

TECHNICAL AND ECONOMIC SUBSTANTIATION OF PERMAFROST THERMAL STABILIZATION TECHNOLOGY UNDER GLOBAL WARMING CONDITIONS

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Abstract. The article contains technical and economic substantiation of the permafrost thermal stabilization technology in the face of global warming. The main methods of permafrost grounds thermal stabilization are analyzed and the method of technical and economic assessment of the technology chosen is proposed. The latter proposed method implies inclusion of random values under global warming conditions.

1. Introduction

The climate warming can substantially intensify the permafrost eruption processes [1]. Depending on the local geological conditions, some land subsidences or land swellings, thermokarst or taliks can occur. All this damages roads, pipelines, buildings and constructions. For preventing of the permafrost soils from degradation some of the thermal stabilization methods are used. The methods imply freezing of the grounds with natural or artificial frost. The implementation of these technologies leads to cutting down not only the time of construction, but also the cost of the initial construction stages. Besides, the needed square for construction can be reduced and the secure operation of the field can be provided.

2. The technologies of thermal permafrost stabilization

The permafrost (of permafrost rocks) – are the grounds that are frozen up to substantial deepness, consisting of underground ice. These grounds are not thawing for long periods of time from several decades up to thousands of years. The permafrost – is the global phenomenon. It covers at least 25 % of the Earth's land surface and over 60 % of the Russian territory, which is primarily the regions rich in hydrocarbons.

The upper layers of the permafrost are in unstable dynamic equilibrium. Their condition depends on various climatic and man-caused impacts [2].

Currently climate is changing fast and substantially from the global warming to possible global or local cooling. Here appears the necessity for preserving of the initial condition of the permafrost grounds because of their high load-bearing capacity.

Various technologies are used for preserving of the natural condition of the permafrost grounds. As a rule the permafrost thermal stabilization technologies are divided into three types: passive (seasonal cooling devices), active (artificial cooling) and of combined action.

Cooling of the ground with artificial frost demands for an energy source, a cooling device, some coolant, pumps with pipelines for pumping of the coolant and several boreholes. For creating of the boreholes, some special bores need to be drilled. The energy source can be

some external network or any mobile facility. The artificial cooling is primarily used for some temporal tasks within the construction period. If any long-term thermal stabilization is needed then the artificial cooling is used for periodical in-pumping of cool air to the ground.

Thus, the thermal stabilization with artificial cooling demands for many technical devices and energy inputs. The needed volume of the frozen ground can be obtained with almost any climatic conditions. Cooling with natural frost is performed through transmission of the cool atmospheric air into the ground, whereby the air temperature is substantially lower than that of the ground. In this instance, various thermal siphons are used [3]. The most widely used are vapor-liquid seasonal cooling devices (SCD). They represent a thin tube, which is mostly dug into the ground. The upper part of the tube is naturally ventilated with air. The upper part of the tube is fitted with ribs for better heat transfer. The tube is filled with coolant, which turns into gas at positive temperature. With condensation temperature, it turns into liquid and flows downwards to the bottom of the tube, where it transmits cooling to the ground. The upper part of the tube is therefore called the condenser while the lower part is called the evaporator.

Hence, the expenses for SCD installation are made up of costs for the tube, the refrigerant, drilling and tube installation works.

Usage of the artificial cooling enables freezing of the ground at any time with any intensity. It reduces also significantly the time of construction. Natural frost appears only during the wintertime. Thus the result of freezing depends on winter temperature and it becomes visible only in spring. The qualitative thermal stabilization provides the necessary amount of the frozen ground up to the next winter. The result depends on the yearly climatic cycle. Moreover, the needed degree of reliability and durability of the SCD should be provided [4].

The choice of the thermal stabilizing technology depends on various factors, both including the technological (specific conditions of the heat-exchange at the boundary or within the frozen layer) and the economic ones (special conditions of the project). On this very stage, one needs to perform a computer-aided modeling of all the possible situations both during the construction period and afterwards.

3. The economic evaluation of the thermal technology selection

The economic evaluation of the thermal technology selection is based on the effectiveness of the project activity and the strategy of decision making on the investment projects.

The basis for managerial decision making on investment projects serves, as a rule, the estimation and comparison of the projected investment volumes and future receipts [5]. Herewith the managerial investment decisions should be directly linked to the realization of specific technological plans. This approach presents the investment projecting as a set of activities (works, services, acquisitions, managerial operations and decisions) aimed at attaining of the specified goal – making a choice of thermal stabilizing technology under the conditions of climate warming.

The choice of thermal stabilizing technology with the respect of economic estimation is based on evaluation of the modified effectiveness indicators within the project activities. The following indicators of effectiveness within the project activities while choosing the thermal stabilizing technology were selected - the net present value (NPV), the modified internal rate of return (MIRR) and the payback period (PBP).

The net present value (NPV) is calculated with the projected cash flows that are connected with the planned investments, where the cash flow is discounted by the probability of climate warming and the time factor. The modified internal rate of return (MIRR) is determined as the rate of return which equalizes the present value of all the expected inflows with the expenditures on the project. The payback period (PBP) – is the time needed to payout

all the initial investments with the net cash flow generated with the investments in the project. It shows the time when the discounted income generated with the investments equals the costs of the investment. This indicator is determined with gradual calculations of NPV for the each period of the project. The time point where the NPV becomes positive is the break-even point.

The choice of the technology is made during the evaluation of the project effectiveness. Higher stability and effectiveness as a rule can be shown by the thermal permafrost stabilizing project with higher values of MIRR (modified internal rate of return), where it is substantially higher than the discounting interest rate which considers both the time factor and the risk of climate warming.

While choosing for the project solution of thermal permafrost stabilizing technology one should also consider the volume and periods of financing. The project of thermal permafrost stabilizing technology with high cash inflows during the first periods is relatively insensible to the interest rate changes. While the project of thermal permafrost stabilizing technology with high cash inflows during the late periods has a much higher sensitivity of NPV indicator, whereas the risk also rises with climate warming.

Hence, the economic estimation while choosing the thermal permafrost stabilizing technology demands for analysis of the dynamics of the project indicators during the whole duration of the project.

The estimation of the project effectiveness with the thermal permafrost stabilizing technology chosen is based on the following principles:

- Analyzing of the project during its whole lifecycle, i.e. starting from the pre-investment analysis up to the project termination;
- Cash flow modeling which involves all the cash outflows within the project (costs) and all the cash inflows of the project (receipts). Here one should envision the possibility of using of various currencies;
- Comparability of conditions while selecting the thermal permafrost stabilizing technology;
- The thermal permafrost stabilizing technology with the highest effectiveness indicator is selected;
- The time factor and the probability of the climate warming is included into analysis of all the stages within the project;
- The estimation of the project effectiveness is a multistage process.

4. Conclusion

The method of technical and economic estimation of the selection of thermal permafrost stabilizing technology includes assessment of the project effectiveness indicators with consideration of random variables of the climate warming process. As the effectiveness indicators of the project activity during the selection of thermal permafrost stabilizing technology were chosen the following ones: the net present value (NPV), the modified internal rate of return (MIRR) and the payback period (PBP). The selection of thermal permafrost stabilizing technology is made through an estimation of the project effectiveness. The higher effectiveness is usually demonstrated by the project with higher values of MIRR (modified internal rate of return) where it is substantially higher than the discounting interest rate, which considers both the time factor and the risk of climate warming. The project that realizes the thermal permafrost stabilizing technology with high cash inflows during the late periods has a much higher sensitivity of NPV indicator, whereas the risk also rises with climate warming.

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