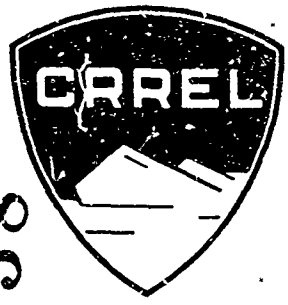

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V.F. Zhukov

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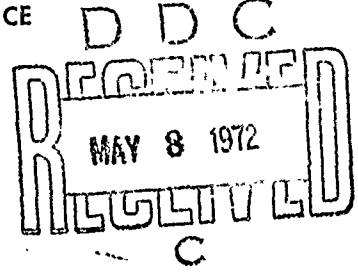

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ENGLISH TITLE: SOME PROBLEMS IN STRENGTHENING THAWING SOILS IN IGARKA AND NORIL'SK

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AUTHOR: V.F. Zhukov

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The frozen soils of Igarka, represented chiefly by loams, are typified by great iciness and a clearly expressed cryogenic texture. Analogous Noril'sk soils which are utilized as footings under the foundations of apartment buildings and industrial structures also contain ice. The latter occurs in the pores and around the soil particles if the soils are the coarse gritty type, and if the soils are loamy, the ice is found in layers.

The ice pockets in the Igarka loams comprise large interbeddings of considerable extent dividing the soil's mineral part into individual intermittent layers. Just recently, V. F. Tumel' suggested adopting the concept of "Igarka type of frozen soil". Subsequently, in continuing the research on the formation of frozen soils having varying composition and occurring under various conditions, it was est lished that the Igarka type is encountered universally in the distribution zone of perennially frozen soils.

The Igarka type of frozen loams with stratified cryogenic texture can be found during the explorations for many construction sites intended for the erection of buildings on

them. The principal variation in the soils' condition on thawing is the extensive consolidation owing to the melting of the ice pockets and at times a certain liquefaction of soils owing to a breakdown in the cohesion among the mineral particles. From the consolidation of the thawing soils beneath the structures, the foundations' settling occurs, which can form 10-20% of the depth of the soil's thawed layer and could lead to an intolerable and destructive sagging of the structure.

The liquefaction of frozen soils after thawing, to which reference is often made by the opponents of the pre-construction thawing of the foundations' base, modifies the bearing strength of the thawed soils. As a result of liquefaction, the soils may be grouped in the category of weak, friable soils with considerable compressibility, which nevertheless is incomparably less than compressibility on thawing. However, we do not yet have a proper concept of the liquefaction of soils or of the loss of bearing strength by them and this question should be considered as still unsolved and subject to study.

The opinion of individual permafrostologists on the liquefaction of thawed soils and on the impossibility of erecting buildings on them is incorrect; it interferes with the adoption of the new technique for building on permafrost, envisaging the pre-construction thawing of frozen soils under the structures' foundations and their strengthening by way of consolidation or filling the macropores with some kind of material.

At the construction sites in Noril'sk, one finds both loams and coarse gritty frozen soils with filling of pores by ice and with icy interbeddings. In general the Noril'sk loamy soils differ little from the Igarka soils and there is no need to make special comments concerning their composition or variation in structure on thawing. The coarse gritty frozen ice-containing soils also become compacted by a certain amount owing to thawing but do so to a lesser extent than the loams. In distinction from the loams, their consolidation is achieved almost wholly during thawing although the coarse gritty soils do have a certain brief instability in cryogenic structure after thawing.

It is known that the thawing of frozen soils in the base of foundations is associated with the risk of the foundations' subsidence and the deformation of the structure;

therefore, it is feasible to arrange a timely (prior to erection of the structure) thawing and strengthening of the very icy soils in order that subsequently, their compressibility under the foundations would be slight and within tolerable limits. Such a concept of erecting buildings and structures on frozen soils had been repeatedly expressed by various persons.

Currently in the standardizing instruction NiTU-118-54, among the principal methods, mention is made of construction with the pre-construction thawing of the foundations' base. This officially embodied the conditions for a broad application of this new technique. For its most rapid adoption in the Igarka and Noril'sk regions, it is necessary to study the basic features in the composition and structure of frozen and thawing soils, and to develop procedures for their strengthening which would be most effective from the standpoint of economy and rapidity of implementation, and of a definite improvement in the stability of thawed soils under buildings.

The consolidation of loamy soils after thawing depends on the rate of removing water from the macropores. At this time, water is pressed toward the earth's surface. As a result of the roughly horizontal occurrence of the interstratifications, the migration of water in a vertical (upward) direction is made difficult. Some of the water may enter the closed spaces and then its movement under pressure (in the direction of maximum hydraulic gradient) will occur via the mineral interbeddings and will be determined by the coefficient of soil's filtration.

By the installation of vertical drains (e.g. of sand piles), we can reduce the resistance to water movement but at the same time, the sandy piles will delay somewhat the compaction (downward shifting) of the thawed soil. One should clarify the radius of the vertical drain's action and thereby establish the required number of sand piles for the volume of thawed soil. We can state hypothetically that the effective radius of a vertical drain will prove great, since the water's migration along the macropores in a horizontal direction occurs almost freely. The displacement of the thawed ground downward under the effect of its own weight (force of gravity) will be opposed by the stability of the cryogenic (stated more precisely, the post-cryogenic) texture and the water's hydrostatic pressure in the drain.

Worthy of consideration is a determination of the penetration of an injecting device through the layer of thawed soil for pumping out the water and for filling the macropores with asphalt, with hardening solutions, with fine sands containing additives of cementing materials, etc.

For the coarse gritty soils not containing ice in the form of interbeddings, strengthening on thawing can occur chiefly from the merging of mineral particles. In other words, in itself, the thawing of such soils leads to their strengthening. Nevertheless, a certain residual part of consolidation is possible only under the effect of load. Therefore one should determine the value for the residual part of soil's consolidation and the force (load) needed for the compaction.

It is not ruled out that, for practical purposes, in certain cases it will be required to strengthen the thawing coarse gritty soils occurring under a certain load from a building, for the purpose of averting the consolidation and deformation of the structure. In order to establish the time of permissible stay of thawed soil under a load, we must know the critical amount of the force not disrupting the stability in the thawed soil's structure. Interesting experimental data on the thawing of coarse gritty soils and the filling of pores by a sandy-cement mixture under one building where local accidental thawing of the foundations' base had begun, were derived in Noril'sk by G.V. Maksimov (1957).

Depending on the techniques utilized for the thawing of frozen dispersed soil, it is possible to have a disruption (in the bonds between the particles) said to be the "liquefaction" of thawing soils. It is possible that the disruption to the texture will sometimes be involuntary in the performance of tasks. Such thawed soil will have a uniform composition, low rate of water release and a gradual compressibility under a load.

It is necessary to clarify the bearing strength of thawed loam with a disturbed cryogenic texture and the related significance of sand "pillows" between the thawed loam and the foundation's base. With the aid of sand cushions, we alter the direction of water flow, filtering under load and we curtail the risk of the soil's bulging from under the foundation.

The use of cushions on water-saturated clayey soils has been discussed thoroughly in the reports written by N. M. Gersenanov (1948).

The review of the question concerning the application of the construction method envisaging the pre-construction thawing of the foundations' base should not be limited to a study of the compressibility of thawing soils or to an investigation of the procedures for their strengthening. It is necessary to conduct at Igarka and Noril'sk some experimental construction with the pre-construction thawing of the footing.

At a conference held in November 1958 in the Permafrostology Institute, we discussed the methods for predicting the settling of foundation soils on thawing. At this time, it was noted that a determination of the periods of soils' thawing has great significance in the calculations. The thawing depth of a footing beneath a structure increases gradually; indeed, at each time moment and in each point under the structure, this depth varies. The irregular thawing is accompanied by a corresponding consolidation of the base and an erratic settling of the foundations, causing a strain on the structure.

In the buildings planned for experimental construction, it is necessary to provide heated basements which are utilized for economic purposes. The thawing pattern will be most uniform under the buildings equipped with basement facilities.

Experimental construction in combination with scientific research, refining the nature of thawing soils and a procedure for designing the bases, will promote the adoption of the new construction technique.

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