ТЕЗИСЫ ДОКЛАДОВ

МЕЖДУНАРОДНАЯ КОНФЕРЕНЦИЯ
«Перспективные материалы с иерархической структурой для новых технологий и надежных конструкций»

X МЕЖДУНАРОДНАЯ КОНФЕРЕНЦИЯ
«Химия нефти и газа»

Томск

Издательский Дом ТГУ

2018

DOI: 10.17223/9785946217408/25

COMPARISON OF COUPLED AND UNCOUPLED THERMO-ELASTIC MODELS IN THE RANGE OF LOW TEMPERATURE BELOW ZERO

[1]Myasnikov A., [2]Komarov I., [1,2]Bek D.
[1]Skolkovo Institute of Science and Technology, Moscow, Russia
[2]Lomonosov Moscow State University, Moscow, Russia

Today Russian Arctic is the most perspective and actively developed region. It is connected with discovering, exploration and the beginning of operation of new hydrocarbons fields in this area. However, development of gas and oil fields in the Arctic is complicated due to the set of factors: vast territory, severe climate, difficult permafrost-geological situation, lack of infrastructure, complicated logistics, etc. One of such complicating factors is permafrost soils which existence results in considerable risks at construction and operation of technical constructions and a possibility of its thawing, loss of coherence and the bearing capacity. Therefore, there is an urgent need for the development of specialized methods and approaches on forced maintenance of soils in a frozen state. One of such methods is thermostabilization of soil.

Besides obvious advantages, soil thermostabilization can also results in negative effects, such as the appearance of micro and macrocracks (frost cracking) in connection with considerable gradients of temperatures on the boundary soil-thermostabilizer and also an over the freezing of the soil massif in general. This process leads to decrease in the bearing capacity of the soil massif.

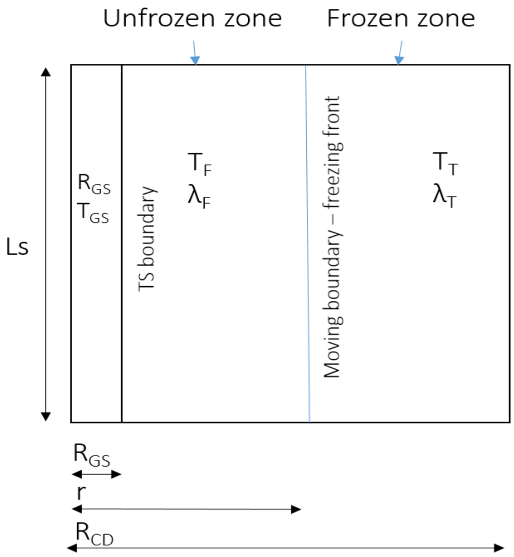
Main part of techniques of risk assessment was developed for not frozen and thawed soils and considers only a geomechanical component, but for assessment of the risk connected with geocryological processes except for a geomechanical component, it is necessary to consider a thermal part.

In this article we are comparing two approaches for assessment of stress-strain state of geomaterials induced by the thermal exposure. The problem is stated as a cylindrical heat source in the ground causing thermal field redistribution with consequent stresses redistribution.

In the range of low temperatures below zero materials are subjected to the stress induced by the alteration and interaction of number of the physical fields such as mass-transfer, thermal, stress etc. Necessity of taking into account a lot of factors and establishing of connections makes the modelling of this kind of processes very difficult. Thus, this research is dedicated to the defining the problem and to set possible assumptions for the problem schematization.

In general, the more complex model you use, the more accurate results you obtain. In some cases, increasing of the model complexity could lead to the opposite results and increases uncertainties and cumulative error due to multiplying of number of parameters. Indeed, it is usually challenging to obtain enough data for model initialization.

On the first stage we considered the uncoupled solution for highly intensive thermal exposure performed as a thermal field redistribution and uncoupled analytical solution for stress-strain state in considered specific conditions. As it was already mentioned we had a source of heat of cylindrical shape which freezes ground under the low temperatures in the range of minus 40 – 80 ˚C. Having thermal field dissipating much faster than stress-strain field we consider the thermal field quasi steady in every particular moment. We use obtained temperature gradient appeared on the boundary of heat source and ground to calculate the stress state according to the analytical solution for the theory of the thin cylindrical shells which might be used in the case when temperature is changing linearly along the shell (Kovalenko, 1971) as we get in the shallow area around heat source. In this area and range of temperatures, due to low temperature values we can assume that there is no phase transition and all unfrozen water had already freezed. So, performed deformations are of the elastic nature.



Picture 1. Scheme of thermal field redistribution (freezing).

r – distance to the freezing front at the time τ

L_S – length of the heat source

T_{HS} – heat source temperature

R_{HS} – heat source radius

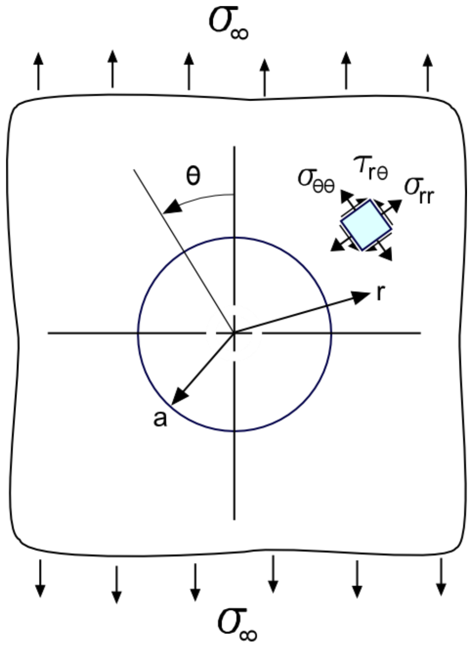
R_{CD} - calculation area

T_F, T_T – temp in frozen and unfrozen zones

λ_F, λ_T – thermal conductivity

T_{bf} – ground freezing point

On the second stage we performed coupled solution for the thermal and stress-strain fields redistribution with modelling of possible material failure in the frame of elastic theory. For the stress field evaluation, we consider plate extension with circular hole – Kirsch problem coupled with thermal problem.



The first goal of this comparison is defining the acceptable range of temperatures where the simplest model is applicable by comparing it with more accurate one. The other goal is to make more complex but still relevant and useful model which performs more realistic reflection of the processes.