Development of recommendations on the planning structure and street design in the cities with cold climate

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Abstract

Urban settlements located in cold regions have their own specific features related to climatic conditions. Winter, which can last for several months a year, affects the daily life of the population. Precipitation in the form of snow, low air temperature, short daylight hours, strong wind, ice – all these climatic features accompany the activities of people in cities with such climates and form their habits. Thus, these features compel urban planners to seek solutions that meet the needs of people living in cold climates. In Russia, the climate, namely, the presence of a long and cold winter, strong wind and insolation insufficiency, is almost never taken into account when designing or improving territories. As a result, streets are unsuitable for a comfortable city life in winter.

In this paper, the problem of imperfection of Russian city-planning standards in the field of space management and planting is considered. The purpose of this paper is to analyze the Russian and foreign standards for city design in cold climates. The report contains the results of an analysis of Russian regulatory documents in the field of street design; the results of a comparison of these documents with documents from Finland, Canada, and the USA; a list of recommendations for adding new and improving existing aspects of street design in Russian regulatory documents.

1. Introduction

Creating an urban environment in which it would be comfortable to be outside at any time of the year is an important, yet challenging task. This is especially true for cities located in areas with cold climates. The more time people spend in the open air, the better it influences their mental health (Beyer, Szabo and Nattinger, 2016). Active street life helps residents build new social ties, while the city economy thrives on taxes collected from small businesses and rising real estate prices (Lee, 2014). Moreover, regular physical activity, including walks, positively affects health, reducing the risk of developing a number of diseases. Winter is accompanied by heavy snowfalls, short daylight hours and long periods with temperatures below 0 degrees Celsius. Severe climate in such periods can significantly limit outdoor activity and affect the availability of the urban environment. People spend most of their lives indoors, which makes streets lifeless. In addition, urban transport is limited to the use of motor traction, and a large amount of snow creates numerous problems in ensuring pedestrian motion safety and road maintenance. On the other hand, a prolonged winter in cold regions provides a number of opportunities for organizing leisure activities, for example, holding winter festivals, developing winter sports or other activities related to snow. These benefits can be used in cities of subarctic areas to offer residents a special category of entertainment not typical for cities in temperate regions.

Nevertheless, in the northern latitudes it is quite difficult to make it comfortable to stay outside – in winter people can spend 70-95% of their time indoors (Pressman and Zepic, 1986). In this regard, it is important to make efforts to improve the aspects of urban planning and space management which will make it comfortable for people to stay outdoors even in winter, namely, to walk, organize leisure, communicate, and visit various facilities. It is necessary to effectively use knowledge on the urban climate in the field of street design and improvement.

In Russia, street design and improvement is regulated by federal and local guidelines which were developed back in the 1960s and were called Building Norms and Rules (Russian “SNiP”). Updated revisions of SNiP were called Codes of Rules (Russian “SP”), however, their content remained practically unchanged. Analysis of existing Russian city planning standards showed that they cover improvement superficially; some of the aspects considered are not related to each other and do not provide an integrated approach to space management; many rules and recommendations do not take into account the climatic characteristics of the area. At the same time, more than 60% of the territory of Russia is in the permafrost region, and the average annual air temperature in the country is -5.5 °C. For example, in the eastern part of the Sakha Republic (subarctic climate zone), in Chokurdakh, the temperature is below 0 degrees for more than half of the year. At 93.1% of Russia's area, average temperature of the coldest month of the year is below −10 °C, and at 82% of Russia's area average temperature of the coldest month of the year is below −15 °C. In many cities, average temperature in winter is not lower than −20 °C, for example in Belgorod (−5.9 °C), Veliky Novgorod (−7.7 °C), Vologda (−9.7 °C), Kirov (−11.9 °C), Orenburg (−10.9 °C), Smolensk (−5.9 °C). Thus, improvement of many Russian cities needs to take into account the peculiarities of the cold climate.

The main purpose of this work is to compare Russian and foreign guidelines and regulations on space management and improvement in cities. Comparative analysis will identify gaps in Russian regulations and, in future, help develop specific amendments to city planning legislation based on relevant experience of other countries with a similar climate.

2. Scientific background for urban planning and improvement in cold climates

International scientific community has paid attention to urban design issues considering natural and climatic conditions since the 1980s. For example, N. Pressman and X. Zepic in their work "Planning in Cold Climates: A Critical Overview of Canadian Settlement Patterns and Policies" attempt to identify a range of problems related to the winter season in the urban environment (1986). The main goal of the work was to develop strategic approaches that would be able to minimize the consequences of the winter season for people and urban life in Canada. Professor I. Eliasson in her article "The use of climate knowledge in urban planning" came to the conclusion that, in spite of the availability of information on the local climate for urban planning, in most cases this data is not organized and actually stays uninvolved in city planning (2000).

In the 21st century, thanks to the spread of the Internet, the number of available publications on problems of urban planning in areas with cold climates increased. Studies began to be published on cities and countries that had previously paid no attention to climatic characteristics in urban planning. For example, the article "Climate-Sensitive Urban Design in Cold Climate Zone: The City of Erzurum, Turkey" presents the results of a study of adaptability of urban environment components in the Turkish city of Erzurum (street orientation, typology of building, planting, improvement, etc.) to cold climate conditions. According to the results of the study, the author states a set of decisions and recommendations that, if they are taken into account in city planning processes, can affect the adaptability of streets to the winter season (Dursun, 2015). In addition to expanding the geography of research objects on this topic, research works emerge on specific elements of urban environment and their adaptation to the cold climate. In "Urban Drainage In Specific Climates," C. Maksimovic analyzes and classifies the problems of design and operation of drainage systems in a cold climate in the case of Scandinavia (2000). Among modern studies on problems of urban planning in cold regions, we can mention the work of Saeed Ebrahimabadi on considering climatic factors in urban design (2015). Essi Oikarinen's analysis of concepts in the approach to climate-aware urban planning and design in the northern climate is also noteworthy (2014). Peter Bosselmann, Edward Arens, Klaus Dunker & Robert Wright studied the impact of the current layout of Toronto on the manifestation of weather factors (1995). Patrick J. Coleman in "Pedestrian mobility in winter" explored the

problem of pedestrian activity in the winter period and considered a number of approaches and solutions for stimulating walking in the cold season (2001).

In Russia, the problem of climate-aware urban improvement has not been studied, in contrast to construction issues in cold climates, as evidenced by a small number of studies on this topic. For example, A. Klochko, PhD, in "The Impact of Climate Change on Architectural Urban Design and Regulation" focuses on the need for further analysis and revision of building norms and standards, taking into account the climate in Moscow (2013). Another work that can be mentioned here is "Specifics of Design and Construction of Low-Rise Buildings in the Arctic," where Professor Yu. Varfolomeev compiles a list of changes recommended for inclusion in SP 42.1330.2016 in order to improve current legislation in the sphere of urban planning (2014). His conclusions are based on the results of a 30-year study of construction and operation of low-rise buildings in the Arctic zone of Russia.

Despite the fact that scientific interest in the problem of urban planning in cold climates continues to grow, available research is rarely used directly in urban design and improvement. Scientific research in this area is not given due attention. City authorities often face a number of limitations: lack of knowledge and tools, political peculiarities, other priorities in planning practice, economic situation. An analysis of the research background on this issue showed that most publications are aimed at structuring knowledge in the field of urban planning in view of climatic characteristics in order to apply this knowledge in future practice. In other words, setting the principles and rules for urban design in cold regions should serve as the basis for improving official standards and introducing new solutions in the field of planning and improvement.

3. International experience in urban planning in cold climates

The climate in some regions of Canada, USA, Finland, and Russia is similar. In these countries there are many cities with long and cold winters, plenty of snow and wind. In Russia these are Murmansk, Yakutsk, Syktyvkar, in the USA these are cities of Alaska, such as Anchorage and Juneau, in Canada – Edmonton and Fort St. John, in Finland – Helsinki and Oulu. The list is not limited to these cities only. In any of the countries under consideration there are settlements with an average winter temperature from 0 down to −15 °C, with extreme cold, and heavy snowfall. Thus, it is permissible to consider the experience of the USA, Canada and Finland when developing recommendations for improvement of Russian standards. Borrowing experience will make it possible to adapt proven practices and simplify the development of guidelines for Russia.

3.1 Regulations for improvement in cold climates in the USA, Canada, and Finland

Emma Sanborn in her work “Integrating Climate Sensitive Design Principles in Municipal Processes: A Case Study of Edmonton’s Winter Patios” views the development of climate-aware urban planning in the context of Canada (2017). Starting from the 2000s, the focus of urban planning has begun to shift towards climatic characteristics, ecology and cultural diversity. Improvement of the urban environment has become an important aspect of city planning policy at the local level. Various guidelines and recommendations focused on the problem of designing an environment for cities with cold climates have begun to appear. For example, a set of recommendations for improvement to be used in the design of urban areas has been developed for the city of Edmonton. The document covers a wide range of aspects: the location of buildings, the layout of the street grid, the design of facades, creation of public spaces, arrangement of public transport stops, planting. Despite the fact that the document is not an official guide, the recommendations contained in it can be used to resolve various issues in the field of urban planning.

For the city of Fort St. John, a set of recommendations for designing the urban environment has also been developed. The document describes such aspects as the use of materials and colors, planting, improvement of public areas, parking planning. For the cities of Thunder Bay

and Vancouver, similar guidelines have been developed, the use of which is recommended when designing an urban environment where the climatic characteristics are of high priority. As can be seen from the above analysis of sources, in Canada there is vast experience in studying the problems of improvement in cold climates, as well as in developing special regulations.

The experience of the USA in climate-aware design and improvement is well reflected in the documents regulating the city-planning activity in Anchorage, Alaska. For example, in the regulations for street improvement and landscape design, attention is paid to greenery planting: plant species should be selected taking into account the characteristics of the climate in the region; evergreen plants that can relieve the winter landscape and offer protection from the wind are recommended for use; in winter it is recommended to use fences protecting trees and shrubs during mechanized cleaning of the site; when planning the territories, planners have to provide zones for storing snow during winter cleaning; in doing this, it is necessary to find a compromise between the convenience of movement for pedestrians and cars and the need to store snow; also, planners are required to provide for possible winter activities that can be organized in popular areas of the city – their size should allow for making a ski track or building an ice rink. As the USA has only a small number of areas with a harsh climate, this country has less experience in developing climate-aware standards and guidelines than Canada.

In Helsinki, Finland, street improvement is regulated by an official guideline. The document contains instructions on how to design, organize and maintain streets to ensure a high-quality urban environment. However, with regard to climate-aware improvement, it only states that outdoor furniture should be located so that the area around it can be mechanically cleaned. The remaining aspects are only covered superficially. Since regulations and official documents in Finland are written in Finnish, it prevented us from analyzing the experience of Finland in climate-aware design and improvement in detail.

Based on the results of the search for studies and standards for improvement in the 3 mentioned countries, it was decided to thoroughly study the experience of Canada and apply it in developing recommendations for enhancing Russian standards for design and improvement. It is in Canada that official and unofficial regulations for different cities are developed with detailed consideration of the basic aspects of improvement. In addition, the largest number of sources found are devoted to the problems and experience of Canada in the field of climate-aware design and improvement. The Canadian climate is characterized by cold winters and cool summers due to the geographic location of the country. In the north of the country, polar climate prevails. On the territory of Canada, there are cities located in subarctic zones with a relatively low average annual temperature and abundant precipitation in winter. For example, in Brandon, Winnipeg, Edmonton or Whitehorse, average monthly temperature in winter can drop down to −15 °C even in the southern part of the country, although you can as well expect temperatures of about −40 °C with strong ice-cold winds. Average annual temperature in some Canadian cities is the same as in many Russian cities.

3.2 Regulations for improvement in cold climates in Russia

According to Russian legislation, city planning regulations (SP and GOST), including ones on improvement, are divided into mandatory and voluntary. The mandatory regulations are mainly technical regulations that set minimum requirements necessary to protect the life and health of citizens, ensure environmental protection, fire safety, etc. In this work, we analyzed the regulations aimed at aspects of improvement and space management. In order to describe the situation more accurately, we divided the aspects found into two groups, depending on the mandatory or voluntary nature of the regulation in question. The mandatory standards for improvement which take the climate into account are listed in Table 1.

Regulatory document	The statement of the aspect
SP 34.13330.2012 "Automobile roads"	Climate zoning should be considered in roadway construction
SP 42.13330.2016 "Urban development. Urban and rural planning and development"	The planning pattern should be developed in view of natural and climatic conditions
	For areas north of 58°N, the dimensions of residential areas may be reduced but not more than by 30%
	Distance from pedestrian walkways to the nearest public transport stop should be reduced to 300 m or to 400 m depending on the climatic conditions
SP 52.13330.2016 "Daylighting and artificial lighting"	Lighting of the roadway of streets, roads and squares of urban settlements located in the northern climatic construction zone of the Asian part of Russia and north of 66°N in the European part of Russia should be designed based on the recommendations listed in the document

Table 1: Mandatory regulations for improvement taking into account climatic characteristics

The list must be supplemented with optional regulations, which are presented in Table 2.

Regulatory document	The statement of the aspect
SP 42.13330.2016 "Urban development. Urban and rural planning and development"	Public spaces should be provided in residential areas taking into account natural and climatic characteristics
	The density of residential and business buildings should depend on natural and climatic characteristics

Table 2: Non-mandatory regulations for improvement taking into account climatic characteristics

As can be seen in Table 1 and Table 2, there are very few aspects in federal legislation that emphasize special requirements for design in cold climates, and they mainly contain general guidelines without details. There is no systematic approach to the consideration of climatic characteristics in design and improvement either in mandatory or in voluntary regulations.

In addition to federal regulations that control city planning throughout the country, there are local regulations for individual regions or cities. Local regulations are necessary to clarify the federal ones and to cover the missing aspects. In order to identify aspects of climate-aware improvement in local regulations, several cities were selected that belong to the same climatic sub-area of Russia, have similar climatic characteristics, are capitals of their regions and have publicly available documents. The results of identifying such aspects are given in Table 3.

City	Average winter temperature	Local regulatory document	A suitable aspect
Syktyvkar	−12.8 °C	Local standards of city-planning design of Syktyvkar	The following aspects are taken into account in the design of small architectural forms (SAF): Correspondence of SAF materials and design to the climate and the purpose of the SAF
			Protection against frost and snow drift, ensuring water drainage
			Convenient maintenance, as well as mechanized and manual cleaning of the territory near the SAF and under the building
			Cleaning of the territory in winter
Yakutsk	−36.7 °C	City improvement rules for Yakutsk	To protect pedestrians and protruding glass shop windows from snow and icicles falling from the edge of the roof, it is recommended to install special protective nets at the level of the second floor. To prevent icicle formation, the use of an electrical circuit along the outer perimeter of the roof is recommended.
			Cleaning in winter
Murmansk	−9.3 °C	City territory improvement rules for Murmansk	As unfavorable climatic factors affect different parts of the city, protective green areas are formed
Vorkuta	−18.8 °C	City territory improvement rules for Vorkuta	Removal of snow and ice during winter cleaning; snow storage; snow disposal; clearing of icicles
Irkutsk	−16 °C	City territory improvement rules for Irkutsk	Materials for advertising boards should be used in view of climatic characteristics
			Specifics of territory cleaning in winter: cleaning technology, frequency of cleaning, snow storage

Table 3: Results of the analysis of local standards for improvement and space management

As can be seen in Table 3, local regulations complement the overall list of aspects that take into account the climatic factor. Nevertheless, all the listed aspects are mentioned superficially, no recommendations for compliance are given. In order to specify the shortcomings and gaps in the Russian regulations, it is necessary to compare them to foreign documents.

4. Comparison of Russian and international regulations for improvement

In order to determine what aspects of design and improvement in Russian regulatory documents need to be enhanced, it is necessary to highlight the existing aspects in federal and local documents. Such aspects are presented in Figure 1.

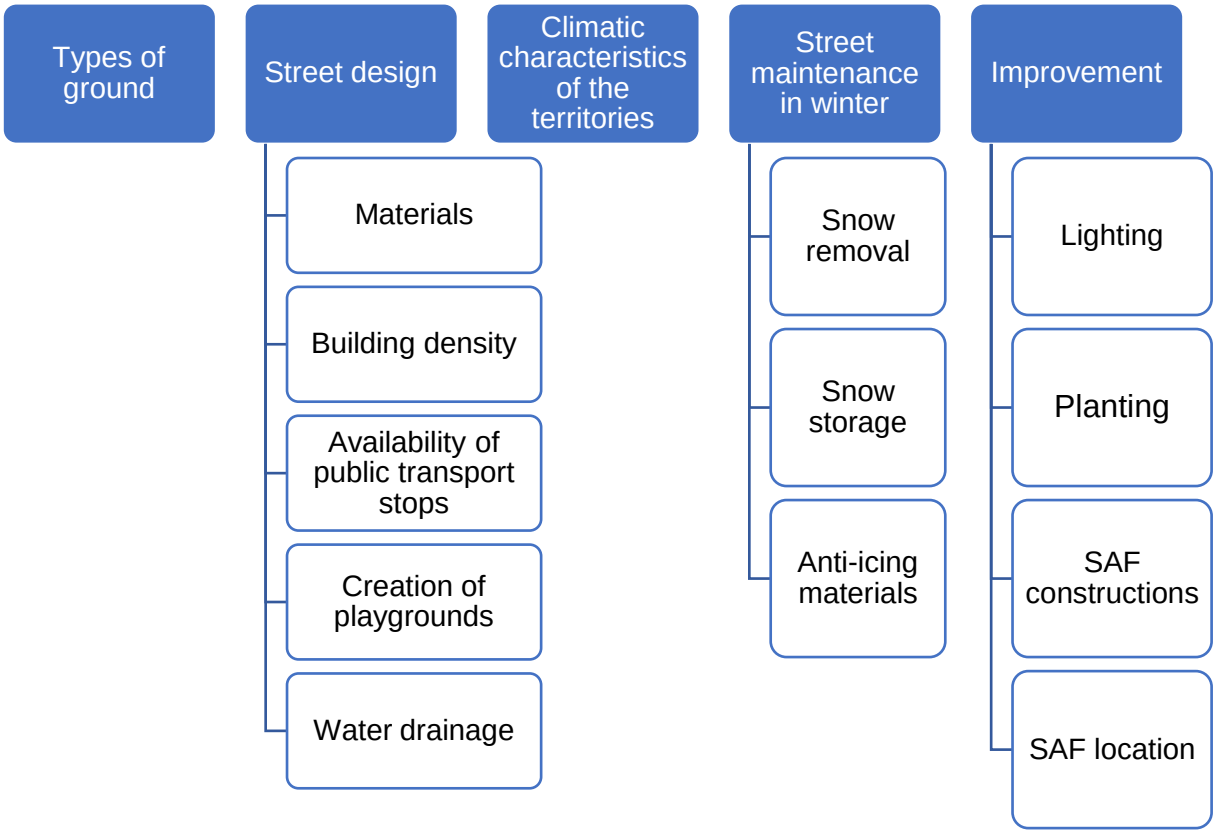

Figure 1: Aspects of improvement and design covered by Russian regulations

Most of the design and improvement aspects listed in Figure 1 need to be enhanced. The aspect of street maintenance and cleaning in winter is covered in most detail, including rules for cleaning frequency, places for storing snow, protection from ice and slippage, cleaning technologies, requirements for mechanized cleaning, protection of pedestrians from falling icicles. For this aspect, a recommendation can bed borrowed from the Anchorage improvement regulations, where it is recommended to fence off greenery in winter in order to prevent it from being damaged during mechanized snow removal. In general, the aspect of cleaning and maintaining streets in winter is covered in detail in the Russian regulations, but the recommended technologies are outdated compared to those used in other countries.

The aspect of street improvement is covered superficially in the Russian regulations, so they can be enhanced by borrowing a number of recommendations from international regulations, namely: Edmonton Winter Design Guidelines; Fort St. John Winter City Design Guidelines; Vancouver Street Restoration Manual; Thunder Bay Urban Design and Landscape Guidelines; Anchorage Design Criteria Manual. The following recommendations can be used to enhance the design and improvement practice:

1. Planting. Recommendations for the use of certain plant species that are suitable for cold climates, including evergreen plants; using greenery to protect streets from the wind; protecting plants from damage during mechanized cleaning.
2. Design of sidewalks. When designing sidewalks, it is important to provide for snow removal in winter. Sidewalks need to be wide enough for mechanized cleaning. In addition, buffer zones should be provided for temporary storage of snow, otherwise snow will accumulate on the sidewalk and reduce its walkability. In addition, it is recommended to use surface materials for roads and sidewalks that are easy to clean from ice and resistant to reagents. Innovative technologies should be used in the field of urban environment design, for example, heated sidewalks can prevent the accumulation of snow and ice.

3. Designing intersections and pedestrian crossings. It is recommended to ensure good visibility of signs and traffic lights at the intersections, so that they are always noticeable in periods of short daylight. It is recommended that the phases of the red traffic signal be shortened so that pedestrians do not have to stand in the cold air for a long time. The roadway in the pedestrian crossing zone must be narrowed to provide pedestrians with the shortest possible trajectory of movement. Elevated pedestrian crossings should be used to avoid the accumulation of snow and water on them.
4. Lighting. In conditions of short daylight hours, it is recommended to use good lighting of sidewalks, motorways, bicycle lanes, public transport stops, pedestrian crossings. At the same time, it is important to develop such a lighting system that electricity is used efficiently and the maximum amount of light is delivered in periods of poor visibility. In winter, additional lighting can be used for trees and facades as part of city decoration.
5. Public spaces. It is recommended to install screens for wind protection, gas heaters and other heating structures in order to make it comfortable to be outdoors. Public spaces, such as parks, should be multifunctional and provide an opportunity to organize winter activities in them.
6. Outdoor furniture. It is important to install outdoor furniture from materials with low heat emission, so that it is comfortable to sit on the furniture at any temperature. It is recommended to place seats and leisure facilities in such a way that the wind blows in the back. In addition, surfaces should preferably be deigned in such a way that accumulated snow is easy to scrape off. Outdoor furniture should not prevent snow removal, so its location is important. It is necessary to provide places for seating with temporary roofs or canopies so that people can stay outdoors during snowfalls. Movable outdoor furniture is suitable, so that people can move it and always be under the sun or stay protected from the wind.
7. Navigation. Urban navigation should be as informative as possible, namely, important directions and an approximate time to the destination should be displayed. It is important to provide an option for changing the content of the signs, so that new directions can be added in winter. By default, signs should be well visible in the dark and during snowfalls, and have such a form that they don't accumulate snow on their surface.
8. Public transport stops. Providing stop shelters with panels displaying transport arrival time will make waiting more comfortable for passengers. In extremely cold regions it is recommended to make enclosed shelters to protect passengers from cold temperatures and wind.
9. Seasonal activity. Winter provides an opportunity to organize seasonal activities, such as festivals and sports events, which will ensure active street life throughout the year.
10. Drainage systems and water removal. In periods of warming after negative temperatures, a large amount of water emerges, which must be removed in a timely manner from streets, sidewalks, roofs and public spaces.
11. Street art. Placing permanent and temporary art objects stimulates traveling around the city and spending time outdoors even in winter.
12. Building. It is recommended to plan the building process in such a way that the distances between residential houses and social objects are minimal. At the same time, the location of buildings should consider the wind chart and insolation. Streets should be protected from the wind and illuminated by the sun as much as possible.

5. Conclusion

In this work, we have managed to analyze the Russian experience and the experience of the USA, Canada, and Finland in improvement and space management. Regulations, official and unofficial guidelines, research works and reports have been studied. A comparative analysis

of Russian and foreign regulations has made it possible to identify aspects and directions in improvement that are not currently taken into account in Russia, or require further elaboration and specification. As a result, a list of 12 directions with brief characteristics of each direction has been compiled. At the next stage we plan to work out solutions, technologies, regulations, and rules: a guideline will be drawn up with specific recommendations on street design, space management and improvement. The resulting guideline can be used as a comprehensive manual for architects and planners in Russia and other countries. Based on the recommendations included in it, amendments to official federal and local city planning regulations will be developed.

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