor, while the sun radiation is definitely comfortable factor. Whereas, summer season has more complex circumstances: during the first stage of monsoon forming (from the end of March until the beginning of July) the south-east monsoon stays the discomfort condition, but since the middle of July (the second stage is from July up to the beginning of September) this wind is needed for ventilation. In the same way the sun heating energy is comfortable during humid cold summer period, while it’s radically uncomfortable during humid hot weather.

The evaluation of the wind and insolation annual variation (figure 4, c)) allows to define the spatial limitations for developing different terrain areas in connection with specific climate conditions features of the city area, and also can be used as a basis for bioclimatic comfort estimation of definite areas.

The most discomfortable areas are the slopes hidden from solar radiation by adjacent uphill in winter and opened to winds both in winter and summer. These areas are little more comfortable under the light southern winds: the humidity of areas closed from wet winds during summertime is much lower. If the areas opened to winds of all directions all year round are lighted by the low winter sun their comfortability is much higher. Mutually, the comfort value would be higher for areas opened to winds and lighted by the sun in winter, but protected from humid summer winds. Areas protected from the winds all year round, but shaded in winter, and areas where the strong summer wind is added, are not so widely spread in the city area.

The city terrain altitude should be regarded as an additional factor: the recommended elevation points level higher than 200 m were changed on the base of data analysis to level higher than 150 m (cloudage bottom elevation, temperature and humidity gradient) [4]. And also the factor of landform
opening to the water area from the side of south-eastern wind exposure, which causes additional humidity and heat loss in the first stage of summer monsoon forming (seaside slopes along the Ussuriyskiy gulf, which are opened to south-eastern wind).

![Figure 4.](image)

Figure 4. a) the microclimatic dynamics of wintertime (November-December) insolation and wind regime; b) the microclimatic dynamics of summertime (April-August) insolation and wind regime; c) cumulated scheme of the microclimatic dynamics of annual insolation and wind regime.

5. Conclusions

The fulfilled architectural and urban planning evaluation of Vladivostok city area microclimatic characteristics is a basis for elaboration of the spatial requirements for architectural development, which are based on vector climatic factors. This kind of analysis would underlie the design of a comfortable city spaces continuous system in monsoon climate conditions of Far-Eastern region south. Preliminary it can be enclosed that the optimal development type in the context of strong winds and complex terrain common for Vladivostok would be low-rise indiscriminate development. The buildings height should not be higher than wind-protecting broadleaved trees massifs in the city and suburbs. Also the height of Manchurian fir treelines sprouted in Vladivostok before 1860 [5].

The research was conducted for the “Vladivostok pace-planning regulations” development (consulting bureau “Strelka”, (Moscow) under the order of foundation for the housing development sector elaboration in 2018.

6. References

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