CONSTRUCTION ON PERMAFROST

TECHNOCENIC CHANGES IN PERMAFROST AND THE STABILITY OF THE FOUNDATIONS OF ENGINEERING STRUCTURES

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An analysis is made of changes in the condition of permafrost due to residential and commercial development in different areas. The changes have been associated with an intolerably large number of deformations and failures of structures in the permafrost zone. An understanding of the geocryological-engineering processes involved in technogenic changes to permafrost will make it possible to accurately predict those changes.

The stability of buildings and installations in the permafrost zone (PZ) is related to the stability of the permafrost itself, which functions as both a foundation and a medium for engineering structures. Until recently, the stability of permafrost soil masses had been assumed to depend only on their natural temperature at the depth corresponding to the base of the bed of rock in which heat circulates over the course of the year [1, 2].

The lowest temperatures in the PZ exist in the middle part of the Arctic coastline of Eastern Siberia. The zonal temperatures of the rocks increase in all directions from this area. We will use this pattern as the basis for describing the deterioration in the stability of permafrost soils, which should be considered by designers when choosing the principles on which to base the construction of various structures.

In addition to temperature, the stability of the PZ is appreciably influenced by its ice content, which is known to increase in the northern direction. The increase in ice content entails a reduction in the long-term strength of permafrost used as the foundation of structures. The more icy rock masses turn out to be less stable [3].

On the whole, the distribution of the zonal thickness of beds of underground ice corresponds to the isotherms of the PZ. Thus, the natural stability of permafrost soil masses is determined by the directly opposing effects of temperature and iciness. Designers must also try to foresee major disturbances in the initial heat transfer conditions during construction and use, in order to avoid the associated nonuniform cryogenic processes frost heaving, cracking, thermal karst, solifluction, etc.

The reaction of the PZ to the same given type of development turns out to be different in different regions. M. I. Sumgin was the first to try predict the geocryological-engineering changes that would occur as a result of planned construction on the northern and southern boundaries of the PZ. Sumgin concluded that at high latitudes, "when the snow cover is removed, the thermal regime of the soils ... will become severe, and the permafrost will be significantly degraded at the southern boundaries" [1].

The possibility of degradation of the permafrost during development in local areas of the southern regions of the PZ was also noted in [3]. It was assumed that degradation would occur even if there were only a small increase in the depth of the thawed region under isolated buildings, since thawed rocks have a higher groundwater filtration coefficient. However, the PZ is not thawing in populated areas in the southern portion...
Fig. 1. Geocryological-engineering map showing subzones of the permafrost zone in Russia: 1) northern coastal subzone, where development usually entails heating and contraction of the PZ; 2) northern continental subzone, where development usually entails cooling and expansion of the PZ; 3) southern coastal subzone, where development usually entails heating and thawing of the PZ; 4) southern continental subzone, where development is usually accompanied by regeneration and cooling of the PZ; 5) natural zonal temperature of the PZ; 6) zonal thickness of subsurface ice beds.

of Middle and East Siberia and is in fact becoming more extensive than outside those areas [4]. Thus, factors which are more influential than development are at work in the indicated regions.

Generalization of the results obtained from study of the natural occurrence of the PZ and technogenic disturbances of the natural conditions of heat exchange between the lithosphere and the atmosphere has made it possible to construct a geocryological-engineering map (Fig. 1) [5, 6]. The map shows geocryological-engineering subzones differing in the direction of the changes which are occurring in the natural permafrost conditions due to technogenic factors.

For example, despite the predictions of M. I. Sumgin, development taking place in the subzones near the Arctic sea (including the northernmost subzone) involve a rise in temperature and frequent thawing of the PZ [7,8]. A large amount of snow accumulates in the towns and villages. The snow is removed only from the main thoroughfares (less than 10% of the developed area) and piles up on lawns, vacant lots, and plazas. Changes also occur in other factors – wind strength is reduced, the moisture content of the soil increases, etc. – which have the aggregate effect of preventing cooling of the rocks.