

# On the Need to Resume Monitoring of Pile Foundations of the Housing Stock in the Russian Permafrost Zone

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## ABSTRACT

The purpose of the short statement is to substantiate the need for systematic monitoring of pile foundations of the housing stock in the Russian Arctic permafrost zone in order to be able to carry out early adaptation measures and prevent damage.

## INTRODUCTION

The Arctic zone of the Russian Federation is home to 2.4 million people (1.7% of the total country's population). This is the most urbanized territory of Russia, the share of the urban population averages 88%. Permafrost degradation within urbanized areas is mainly associated with the decommissioning due to deformations and destruction of a significant share of the housing stock, buildings and structures. This can lead to the deepest shock for the municipal and regional economies subject to the fulfilment of climate warming forecasts until 2050. In the context of reducing vulnerability and increasing the resilience of Arctic cities to permafrost degradation, early and scientifically based adaptation is an important priority. In this case, the key adaptation mechanism, a tool for reducing vulnerability, in our opinion, is the preservation of the pile foundations of buildings and structures by thermal stabilization systems. However, the installation of thermal stabilization systems is cost-effective only at the initial stages of thawing. That is why systematic and regular monitoring of the pile foundations state is so important. Larger Russian companies (such as “Gazprom”, “Transneft”) already run their own extensive monitoring (thousands of temperature boreholes). Nowadays, the government plans to drill geocryological boreholes at 140 weather stations. However, the need to monitor the pile foundations of the housing stock is not given sufficient attention. This information is extremely important, including for the purposes of predicting geocryological changes in built-up areas.

## RESULTS AND DISCUSSION

In previous works author estimated the value of the housing stock in the areas of predicted permafrost degradation in the Russian Arctic (Badina, 2021). According to the calculations, climate change damage to the housing stock within permafrost zone of the Russian Arctic by 2050 may reach about 10 billion US dollars in 2020 prices (Melnikov et al., 2021). That is, according to the most negative scenario, almost the entire existing housing stock will be subjected to deformations and (or) destruction.

At the initial stage of research, it is rather difficult to assess the potential of counteracting to the foundations thawing through the thermal stabilization systems installation for the entire housing stock of the Russian Arctic permafrost zone. Therefore, this short statement proposes approbation

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of the approach on a large-scale object – the city of Norilsk (north of the Krasnoyarsk krai), where the author obtained necessary information in the framework of expeditionary studies.

Norilsk is a good case for a detailed study for a number of reasons. Firstly, the problem of deformation and destruction of residential buildings due to permafrost thawing is very relevant for this city. For instance, in the first decade of the XXI century, there were 356 residential buildings under the special control of the specialized Department of “Nornickel”, including 252 buildings with deformations of varying degrees. Secondly, in this city, one of the few in the Russian permafrost zone, the state of the housing stock foundations is being monitored. In 2013, according to geothermal measurements at various depths, out of 82 tested foundations of residential buildings in Norilsk, the soil temperature reached 0 degrees and more in about 1/3 of the cases (even taking into account not monthly, but single measurements)<sup>2</sup>. Finally, according to geocryological changes forecasts by the middle of the 21st century (for example, (Streletskiy et al., 2014)), Norilsk located at the zone of the highest risk. At the same time, exactly in Norilsk original practices for the renovation of buildings are already being used. For example, a family dormitory, which had been empty and emergency for a long time, was modernized into a modern shopping mall.

According to forecasts (Melnikov et al., 2021), the maximum damage for buildings and structures (including fixed assets of the economy and residential houses) under a moderate warming scenario in Norilsk by 2050 will be 8 billion US dollars. At the same time, according to our estimates, the total value of buildings and structures in 2020 prices in Norilsk is about 9 billion US dollars (of which 1.6 billion US dollars is the cost of housing stock). Thus, about 95% of the current buildings and structures value can be completely or partially lost. For a better understanding of the probable damage scale, it should be noted that the budget of Norilsk for 2020 was only 0.3 billion US dollars (only 61% of them are own revenues), which indicates extremely low internal resources to counter the emerging threat.

## CONCLUSION

We have estimated that the cost of thermal stabilization of the Norilsk housing stock will be from 140 to 1128 million US dollars, while the value of the existing housing stock is estimated at 1.6 billion US dollars. Therefore, the cost of thermal stabilization is from 8% to 70% of the market value of the housing stock. Close proportions between the costs of preventing negative consequences and the probable damage magnitude, apparently, are typical for the rest of the urbanized territories of the Russian Arctic permafrost zone, depending on how early thermal stabilization measures will start.

## ACKNOWLEDGMENTS

This work was supported by the Russian Science Foundation (RSF project No 21-77-00047, <https://rscf.ru/project/21-77-00047>).

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<sup>2</sup> According to reports of Research Production Association ‘Fundament’, Norilsk.

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