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Functional Loss Risks of highways in Permafrost Areas Due to Climate Change

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Abstract

The article gives the analysis of functioning of highways, which are exposed to the destruction risks caused by climate change in the territories of the Arctic zone and the location of permafrost, original methods for preserving transport infrastructure facilities survival are proposed. Methods for quantitative risk assessment of natural hazards for transport infrastructure, adaptation measures in road construction to possible climate change are discussed. The technology of self-adjusting soils stabilization using vapor-liquid seasonal cooling devices immersed inside screw piles is proposed for improving the reliability of pile-elevated road structures.

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Keywords: permafrost; climate change; highway; risk assessment, technology of self-adjusting soils stabilization

1. Introduction

The length of roads in the Arctic zone and the territories of permafrost in the Russian Federation is 79 thousand km, i.e. 5.3% of the total length of public roads. The share of Federal roads of the 79 thousand km of roads located in the Arctic zone and the territories of permafrost is 8%. It is slightly less than the length of roads located on the territories of permafrost in Canada.

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As it is estimated by Arctic and Antarctic Research Institute [1] by the year 2030 natural hazards and risks of functional loss of the transport infrastructure in the Arctic zone and permafrost territories increase is expected (approximately by 15...20%) due to climate change.

On the Federal roads R-21 “Kola”, R-297 “Amur”, A-331 “Vilyuy”, A-360 “Lena”, A-381 the access way to the Naryan-Mar airport (Fig. 1) there are several sections which are situated in the territories with the discontinuous and patchy permafrost.

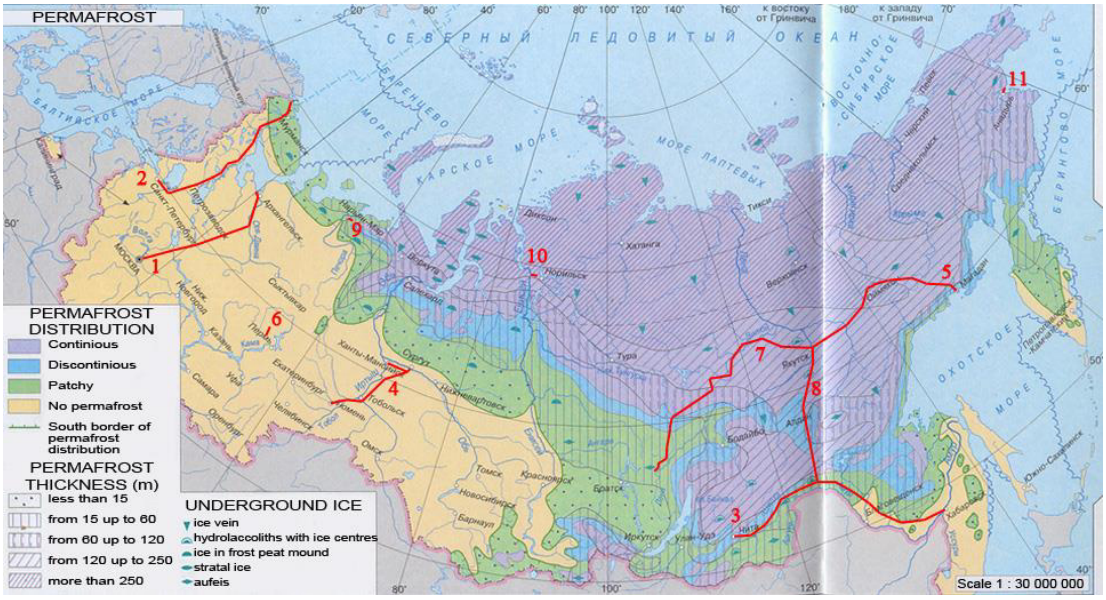

Fig. 1. Public Federal roads location on the map of territories with cryotic soils (Russian Federation): 1 – “Kholmogory” Moscow - Arkhangelsk (sections); 2 – “Cola” St. Petersburg- border with the Kingdom of Norway (sections); 3 – “Amur” Chita - Khabarovsk; 4 – Tyumen - Tobolsk - Khanty-Mansiysk; 5 – “Kolyma” Yakutsk – Magadan; 6 - Nytva – Kudymkar; 7 – “Vilyuy” Tulun – Yakutsk; 8 – “Lena” Never – Yakutsk; 9, 10, 11 – the access ways to the Naryan-Mar, Dudinka and Anadyr airports.

It appears that these road sections and engineering structures on them are the most vulnerable to natural emergencies associated with climate change. The negative consequences of climate change can directly affect the construction conditions and transport infrastructure operation. Due to climate change, including permafrost thawing, a significant part of the transport infrastructure located in these areas is prone to risk of total or partial functionality loss.

Climate change leads to permafrost temperature increasing which leads to adverse geocryological processes intensification that influence structures stability. Thereby risks of road constructions functional loss are growing. Partly because of this, but also due to other factors related to the operating conditions the number of accidents and infrastructure damage in the permafrost zone significantly increased in the last two decades. In Western Siberia each year there are about 35 thousand accidents on oil and gas pipelines, about 21% of them are caused by mechanical impacts and deformations [2].

It is possible to propose a set of measures to adapt to future conditions if there are forecasts of changes in permafrost and maps indicating the most vulnerable regions. Accomplish this it is necessary to consider a number of methods to predict and quantify somehow the influence of permafrost degradation on transport infrastructure.

Geocryological hazards assessment for transport infrastructure should take into account the main permafrost parameters changes under conditions of future climate, and in particular how they differ from the conditions laid down in the structural analysis.