Construction developments in the Soviet North

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by G.H. Johnston

ABSTRACT

The Soviet North, encompassing about 4 million square miles or almost 50 per cent of the total land area of the Soviet Union, is roughly comparable in area to the total land area of Canada. It is exceedingly rich in natural resources and development of these northern regions is most important and necessary to the over-all development of the Soviet Union. As in the Canadian North, long distances, difficult access, and severe climate and terrain conditions, notably permafrost which underlies about one half of the land area of both countries, pose many difficult engineering and construction problems. Northern technology is essentially the same in both countries, there being no basic differences. Large hydro-electric, mining, oil and gas, and industrial projects have been or are being developed. Living conditions are now being improved and multi-storey dwellings are being constructed in new towns and also during redevelopment of their older cities and communities in Siberia.

LE DÉVELOPPEMENT DE LA CONSTRUCTION DANS LE NORD SOVIÉTIQUE

par G.H. Johnston.

SOMMAIRE

Le nord soviétique qui s'étend sur environ quatre million de milles carrés ou presque 50 pour cent de la superficie totale de la terre en union soviétique, est approximativement comparable à la superficie totale de la terre au Canada. Cette terre soviétique est extrêmement riche en ressources naturelles et le développement de ces régions du nord est très important et nécessaire au développement global de l'Union Soviétique. Comme dans le Nord canadien de grandes distances, la difficulté d'accès, le climat et les conditions de terrain rigoureux, particulièrement le pergélisol sous environ la moitié de la superficie totale de la terre des deux pays, présentent plusieurs problèmes difficiles de génie et de construction. La technologie dans le Nord est essentiellement la même dans les deux pays, sans différences fondamentales. De grands projets hydro-électrique, d'exploitation minière, d'huile et de gaz et des projets industriels ont été ou sont actuellement développés. Les conditions de vie sont maintenant améliorées et des immeubles à logement à plusieurs étages sont maintenant construits dans de nouvelles villes et aussi dans le nouveau développement des villes et des communautés plus vieilles en Sibérie.

CONSTRUCTION DEVELOPMENTS IN THE SOVIET NORTH

by

G.H. Johnston

Every Canadian is aware of the great increase in activity that has taken place in Canada's North in the past few years as our "last frontier" is breached in the search for gas and oil. The USSR, too, has a vital interest in her North and has been very active in the development of the vast natural resources in her frontier areas, but for a longer period of time than we have, and on a generally larger scale. Everything about the Soviet Union is "big"; the total land area is about two and a half times that of Canada; the population is more than 10 times that of this country; and some of their resource developments, for example, dams, are the biggest in the world.

The Soviet North is also big. It covers about 4 million square miles (10.4 million km^2) and is therefore roughly comparable to the total land area of Canada. The northern region of the USSR has been defined in several ways but in general its southern extent follows approximately the 63°N latitude west of the Ural Mountains in European Russia; it then dips sharply as the Urals are crossed and follows the 58°N latitude through western and central Siberia and finally drops even further south to about the 55° parallel in eastern Siberia. Although the Soviet North covers almost half of the USSR it contains only 2.5% of the population or about 5 to 6 million people, of whom approximately one million are natives. It does have a number of large cities, however, for example, Yakutsk, Noril'sk and Irkutsk with populations exceeding 100,000, 150,000 and 500,000 respectively. Compare that with Canada where about 58,000 people live north of latitude 60° in 1.5 million sq. miles (3.9 million km^2) (39% of the total land area of Canada) and where the largest centres are Yellowknife and Whitehorse with populations of 7,000 to 11,000.

Many similarities can be noted if we compare the northern climate, terrain and physiography of the two countries but there are also significant differences. Although mean annual air temperatures are similar in both countries, Siberia experiences colder winters and warmer summers. In Siberia mean January temperatures are generally below -40°F (-40°C); in Canada they average about -30°F (-34°C). The coldest regions in the northern hemisphere are in Yakutia around Verkhoyansk and Oymyakon where the mean for the coldest month is below -55°F (-48°C). On the other hand, mean July temperatures of about 60°F (16°C) coincide roughly with the Arctic Circle in Siberia dropping to latitude 50°N in the far east. In Canada this isotherm lies considerably south of the Arctic Circle extending from Great Slave Lake southeastward to the south end of James Bay at latitude 51°N. Several factors contribute to the

more continental nature of the climate in Siberia. The land mass is much larger than in North America and there are no large water bodies comparable to Hudson Bay which exerts a considerable influence on Canada's northern climate. In addition, the eastern mountains of Siberia prevent Pacific disturbances from moving inland, particularly during the winter, resulting in a generally lower snowfall over the interior. Annual snowfalls, although low, are generally greater in northern Canada than in Siberia; snow accumulation is particularly high east of Hudson Bay before it is ice covered.

The history of continental glaciation, and therefore of soil deposits, is quite different. Ice caps and glaciers covered all of Canada during the Pleistocene except for the western Yukon and possibly the northwest section of the Arctic Islands, whereas only a few small local ice caps formed in Siberia. Thus much of the Precambrian Shield in Canada was scoured clean by the glaciers and glacial soils of varying origin and particle size were deposited in many parts of the country. On the other hand, residual soils are widespread in Siberia and the numerous large rivers have wide flood plains and well developed terraces. Exposed bedrock is less widespread in the unglaciated areas.

The climate and glacial history have influenced the development of vegetation and forest cover. Canada has a much larger arctic tundra or treeless area, caused in part by the presence of Hudson Bay, whereas the tundra of northern Russia extends in a narrow band along the Arctic coast. Heavy forests are relatively widespread in Siberia and are being extensively exploited for pulp, paper and timber.

Both Canada and the Soviet Union are well "endowed" with permafrost which underlies about 50% of the total land area of both countries. The permafrost region of the USSR, however, is more than twice as large as that of Canada. In Siberia, permafrost extends southward to about latitude 47°N in contrast to Canada where the most southerly permafrost is found around James Bay at latitude 51°N. The significant differences in glacial history, climate and terrain also contribute to variations in permafrost conditions. Permafrost is much thicker in the USSR. At the boundary of the discontinuous and continuous zones the thickness of permafrost ranges from 200 to 300 feet (60 to 90 m) in Canada and from 750 to 1,000 feet (200 to 300 m) in Siberia. The thickest known permafrost in Canada is about 1,800 feet (550 m) in contrast to more than 3,000 feet (950 m) in parts of Siberia. (It should be noted that relatively few detailed observations of permafrost thickness have been made in the northern regions of both countries.) The construction problems posed by the presence of permafrost are, of course, the same in both countries.

Although Siberia has a long history of settlement dating back more than 300 years, development of this vast remote area was relatively slow up to the Second World War. About 1940, major decisions were made to develop the rich mineral, oil, gas and water resources of their last frontier because of the needs of the national economy and also because

of the basic desire and policy of the Soviet Union to be entirely independent and self-sufficient.

The Russian North is extremely rich in natural resources, undoubtedly unequalled by no other country in the circumpolar world. Siberia possesses some 75% of the energy resources of the USSR including oil, gas, coal and water power and will soon become the main power base for the country as a whole. It already accounts for most of the diamonds and almost all of the apatite concentrates, and a large proportion of the gold, tin, tungsten, mica and nickel production, nearly one half of the logged timber and more than 25% of the paper output. Extremely large reserves of gas and oil have been found and there are tremendous potential reserves of iron ore, coking and fuel coals and a vast, and as yet mainly untapped, hydro-electric potential.

The future economic growth of the USSR will call for increasingly greater amounts of raw materials and power sources. Thus the development of its North is important and necessary to the over-all development of the Soviet Union as reserves of natural resources are depleted in the already developed parts of the country. The economic importance of their northern regions will therefore increase substantially and directly.

As in Canada, the costs of developing these northern regions and resources are tremendous. Exploitation has been undertaken on a very large scale and with great capital investment. A member of GOSSPLAN, a senior Government Committee for National Planning, who is also Chairman, of the USSR Inderdepartmental Committee on Problems of the North, has stated that the development of natural resources in the Soviet North can be justified economically if one of two following conditions exists:

(1) when the special value of these resources justifies the high outlays necessary for the development and exploitation, that is, the utilization of the resources in the North is economically no less effective than in other regions with more favourable climatic and transportation conditions, or

(2) when the resources in question are generally scarce in the country and the development is essential for the primary need of the national economy and for strengthening military preparedness.

Siberia is most important to the economy of the USSR and has long had special priority in Soviet planning. Great emphasis is placed on scientific and technological research to investigate and provide solutions to the many problems experienced in the North. In this regard considerable success has been achieved. Careful planning well in advance of actual development is always stressed to avoid having to cope with major problems on site and, of course, to keep costs within reasonable limits. Planning may always be stressed but reports indicate that success is not always achieved. For a number of major projects or when particularly difficult problems have been encountered, special study groups have been established to investigate and provide solutions on the site.

All activities in the Soviet Union are administered through a number of State Committees of the Council of Ministers of the USSR. All proposed developments must be considered by the State Committee for Planning (GOSSPLAN). Gosstroy, which is the State Committee for Construction, is responsible for all construction in the Soviet Union and co-ordinates and directs activities carried out by various ministries and departments. It establishes standards for construction, supervises all construction projects, and undertakes and directs work at various research institutes within its sphere of operation. Several ministries have an interest in, or are directly concerned with, construction. For example, the Ministry of Transport Construction is responsible for all major construction for highways, railways, bridges, harbours and communication; the Ministry for Energy and Electrification is responsible for construction and operation of both hydro and thermal power generating stations. There are also Ministries for each of the gas and oil industries and a Ministry for Industrial Construction and a number of others which have their own construction agencies - all of which come under the over-all direction of Gosstroy. Construction management and operations are conducted, therefore, through a very complex system which is wholly State controlled.

Development of the USSR North is expensive, costing 3 to 4 times more than in more temperate regions. Construction costs are said to be higher by from 2 to 8 times, varying with location, than for similar construction in European Russia. Thirty per cent of this increased cost is the result of coping with the severe natural conditions and 70 per cent is the result of such economic factors as fuel, transportation and labour.

The severe climate drastically affects construction operations: in some areas of their Far North there are 350 days of below-freezing temperatures and it is necessary to provide heat the year round. Outdoor activities of construction workers and equipment are severely hampered not only by low temperatures but also by strong winds and drifting snow which create other hazards. In some areas, construction operations are curtailed or shut down completely during the winter months. The long periods of darkness and primitive living conditions also raise psychological and physiological problems. Many of these statements are familiar to us in terms of the Canadian North.

Transportation and access have long been major problems complicating the development of their northern areas and the movement of construction materials, equipment and other supplies. Today, the Soviet European North is connected to the southern parts of the country by a reasonably well developed land transportation network and, of course, there is the all-year shipping route north of Scandinavia to the port of Murmansk. In Siberia they are blessed with a number of very large rivers which are used extensively for north-south communication. The river systems, including the Ob, Yenisey, Lena, Aldan and many others, are linked to the Trans-Siberia Railroad in the south either directly or by short branch lines or roads and in the north by the Northern Sea Route along

the Arctic coast. Contrast this with the Canadian North where the Mackenzie River is the only navigable river and access to our Far North, including some Hudson Bay points, is only possible by sea for a very short period each year.

Movement of materials and equipment inland from river ports to new resource developments in Siberia is usually over winter roads which can be used for 7 to 9 months of the year. Permanent highways which are costly to build and maintain over permafrost are constructed only where economically warranted and around the major centres of activity. Air transportation, however, plays the most important role in providing access to their remote areas carrying everything from passengers to oil rigs anywhere in their North. Large helicopters and freighter aircraft are widely used for transport of materials and equipment. The air system has been extremely well developed and even the most isolated communities are served regularly by aircraft. Distances to be traversed are tremendous even by Canadian standards. For example, travel by modern jet aircraft from Moscow to Yakutsk in eastern Siberia takes about 8 hours actual flying time. One crosses 6 time zones and even then is only about two thirds of the way across Siberia. Transportation still constitutes a serious bottleneck, however, despite the great improvements that have been made in recent years and considerable emphasis is placed on continuing research and development to facilitate access to the northern areas. Preplanning is vital and is always stressed because, in many cases, by the time materials and equipment are moved by rail, river boat and finally overland, it may take as long as 2 years to get them to a particular construction site.

Another major recent problem in the USSR North has been the high turnover in the labour force. The local inhabitants are few in number and many are unskilled or are following their traditional pursuits of fishing, hunting or trapping. A large proportion of the work force must therefore be brought in to the project site from other areas. To attract and stabilize the skilled work force various wage incentives are provided. In far northern regions, workers receive increments or bonuses, which may be as much as the basic wage, as well as cost of living allowances which, in extreme northern conditions, may also be equal to the basic wage. In addition, to make living conditions more attractive to the labour force, greater attention is now given to providing adequate housing, amenities and educational facilities at the job site.

Development of the Soviet North in the early years proceeded very slowly. Buildings were small and built of logs; foundations were simple. Building movements due to frost heaving or thaw settlement of permafrost were not of major consequence. In the late 30's and early 40's some larger structures, mainly of wood, were erected but apparently, because of lack of communication and experience, unsatisfactory performance and failures were frequent. After the war, however, when very large-scale resource developments were undertaken, major emphasis was placed on research, development and planning in an attempt to eliminate, or at least substantially reduce, the problems encountered and to operate more

efficiently and economically. Today, as a result of reorganization and concentrated effort more emphasis is placed on utilization of improved construction methods, designs and communication. More attention is given to close control of construction operations to ensure that design recommendations are carried out.

Transportation links are still inadequate. According to the Director of a special Institute for Construction Research in the Far North ... "the most important cost increasing factor ... is the difficulty of producing and supplying building materials, components and structures, which together make up as much as 85% of the direct cost of construction." In addition, standard designs of buildings and structures, which were developed for temperate latitudes and are entirely unsuitable for the special Northern conditions, are still being widely used. In spite of the considerable success that has been achieved in overcoming many of the construction problems due to permafrost, costs are still very high and research activity is continuing at a high level.

In the early years of the post-war period of intensive development, wood or logs were used for many buildings, industrial and residential, some of which were 2 or 3 storeys high. These were supported on timber piles placed in steam-thawed holes in permafrost. In the late 50's and early 60's, however, construction of larger buildings (5 to 6 storeys) of masonry, concrete and brick was started. Because of heavier loads, both structural and thermal, such structures were supported on precast concrete piles placed in drilled holes. Steam thawing of these holes was still widely used. In all cases an air space was left beneath the building to prevent thawing of the permafrost. The trend in recent years, however, has been to prefabricate structural elements for building components, e.g., for walls and floors. These are mainly of concrete but in some instances sandwich panels consisting of metal sheathing with an insulation core, have been used. In most cases these units, and also wood doors, frames and windows are standardized, prefabricated in factories and transported, sometimes over great distances, to the construction site. Steel and aluminum are not widely used because they are in short supply and require skilled labour for fabrication and erection. On-site construction using brick or cast-in-place concrete is now used to a lesser degree because of lack of skilled labour and also because of the very short period of suitable weather. Precast concrete sections, therefore, are being widely used because less labour is required, closer quality control can be obtained during fabrication, and production at the plant and erection at the site can be carried on the year round.

Provision of services not only in new towns but also in older long-settled communities is receiving greater attention in the remote areas of the Soviet Union to upgrade living conditions. Where permafrost conditions permit, utilities are placed underground but otherwise, utilidors located just below or on the ground surface are common. Many of the smaller settlements, with populations of several hundreds or thousands, still use truck or wagon for hauling water and sewage.

Development of the extremely large hydro-electric potential of their numerous rivers has been a prime objective of the Soviet planners. Power is essential for the many industrial and mining complexes that are springing up throughout their North and they are extremely fortunate in having many natural hydro sites available for development. In contrast, Canada has only a few potential sites and these do not compare in capacity to those of Siberia. Thermal stations using diesel fuel, gas or coal are secondary sources of power. Some difficult and unique problems have been overcome by Russian dam constructors. At Chernysheviskiy, for example the impermeable core for the main earth and rock-fill dam was placed during the winter to take advantage of low river flows. Clay for the core was brought to the site in insulated trucks, mixed with calcium chloride and stored in large piles to prevent freezing. The core material was heated with electric probes to allow placement and compaction at temperatures as low as -40°F (-40°C). At this same site, the dam was placed on bedrock which contained ice in fissures. As this ice would melt due to the water in the headpond, a tunnel was constructed on the river bottom under the dam to allow drainage of the melt water and to permit grouting of the voids so as to seal off the foundation.

Another example is the dam constructed on a river to supply water to the diamond centre at Mirny. A system of ducts, through which cold winter air is circulated, was constructed in the dam to maintain the core and the ice-rich foundation soils in a frozen condition.

There are very large proven reserves of oil and gas in the Soviet Union; it appears that the ultimate potential is much larger than that of North America. At present only two gas lines, which are considered to be experimental, have been built on permafrost. These are a 20-inch (50 cm) line, 250 miles (400 km) long in Yakutia and a 28-inch (70 cm) line, about 150 miles (240 km) long to Noril'sk. Parts of these lines are buried, parts are on the surface and parts are supported on piles above the ground. Few difficulties have been experienced, apparently, with either construction or operation. Design and construction of large-diameter gas and oil lines (up to 4 ft; 122 cm) on permafrost are planned. Intensive research into the design and construction problems associated with pipelines in permafrost has been underway for several years.

In the past very large labour forces have been used on construction jobs in the Soviet North but in recent years great efforts have been made to mechanize all operations as much as possible. As was reported in the New York Times, a senior minister of the USSR stated that "Our problem is not to attract people to settle in those inhospitable areas. If we could help it, we would not want to send anyone there. We are looking forward not to the era of mines under air-conditioned plastic domes but to increasing mechanization and automation that will reduce the required manpower to the absolute minimum." Unfortunately, considerable delays on construction jobs and very costly repairs were experienced when attempts were made to use equipment designed for temperate zones. Consequently, the Soviet Government has made a concentrated effort in the past five years to provide vehicles and equipment designed to withstand the low temperatures of the North.

Based on reports in the Russian literature and also on observations made by the increasing number of visitors to the Soviet North it is obvious that there are no basic or essential differences in northern technology between our two countries nor in the scientific appreciation of permafrost problems. It is also clear that the cost of developing the natural resources of our respective northern regions is and will be more expensive compared with more southerly areas. Careful planning, design and efficient utilization of men, materials and equipment by those cognizant of, and experienced in, northern conditions and operations are vital, for mistakes can be disastrous and extremely costly.

Engineering and construction achievements in the Soviet North are most impressive. The large scale of many of their developments in a most inhospitable and remote region and under extremely adverse conditions, the problems they have encountered and the manner in which they have overcome them, including the intensive research and development activity they have undertaken, are of particular interest to us. Many Russian books and papers dealing with permafrost engineering and problems of the north have been translated by and are available from the National Research Council in Ottawa which has maintained close liaison with Soviet workers for a number of years.

On the other hand, Soviet engineers and constructors are anxious to learn and gain from our experience in the Canadian North. They are particularly interested in our methods of obtaining and maintaining high standards and quality of construction, the use of lightweight building materials, which are more economic, easier to transport and simpler to erect, and mechanization of construction operations including the design and operation of heavy construction equipment and vehicles for cross-country transport in the North.

Canada and the Soviet Union have large northern frontiers to develop. Theirs is further advanced than ours, in some respects, but we each have been able to gain valuable information and insight into common problems through reciprocal visits and exchanges of information. The development of the vast potential of the North is and will continue to be vital to the economy of both countries.