

type of impact is differentiated due to the cause of violations, which finally lead to a decrease in the operational reliability of engineering structures.

Justification of the number of measurements is one of the most important elements of the observation methodology because the optimal frequency of observations ensures the sufficiency of the information field for making control resolutions. Several levels of observations range depending of the state of foundations and activation of hazardous processes are substantiated: normal, detailed, intensive and emergency.

Observations results are presented in a space-time form, which contains all observations results and results of measurements automated analysis. The results of observation for each object are collected in separate file which contain: basic engineering-geocryological information, the scheme of observation, the results of the measurements, and the state of the monitoring network, a photo gallery and an overall object state assessment. Thus, the file contains full information about the object and its monitoring during the cycle of its operation. The system is accumulative and is an information base for the development of engineering protection of structures and management of a control decisions.

Hazardous cryogenic processes on Yamal peninsula, Marre-Sale and Bovanenkovo study areas

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Cryogenic processes in the cryolithozone are caused by the reaction of the upper horizons of sediments to the changes of thermal regime on the surface or the thermal and mechanical impact of water on the banks water bodies. Thermokarst, thermo-erosion, cryogenic slope processes, frost heaving, frost cracking, gas emission craters are the most dangerous of them, especially to the industry, due to the possibility of the sudden activation on the large areas. Although, the duration of such activation periods does not exceed several years because northern permafrost regions have frozen ground of low temperatures and relatively short summer period.

The purpose of the work is to establish the conditions that trigger the activation of hazardous processes on two study sites on the Western Yamal – one on the coast (Marre-Sale) and one in the inner region (Bovanenkovo).

Observations on Marre-Sale site show the extremely high spatial variability of the rate of retreat of the sea coasts within one year. During 40 years of

observations the average coastal retreat rate was 1.6 m/year; the maximum reached 3.7 m/year (2012); the minimum – 0.5 m/year (1978, 2017). Long-term general course of the coastal retreat rate has oscillatory nature: between high rates periods (1987–1995; 2005–2012) there are low rate periods, where minimum retreats were recorded.

No direct relationship between air temperatures and the rate of bank destruction were detected, but the periods with low retreat rates correlate well with low average summer temperatures. Moreover, the coastal retreat rates have a high correlation with the Arctic oscillation index. Another factors that affect coastal retreat rates on the Western Yamal are the seasonal sea ice regime, the number of storms and the rate of thawing of shallow water permafrost.

While seacoast on Western Yamal was relatively stable, in the inner region on Bovanenkovo site the retrogressive thaw slumping associated with the melting of tabular ground ice was observed more frequently. In recent years relief is being reshaped – a new cycle of activation of previously stabilized forms has been noted. Snow accumulates in the newly formed depressions, which leads to an increase in the temperature of the sediments below. In this case high rate of retrogressive thaw slumping process where tabular ground ice is exposed in the outcrops of 6-12 m height may pose a real danger to the infrastructure.

The surface of the tabular ground ice deposits is heavily eroded, but the absolute elevations of the bottom of the tabular ground ice bodies is the same over large areas - absolute depths between 10 m and 40 m below sea level (21.5 m b.s.l. on Bovanenkovo).

The cavities filled with gas are being formed, when tabular ground ice is thawing from the bottom. The gas pressure in such cavities may exceed the strength of above permafrost sediments, especially when the above layer of frozen ground is too thin. At first this may result in formation of small mound on the surface, which may then burst into the gas emission crater, which later will transform into lake. Gas emission craters are expected to appear in areas of the floodplains where fragments of tabular ground ice deposits with cavities and gas caverns on the bottom are preserved, permafrost above is thin enough and is characterized by high temperatures.

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Application of laser scanning for evaluation of deformations of linear objects in the cryolithozone

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