INTENSIVE TECHNOLOGY FOR CONSTRUCTION OF A ROADBED IN THE PERMAFROST ZONE

Shepitko, Taissia V., *Russian University of Transport, Moscow, Russia.*
Lutsky, Svyatoslav Ya., *Russian University of Transport, Moscow, Russia.*
Artyushenko, Igor A., *Russian University of Transport, Moscow, Russia.*

ABSTRACT

An intensive technological regime for increasing the stability of weak soils is proposed to ensure safety of the roadbed on the site with the eternally frozen base of the Northern latitudinal railway Salekhard–Nadym. It is shown that it is necessary to take into account talik zones at the design stage, which can cause various deformations. On the basis of the fundamental principles of the mechanics of frozen soils, technological regularities are established for increasing the strength characteristics which include the angle of internal friction and cohesion of soil with decreasing humidity and draining water from the active layer and talik beyond the construction site. The application of intensive technology for reinforcing the roadbed during the construction of routes in the permafrost zone is substantiated.

Keywords: *railway, safety, stability, eternally frozen soils, roadbed, intensive technology.*

Background. *Stability of the roadbed in the regions of permafrost soils must be ensured throughout the entire life cycle of the railway, starting from the stage of design and geological survey, during which data appear on the thermophysical and physicomechanical processes occurring in soils. Under the influence of these processes, deformation occurs during thawing, adversely affecting safety of the engineering structure [1, 8]. The works on the theory of the roadbed of G. M. Shakhunyants [10] and M. N. Goldshtein [2], devoted to its design and operation, do not fully reveal the problem of changing the physical and mechanical characteristics of soils in the process of construction.*

The urgency of this problem was confirmed when considering the results of engineering surveys and assessing the stability of the base on the sections of the construction of the Northern latitudinal railway [5, 6]. The analysis showed that in the high-temperature permafrost (with a positive soil temperature at the boundary of zero amplitudes) the second construction principle (with the assumption of thawing) leads to especially numerous deformations of the earth foundation.

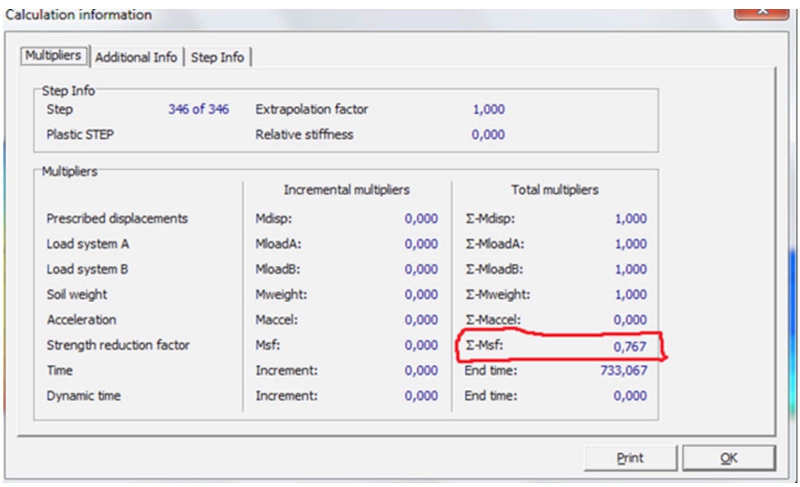
At the stage of designing the construction of a new railway line in the area of permafrost soils, it is necessary to take into account the presence of possible hazardous areas. Such, in particular, are talik zones, which have a negative impact on the construction of the roadbed and its subsequent operation [10]. Such zones can be the cause of the appearance of various deformations on construction sites [1]. To destruct high power taliks, a modification of intensive technology was developed in combination with piles in the geotextile shell [4].

The intensive technology developed at Russian University of Transport (MIIT) has proved effective to prevent deformations of the roadbed. It had been patented [3] and for the first time it was implemented by JSC Tsentrostroymekhanizatsiya during construction of the motorway Moscow Ring Road–Kashira [7].

Objective. *The objective of the authors is to consider the intensive technology for construction of a roadbed in the permafrost zone.*

Methods. *The authors use general scientific and engineering methods, comparative analysis, evaluation approach, modeling, graph construction, specific enginnering methods of transport construction in permafrost zones.*

Results. *Let's consider the experience of realization of intensive technology at the example of sections of the roadbed of Salekhard–Nadym railway line. Analysis of the stability of the base, carried out in [5, 12], showed the presence of potentially hazardous areas with a stability coefficient (K_{st}) of 0,688. Since $K_{st} < 1$, the strength of the base is not ensured. The check in the program complex Plaxis (Pic. 1) confirmed the instability of the base: K_{st} = 0,767.*



Pic. 1. Results of calculating the stability coefficient using the software complex Plaxis.

The intensive technology makes it possible to improve the strength characteristics of the foundation soils by means of sealing and moisture reduction measures (Pic. 2).

The first stage of the intensive technology is arrangement of drainage systems to accelerate consolidation. This process is executed through removal of water, squeezed out of the thickness of the weak base.

The second stage is accomplished to harden the foundation soils by compacting them with the use of an additional external load from ground vibrating rollers, which allows to reduce humidity, increase the strength and the modulus of deformation of soils.

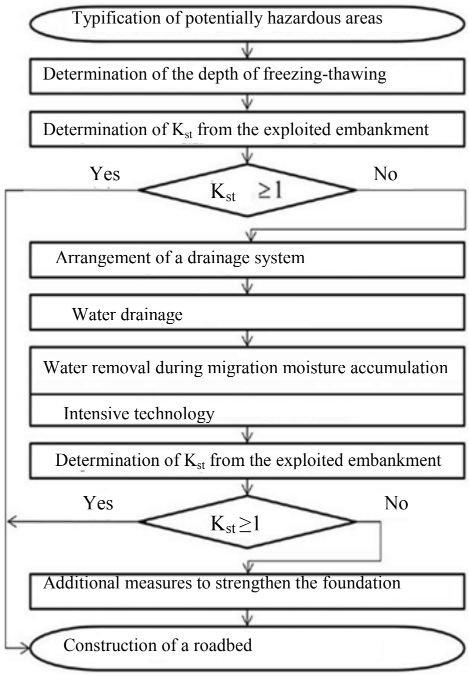
In accordance with the recommendations on the intensive technology [7, 11], its design includes the choice of organizational and technological methods that, in combination, improve the performance (characteristics) of the foundation of the roadbed:

– reduction and subsequent damping of subsidence (S);

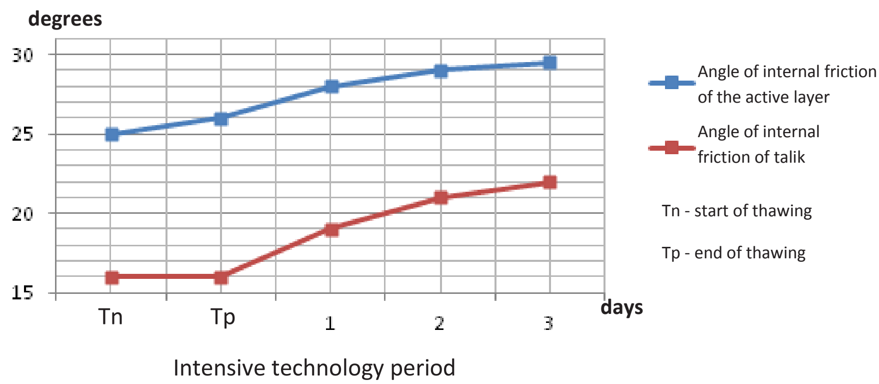
– growth of the deformation modulus (E);

– increase of the strength characteristics of the soil (C, ϕ).

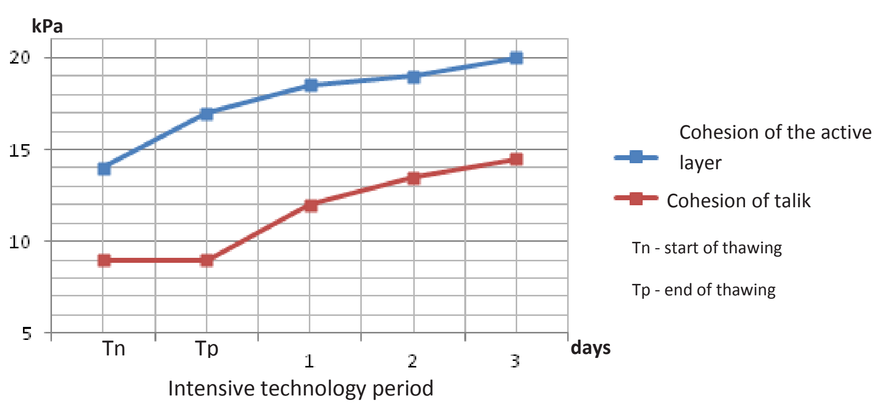
Due to the use of the intensive technology in the design of earthworks on the section Salekhard–Nadym, the humidity of the active layer and talik decreased from 33,5 % to 23,3 % and 29,4 %, respectively. In accordance with the regularities established in [8], with a decrease in humidity and water removal from the active layer and talik beyond the construction site, strength characteristics increase: the angle of internal



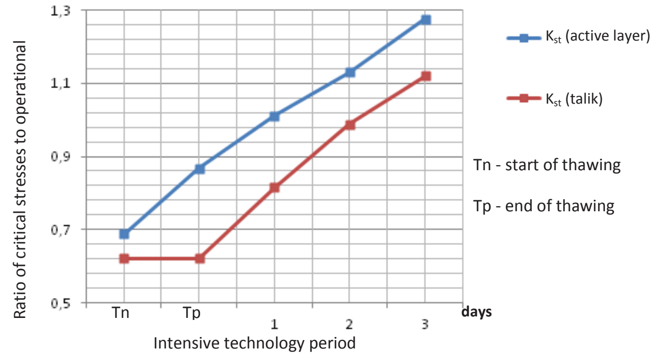
Pic. 2. Schematic diagram of increasing the stability of the roadbed on a subsidence base.



Pic. 3. Change in the angle of internal friction of soils of the active layer and talik.



Pic. 4. Change in cohesion of soils of the active layer and talik.



Pic. 5. Change in stability coefficient of the base.

friction (Pic. 3) and soil cohesion increase (Pic. 4). As a result, the stability coefficient increases and the base of the embankment stabilizes (Pic. 5).

Thus, the use of the intensive technological mode of compaction of a subsidence layer of soil during thawing of the base allowed: to reduce moisture of the active layer and talik; to increase cohesion of the active layer from 14 to 20 kPa, cohesion of talik – from 9 to 14,5 kPa; to increase the angle of internal friction of the active layer from 25 to 29,5 degrees and the angle of internal friction of talik – from 16 to 22 degrees.

At the same time, the intensive technology developed at Russian University of Transport (MIIT) [6, 7] was implemented in the form of technological regulations for construction of a roadbed on the sections of high-temperature permafrost soils of the railway lines Obskaya–Bovanenkovo–Karskaya and Obskaya–Salekhard.

Conclusions. *The use of the intensive technology to compact and reduce moisture contents of soils of the base of the roadbed on high-temperature permafrost leads to an increase in the strength characteristics (cohesion and angle of internal friction) of soils of the active layer and talik during the construction period. For destruction of high power taliks, a modification of the intensive technology in combination with piles in the geotextile shell has been developed. The technology itself should be recommended first of all in order to improve safety of the roadbed in the construction of railways and roads in the permafrost zone.*

REFERENCES

1. Departmental building codes VSN61–89. Research, design and construction of railways in permafrost regions / Ministry of Transport of the USSR [*Vedomstvennye stroitel'nye normy VSN61–89. Izyskanija, proektirovanie i stroitel'stvo zheleznyh dorog v rajonah vechnoj merzloty / Mintransstroj SSSR*].Moscow, TsNIIS publ., 1990, 208 p.

2. Goldstein, M. N. Mechanical properties of soils [*Mehanicheskie svojstva gruntov*]. Moscow, Stroyizdat publ., 1979, 304 p.

3. Roadbed and the method of its erection: patent No. 2273687. Russian Federation [*Dorozhnoe polotno i sposob ego vozvedenija: patent № 2273687. Rossijskaja Federacija*] / S. Ya. Lutskiy [*et al*]. Patent Owners Lutsky S. Ya., Ashpiz E. S., Dolgov D. V. Appl. On 24.02.2005; publ. on 10.04.2006.

4. Burukin, A. Yu., Lutsky, S. Ya., Khripkov, K. N. Deep hardening of soils at the base of roads on taliks [*Glubinnoe uprochnenie gruntov v osnovanii dorog na talikah*]. *Proceedings of the 2nd international symposium on the problems of the roadbed in cold regions*. Novosibirsk, 2015, pp. 64–71.

5. Lutsky, S. Ya., Artyushenko, I. A. Analysis of the load-bearing capacity of the subsidence base of the roadbed on permafrost soils [*Analiz nesushhej sposobnosti prosadochnogo osnovanija zemljanogo polotna na vechnomjorzlyh gruntah*]. *Interaktivnaja nauka,* 2017, Iss. 10, pp. 8–13.

6. Lutsky, S. Ya., Shepitko, T. V. [*et al*]. Construction of communication routes in the North [*Stroitel'stvo putej soobshhenija na Severe*]. Moscow, Latmes publ., 2009, 286 p.

7. Recommendations on intensive technology and monitoring of the construction of roadbeds on weak grounds [*Rekomendacii po intensivnoj tehnologii i monitoringu stroitel'stva zemljanyh sooruzhenij na slabyh osnovanijah*]. Moscow, TIMR publ., 2005, 96 p.

8. SP 25.13330.2012. Foundations and bases on eternally frozen soils. Updated version of SNiP 2.02.04–88. Introd. 01.01.2013. [*SP 25.13330.2012. Osnovanija i fundamenty na vechnomjorzlyh gruntah. Aktualizirovannaja redakcija SNiP 2.02.04–88.– Vved. 01.01.2013*]. Moscow, 2013, 140 p.

9. Tsytovich, N. A. Mechanics of frozen soils [*Mehanika mjorzlyh gruntov*]. Moscow, Vysshaya shkola publ., 1973, 446 p.

10. Shakhunyants, G. M. Railway track [*Zheleznodorozhnyj put'*]. Third ed., rev. and enl. Moscow, Transport publ., 1987, 479 p.

11. Lutskiy, S. Ya., Roman, L. T. Technological Control of Permafrost Soil Characteristics in Roadbeds. *Soil Mechanics and Foundation Engineering*, Vol. 54, No. 3, pp. 187–191.

12. Lutskiy, S. Y., Shepitko, T. V., Cherkasov A. M. Composite technology of earthwork construction on taliks in cryolithic zones. *Sciences in Cold and Arid Regions,* 2013, Vol. 5, pp. 577–581.

Information about the authors:
Shepitko, Taissia V. – D.Sc. (Eng), professor of Russian University of Transport (MIIT), Moscow, Russia, shepitko-tv@mail.ru.
Lutsky, Svyatoslav Ya. – D.Sc. (Eng), professor of Russian University of Transport (MIIT), Moscow, Russia, lsy40@mail.ru.
Artyushenko, Igor A. – Ph.D. student at the department of Railway engineering and construction of Russian University of Transport (MIIT), Moscow, Russia, tywka351@mail.ru.

Article received 01.11.2017, accepted 14.01.2018.