

Characteristics and perspective of urban construction development in the Arctic zone (using the example of the City of Yakutsk)

The Sakha Republic (Yakutia)

The Sakha Republic (Yakutia) is located in the northeastern part of the Eurasian continent. The total area of the continental and offshore territory of the Republic represents 3,103 km². Over 2/5 of the territory is beyond the Arctic Circle. In length, Yakutia covers 2,500 km, in width 2,000 km.

The distance from Yakutsk to Moscow is 8,468 km.

The largest part of the Republic is mountains and plateaus, representing over 2/3 of the area. Only 1/3 of the whole territory is flatlands.

Almost all the continental part of Yakutia is covered by permafrost. The average thickness of the permafrost layer represents 300-400 m, and in the Vilyui river basin up to 1,500 m, or the deepest reach of the permafrost into mountainous terrain on the planet.

The climate is extremely continental, with long winters and short summers. The maximum amplitude during the year ranges between 85 and 100 C.

The territory of Yakutia covers four geographic zones: the taiga or boreal forest (almost 80%), the tundra, the forested tundra and the Arctic desert.

Over most of the territory of Yakutia one can find over 100 various types of minerals, such as gold, diamonds, lead, coal, oil, gas, mica and others.

The diamond industry occupies a predominant position in the mining industry of the Republic. The Yakutia diamond province is the largest in Russia, and holds 90% of reserves and 95% of the total production.

In today's conditions, the energy sector is of great strategic and economic significance (coal, gas, oil, condensate). There are today 900 exploited fields for bituminous, wood, coke coals and other types of coals. The total reserves of coal down to 1800 m deep are estimated to be no less than 10 trillion tons.

The Sakha Republic (Yakutia) includes 35 administrative and territorial units: 34 ulus (districts) and 1 city (with adjacent territories), Yakutsk. The ulus (districts) in turn are divided into "nasleg" or boroughs, the total number of which is 365, including 31 considered as ethnic or indigenous boroughs.

The capital of the Republic is the City of Yakutsk, founded in 1632 by Russian explorers on the middle reaches of the Lena river, is today an important administrative, political, economic, cultural, scientific and educational center in the northeast of Russia.

The total number of cities is 13. The main centers founded in the 17th century are Vilyuisk (1634), Olekminsk (1635), Verkhoiansk (1638) and Srednekolymsk (1644), which are by right some of the oldest Siberia cities.

As of January 1, 2002, the population of the Sakha Republic (Yakutia) represented 982,400 inhabitants. Notwithstanding its size, the Republic is characterized by a low population density: during the last century, from the start of the century to the end, the average density was dozens of times lower than in the European part of Russia. The population of Yakutia lives in 676 settlements, most of which are rural (601). Nonetheless, 65% of the population of Yakutia lives in cities and working villages.

The City of Yakutsk

The City of Yakutsk is one of the first cities in Siberia. The first mention about the Lena banishment prison goes back to 1632. Yakutsk started playing an important role for the Russian government starting already in the 17th century. The city served as a military and political hub for all of Northeastern Asia. From here, military expeditions were sent in many directions to discover new territories.

Today, the City of Yakutsk, the capital of the Sakha Republic (Sakha), is a large administrative, cultural and scientific center in the Republic and occupies a dominant place among the cities of Eastern Siberia.

The City is located on the middle part of the Lena river, quite far from other large cities. It is located exactly in the center of the Republic, and at the crossroads of the main federal transportation highways (waterways, highways, airways and railroads).

The advantageous geographic location of the City creates conditions to make it into a large transportation hub with a significant capacity to transfer freight from one type of transportation to the other, which dictates its future development.

The City of Yakutsk is the largest city in the Far North on the planet. For comparison, let's note that Fairbanks in Alaska (USA) has about 80,000 inhabitants, Norilsk 200,000, Yellowknife in Canada about 20,000.

Yakutsk, like all the Republic, is on a zone of extreme continental climate and permafrost, at 62° N, and on the left bank of the Lena, in a large valley called "Tuymaada" (the valley is a flatland, formerly the bed of the river). Tuymaada can hardly be called a proper place to build a city. The lack of sloping terrain and drainage divides means that the area is mostly swampy. The low lay of the land is the reason why a large part of the basin and some areas of town get flooded every spring.

Multiyear observations show that the average annual temperature in Yakutsk is -10.2 °C. The lowest temperature (-64.4 °C) was recorded on February 5, 1891, and the highest (+38.3 °C) on June 15, 1942. No other city on earth experiences amplitudes of over 102 °C. The coldest month is January. The average temperature then is -42.7 °C, but there can be significant fluctuations. In 1900, it reached -51.4 °C. The warmest in Yakutsk was January 1963: the average temperature was -32.7 °C. Most years, July is the hottest month of the year, with an average temperature of +18.7 °C.

Fog is the most characteristic atmospheric phenomenon for Yakutsk, as well as for all the central districts of the Republic. On average, Yakutsk experiences 60 foggy days. In the winter, when temperatures reach -40 °C, the humidity in the air (smoke from furnaces, exhaust gases, air breathed out by humans) turns into small ice crystals, and the City gets covered in ice fog, which gets thicker as temperatures goes down. During those foggy days, one notices the lack of oxygen in the air.

The winds in Yakutsk are very insignificant. The average annual wind speed represents 2.4 m/sec (5 mph).

A very important characteristic in the climate in Yakutsk and the surrounding areas is the low level of precipitations (on average 202 mm or 4 inches per year), which happen mostly during the second half of the summer. And although the city experiences a steady snow cover 199 days out of the year, the total snowfall is insignificant (about 30 cm, or 12 inches). The relative humidity is also quite low (on average 57% per year).

The specificity of the climate in Yakutsk is continuous sunshine. Fog obscures the light only 60 days per year. In the summer, the central part of Yakutia is the sunniest area of Eastern Siberia. From May 27 to July 18, during the white nights in Yakutsk, the sun practically does not go under the horizon.

The weather in Yakutsk also depends on the Lena river, which is one of the ten largest rivers on earth. The changeability of the weather is usually linked to the spring ice breakup. In the Yakutsk area, it usually happens mid-May. The breakup in Yakutsk takes place when a high volume of water (up to 9 meters over the winter minimum) floods the areas of the city closest to the river. For seven months, the Lena river is locked under an ice shield 1 to 2 meters thick. The high waters arrive by mid-May and the flood lasts from 30 to 70-80 days, when the river goes off

its banks and floods the basin which is called within the city limits as the “green field”. The yearly fluctuation in the water level is 10-11 m.

Foundation building in Yakutsk

The method which is used to build on old permafrost is to construct buildings on pile foundations with a ventilated underground, and is rather reliable. However, one needs to observe quite strict requirements due to changes in the geocryolitic conditions: the temperature of the permafrost should not rise, and the depth of its seasonal melting should not increase.

Other types of foundations than piles need to be used, that could keep their characteristics over a wide range of changes in the consistency and temperature of permafrost, including melting. At the present type, a few such foundations are being devised. The Permafrost Institute of the Siberian branch of the Russian Academy of Sciences has done research and provided scientific and technical data to use different types of foundations in the North.

General Plan of Yakutsk

The present General Plan for Yakutsk was approved in December 2004.

As a basis for the new General Plan, we used the Urban Development Concept for Yakutsk (2001) and the General Plan of the City done in 1987.

The new plan ensures continuity in urban construction planning using the same decisions that were earlier incorporated in the urban development documents.

We consider that a Northern city must have a very compact planned structure. The advantages of a compact city in the extreme conditions of the Arctic North are positively reflected in practically all aspects of the activities of the city. They include energy and heat savings, a reduction in the length of utilities infrastructure and so on. They have been demonstrated a long time ago by urban construction science and are successfully used in many Northern cities.

The city of Yakutsk covers about 12,200 hectares. The new General Plan is calculated for a population of 300,000 within the city limits and 350,000 with the surrounding areas. This means that the total housing must grow from 3.5 million m² to 5.7 million m². This makes it definitely a very large agglomeration in a Northern climate. But it has proven historically impossible to artificially limit the growth of the population. One can only somehow slow down the growth of the population in the city by developing the adjacent settlements, like for instance the city of Pokrovsk and the village of Nizhni Bestiakh. In order to do this, we need well thought-out plans for the social and economic development of these settlements and the plan governing the location of production units in Central Yakutia.

For devising the Yakutia territorial planning scheme, we stuck to the concept that new cities should be planned for a population not exceeding 35 to 50,000 people. These new cities must offer a minimum choice of amenities, and be oriented towards one type of industrial production only. For instance, mining, oil extraction, oil processing, power supply etc.

In the approved plan governing the location of production and resource units in Yakutia, also called the Megaproject of Russia for Yakutia, there are unprecedented plans for developing southern and western Yakutia, which hold the largest concentrations of mineral and energy resources. In the near future, we will have to plan a number of new cities, which we hope will reflect our vision for a new contemporary city in the North.

The development of new territories for the city of Yakutsk is planned for the southern area of the city, the industrial district. Apart from this one, there is also a plan to develop new areas in the basin by hydraulicking them. For instance, District 202 in Yakutsk is an example of this type of district on hydraulicked terrain.

Characteristics of construction of hydraulic fills

The conditions governing construction on hydraulic fills differ radically from construction on the original river bank of the present city. The main difference resides in the fact that the construction platform is formed on areas that are part of the river basin and get flooded every year.

Hydraulicking is done by using a large volume hydraulic excavator working from the bottom of the tributaries of the Lena and its course. The gravel mixed with water removed from the bottom is driven by tubes to the newly reclaimed area, where it is deposited layer after layer to form a proper construction platform. The thickness of the gravel represents about 9-12 meters, which means the platform is higher than the highest flooding level.

Together with the hydraulicking process, dredging work is done in those places most likely to see ice jams during breakup, and also to ensure safer shipping along the Lena. The highest point of the gravel deposits also serves as a flooding levee for the existing city, whose level is much lower than the estimated flood level.

Further, the gravel layer turns to a frozen dry state, which is very different from the engineering and geological conditions of the present city. These differences require completely new methods to build the foundations for the buildings and infrastructure. Without going into details, one should note that the builders have the ability on these gravel layers to partially use the underground space, and also to look at other solutions than pile foundations. This choice is seen to be the right one when one looks at the construction of District 202, where three different types of foundations were used, including a building that was erected on a monolithic plate built on the surface of the gravel layer.

This type of foundation, and also the use of the underground space, are the first such experiences in permafrost in the world.

The underground space can be used for parking, conduits for communication lines and heated pedestrian passages, something our architects demonstrated in the planning project for District 203 on gravel layers for the city of Yakutsk. At the present time, the construction in the District is undergoing the process of finding investors and developers, and the construction will start very soon

Traditional dwellings in the North

Arctic region: I would like to draw your attention to the uniqueness of the reindeer herders' dwellings.

The reindeer herders lead a nomadic lifestyle year round, following the herds and moving them to new pastures.

For many centuries, they used their own type of shelter, the yurt of the reindeer herders, or, as we call it, a chum or yaranga. A similar dwelling exists in North America, called wigwams.

The heat technology, mobility, economy, building, set-up and dismantling technologies, and the cheapness of the chum exceeds all the parameters of any known of mobile dwelling for those who lead a nomadic life. The inhabitant of the North needs only one very short winter day to dismantle the chum, move to a new pasture dozens of miles and set it up again. And in order to move his belongings and his shelter, he needs only 2-3 reindeer teams.

In this type of dwelling, people can survive intense cold (-40 to -50 C), blizzards that last for weeks and be protected from mosquitoes and gnats. And in order to build this shelter, he does not need to buy anything, he gets all the materials from his own lifestyle, from the reindeer herd and natural materials.

Unfortunately, contemporary science and technology, that has mastered cosmic technologies and delved into the tiniest nanotechnologies, cannot offer an alternative even similar to the reindeer herders' chum, let alone a better one.

Not long ago, the reindeer herders were offered special tents, made of so-called space materials. However, the tents did not withstand the Arctic cold and came apart. That's why the herders say there is nothing better than the yaranga or chum.

There is a lot for us to think about on how to improve life and elevate the level of comfort in the lives of the people in the super-extreme climatic conditions of the North.

Central Yakutia

In the past, the people living in the middle latitudes of Yakutia were mostly sedentary. This lifestyle was dictated by the traditional activities of the Yakuts: cattle raising, horse breeding, fishing and hunting. The hunters were semi-nomadic, moving to new hunting grounds and switching to other types of hunts depending on the season and the type of game.

The harsh conditions in the North led the Yakuts to have two types of dwellings: the “kystyk” or winter dwelling, and the “saiylyk”, the summer dwelling, dictated by nature and the fight for survival. These conditions led the Yakuts to live in family groups, creating family-based societies and clans.

The way of life of the Yakuts depended greatly on traditional activities. The cattle breeders for instance take the cattle out to the pastures in the summer, going from pasture to pasture, and in the winter, they hold them in stables. Such a way of life dictated the need for the Yakuts to develop two types of housing.

The winter dwellings were small villages, where everybody gathered to survive the long winter. Sometimes several families lived in one yurt, which allowed to save on fuel.

The winter dwellings were kind of a square yurt, perfected over several centuries, with unique characteristics, like its compacity, construction techniques, and great energy saving properties and others.

The Yakutsk moved at the start of the grass growing season or the start of the cattle pasture season into their summer dwellings, which, depending on finding adequate pastures, could be from a few kilometers to dozens of kilometers away from the winter dwelling. In the summer dwelling, each family occupied its own territory, moving the herds around and making provisions of forage for the winter.

Some northerners still keep this way of life until today.

In the cities and large villages, a majority prefers to spend the summer at a datcha (summer dwelling) closer to nature.

This important factor in the life of northerners was reflected in the General Plan of the city of Yakutsk, where the presence of the dachas was included in the planning. Therefore the General Plan considers the principle of classifying the dachas into the category of secondary housing for urbanites. This principle was highly valued by the Main Direction of State Expertise of Russia, as a genuine and innovative proposal by the Yakutsk architects.

I believe that this positive example will be further developed into the engineering plans for other cities and settlements as well as the new cities on the territory of Yakutia.

Geopolitical aspects of contemporary urban planning

We, urban planners, need to recognize to a certain point our responsibility for the decisions we make. We need to think of the consequences at the scale of the planet when the wrong decisions are made. This is first of all regarding the issues of environmental protection. Besides the technical steps undertaken to reduce toxic emissions into the atmosphere, we need to pay attention to preserve water and forest resources.

The majority of Yakutia is covered by tundra with a large number of lakes and wetlands, mountains with enormous reserves of clear water and forest zones. The effect of Yakutia on the global climate can be compared to that of the Brazilian rainforest.

Forests are the main type of vegetation in Russia, they cover 45% of its territory.

Russia has the largest timber reserves in the world. As of 1993, the total forested area represented 886.5 million hectares, and the total timber reserves 80,7 billion m³, or respectively 21.7 and 25.9% of the world reserves. The

difference between the two numbers means that Russia has more mature and productive forests than the rest of the planet.

Forests play a considerable role in the gas balance in the atmosphere and the regulation of the earth's climate. The overall balance represented by Russian forests, calculated by B.N. Moisseiev, represents 1,789,064.8 tons of carbon dioxide and 1,299,019.9 tons of oxygen. These gigantic volumes of gas migration are largely responsible for the stabilization of the gas composition and the climate of the earth.

The largest forest reserves of Russia are found in Siberia and the Russian Far-East, but also in the European North. For 500 years now the forested areas of Russia have been constantly dwindling, but the reduction has become particularly acute in the 20th century. However Russia has been less affected by this process than the rest of the world. Over the last 10,000 years, it is estimated that 2/3 of the forests of Eurasia have disappeared. For Russia, the process has not been estimated, but it is certainly under 1/3.

In recent years, because of large releases of toxic gases into the atmosphere (carbon dioxide, methane, etc.), woodlands and other natural ecosystems have started to be considered from a totally new angle. Conserving and developing woodlands is now seen as a way to fix (deposit) atmospheric carbon, which would at least allow to compensate for large emissions of carbon dioxide due to the burning of natural fuels. The total amount of carbon fixation by the Russian forests are estimated at 261 million tons per year, or the equivalent of 959 million tons of carbon dioxide.

This is why we need to adopt thoughtful decisions regarding the location of industrial productions units on the territory of Yakutia, and first of all the construction of hydroelectric dams, planned within the frame of the Russian Megaproject for Yakutia, but also for the planning and construction of new industrial cities on the territory of Yakutia.

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