DISCUSSION OF SNiP 2.02.04-88 NORM "BASES AND FOUNDATIONS ON PERMAFROST SOILS"

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From the Editors: The complexity of construction on permafrost soils, as well as numerous cases of deformation of structures constructed on such soils, calls for an especially careful design and construction approach. The preparation of all editions of the SNiP Norms for design of bases and foundations on permafrost soils (including the last edition 2.02.04-88 of the SNiP Norms), has always been carried out with the participation of many different organizations, and their discussion is of a wide nature. However, after edition of the latest SNiP Norms and their approbation in the engineering practice, continuation of this discussion is highly desirable.

For this reason, on publishing the present article without any evaluation of the recommendations contained in it, the Editors ask the specialists in the field of foundation construction on permafrost soils to express their opinions about the questions considered in the article as well as about other criteria of the SNiP 2.02.04-88 Norms.

The issuance of the SNiP 2.02.04-88 Norms [1], which constitute a development and refinement of the SNiP II-18-76 Norms [2], with the same title, has undoubtedly improved the quality of design of bases and foundations on permafrost soils. However, in the SNiP Norms [1] there are concepts which result in design difficulties and in uneconomical or unreliable design solutions.

On regulating the field of possible application of Principle I of utilization of bases, in Sec. 4.11 of the SNiP Norms [1] it is stated that even under substantiation by analysis it is not permitted to load the foundations when the soil temperature exceeds the following values: for sandy and large-lump soils \( T = T_{bf} - 0.5^\circ C \); for silty-clayey soils \( T = T_{bf} \), in which \( T_{bf} \) is the temperature of start of freezing of the soil.

However, the Norms do not indicate to what temperature the text refers. In the writers' opinion, since the temperature of the frozen soil of a base during the design period varies from 0\(^\circ C\) to the design mean-annual \( T_0 \) or \( T_0' \), as specific value \( T_0 \) or \( T_0' \) can be adopted. Starting from this assumption, in the southern part of the zone of occurrence of permafrost soils, where \( T_0 \) exceeds the above-mentioned values [1], construction by Principle I without previous cooling of the soil-base is not permitted.

Preliminary cooling of the base by means of the cooling system of the building even for the top permafrost ground surface (TPFGS), combined with the seasonal thawing layer, continues for no less than two winter periods; hence, even when use is made of an artificial cooling system (for example, by means of a SOU cooling device), loading of the foundations is postponed as a minimum until the spring of the next year after their construction. In those cases in which the TPFGS is not combined with the seasonal freezing-together layer, these periods are substantially lengthened, which leads to significant increase in the cost of the construction work, and, for all practical purposes, to its interruption in accordance with Principle I in the southern part of the zone of occurrence of the permafrost soils. However, extensive experience with construction and operation of buildings and structures in Vorkuta, constructed by Principle I under such conditions, including on uncombined permafrost, shows that with the corresponding constructional solutions building stability is ensured with the resulting increase in the reliability of the soil base on account of decrease in its temperature during the operation process.

In the writers' opinion, the SNiP Norms should not impose limitations on use of design solutions substantiated by the corresponding analysis. On the other hand, the construction experience should be reflected in the recommendations.

Of the considerable importance for design of bases in accordance with Principle I is the determination of the settlement of thawing soils. This question was the object of ample discussions in the preparation of the draft of the SNiP Norms [1], including instructions concerning ice-content. Despite the fact that agreement was reached, in 4.30 the final text contained the following formulation: "If \( A_{th} \) and \( \delta \) are obtained from laboratory soil test data, then their design values for determination of the..."
settlement of a thawing base must be multiplied by the correction coefficient \( K_i = 1 + \Delta_i / \delta \), in which \( \Delta_i \) is the difference between the total ice content of the \( i \)th soil layer and the ice content of the tested specimen, taken from the same layer. This places the settlement caused by thawing of the ice inclusions as a function of the settlement of the mineral interlayers, although their independence is generally known. For clarity, let us imagine that the mineral interlayers are of low compressibility, \( A_{th} = 0 \) and \( \delta = 0 \), as is usual for sandy soils. Then in accordance with Sec. 4.30 and the recommended equation, the settlement due to thawing \( S_{th} = 0 \) does not depend on the size of the ice inclusions.

The possible consequences of consideration of the ice content is illustrated by an example of analysis of the settlement of a thawing soil at a depth of 10 m and with a thickness of 2 m having the following characteristics: \( A_{th} = 0.010 \), \( \delta = 0.03 \) MPa\(^{-1}\), and \( \Delta_i = 0.15 \).

In accordance with the SNiP Norms [2], \( S_{th} = 0.372 \) m, and in accordance with the SNiP Norms [1], \( S_{th} = 0.0268 \) m, whereas the settlement due to thawing of the ice inclusions alone \( \Delta_i \) is 0.3 m. Underestimation of the real settlement by one order of magnitude characterizes the possible consequences of application of the norm in question, and indicates the need for urgent correction of the SNiP Norms [1]. Otherwise, in the coming years we would witness above-normative deformations of buildings constructed on permafrost soils by Principle II of utilization of soil bases.

In construction by Principle II under conditions of use of end-bearing piles resting on soils which are incompressible under thawing, a very substantial effect on the stability is exerted by negative friction forces. In Sec. 4.38 of the SNiP Norms [1] it is recommended to take into account these forces only in the layer of thawing soil.

Under conditions in which the TPFGS is not combined with the seasonally freezing layer, thawing of the permafrost soil under the thawed mass leads to hanging, from the pile, of all this mass above the thawing layer and, consequently, to development of negative friction forces over the entire pile length above the underside of the thawing soil layer, and not only in this layer. It can be confidently stated that the specific negative friction forces in the layer of thawing consolidated soil are significantly higher than in the thawing layer, and their disregard may result in incorrect underestimation of the load on the pile and the soil base, with the ensuing consequences. Evidently, this error must be amended in the SNiP Norms.

The writers' analyses of numerous results of static tests on construction piles under different frozen-soil conditions showed that their bearing capacity does not confirm with the required [1] confidence probability \( \alpha = 0.85 \) the analysis results for the characteristics of interaction of the piles with the frozen soil \( R \) presented in the SNiP Norms [1]. The analyses showed that \( \alpha = 0.85 \) is reached only when \( R \) decreases by 25-30\%. This can be attributed to general downgrading of the construction level and of the work quality in connection with the special-stint method of construction as well as to other causes.

In pile analysis from data from static tests, the adopted safety factor for the soil \( \gamma_g \) does not correspond to the experimentally observed coefficient of variation and the recommended value [1] \( \alpha = 0.85 \). According to the writers' data, \( \gamma_g \) should be increased and it should depend on the number of tests.

Permanent verification of construction norms and of full-scale tests makes it possible to take into account the present-day conditions, methods and quality of the construction work, in particular for pile foundations, as well as to prevent undesirable safety factors or decrease in the reliability of the constructed structures.

In the SNiP Norms [1], the design methods depend on the state of the frozen soil (hard-frozen or plastic-frozen), the limit of which has been differently treated in [1, 3]. Moreover, as already pointed out, the temperature of the soil base significantly varies with time and depth, and, consequently, its state also varies. Hence, in the SNiP Norms [1] it is essential to uniquely determine the position in space and time of the soil standard from which the soil state is established for design of the bases and to adopt a unified method of delimitation of this state, or in general to abolish such a delimitation.

The engineering practice shows that in all the categories of frozen soils, excluding those which are heavily iced, for their utilization by Principle I, the soil-base analysis is for the first group of limit states, corresponding to the bearing capacity. For deformation analysis, the required soil characteristics are almost always nonexistent. As a result, forced disregard of the SNiP Norms [1] takes place. For this reason, inclusion in the Norms of a priori stringent requirements difficult to fulfill is unwarranted. These requirements can be eliminated from the recommended appendices.

For calculation of the normative depth of seasonal freezing in the obligatory Appendix 3, the mean-annual temperature of the permafrost soil \( T_0 \) appears in the two interrelated equations (3) and (14) which predetermine an iteration process for finding these characteristics. Use of that process should be specified, or other methods of determining these characteristics should be applied.

In Eq. (2) of the obligatory Appendix 5, there is an error in the signs.