Arquluk program
Abstract

Infrastructure construction inevitably disturbs the environment. In permafrost regions, this disturbance is emphasized by climate change. Signs of road and runway degradation are becoming increasingly evident in Northern Canada, threatening the structural and functional capacity of transportation infrastructure. Reducing service level and, in extreme cases, service interruption may have considerable social and economic consequences for northern communities and societies involved in Northern development. In this respect, maintaining stable and secure transportation infrastructures is a great challenge in engineering.

ARQULUK, a research program on northern engineering, has focused on developing cost-effective solutions for designing and managing transportation infrastructure built on permafrost, thus improving climate change adaptation. ARQULUK was built based on the needs of the stakeholders involved in the development and management of Northern transportation infrastructure. The program has 12 partners from various groups in the private and public sector such as road administrations, engineering consulting firms and the construction industry. The research program's objectives are to develop a better understanding of factors contributing to permafrost degradation, improve investigative techniques for thaw-sensitive permafrost to locate and characterize problem areas, and develop cost-effective protection techniques. By achieving these objectives, the program actively supports the development and maintenance of long-term stable and economic transport services while also bridging the gap between basic research and practical engineering needs.

Over 5 years, the program has trained several undergraduate and postgraduate university students to meet the needs of qualified experts, primarily in design and maintenance, but also in the management of northern transportation infrastructure, which is a major barrier to social and economic development in Northern Canada. Stakeholders from North, including engineers and personnel of industrial partners, were also trained due to collaborative work, the Arquluk symposium and the development of technical guidelines.

Among Arquluk's achievements is the detection of massive-ice in soil using a geophysical method, microgravimetry, by comparing mass difference between the ice and the surrounding soil. The program also developed a data analysis method for longitudinal profiles of existing infrastructure to locate permafrost related degradation. A prototype for a new core-barrel, protected by a Canadian patent, was designed and constructed to measure in situ thaw consolidation properties of soils. It was also shown that, concerning creep behaviour of soils, the effect of heavy vehicles on thin embankments (dynamic creep) is to be considered; thereby, two charts have been developed to evaluate the settlement caused by static and dynamic creep.

Managers of Northern infrastructure will now be able to work with a practical risk assessment (hasard and consequences) Excel-based program and also, when a mitigation method is needed to preserve underlying permafrost, a decision tree will guide their selection of the best technique to apply while taking into consideration the local context and needs. Furthermore, thanks to a simple calculation model developed in Microsoft Excel, Northern stakeholders will be able to quickly evaluate the necessity to use a high albedo coating by using surface and thaw penetration temperatures. Through charts using the height of the embankment (reloading)

and/or required surface albedo, it is possible to attain thermal stabilization and limit permafrost degradation thus reducing transport infrastructure degradation.

The program improved the understanding of the impacts of water and snow on permafrost degradation in terms of heat transfer. In order to reduce the impact on permafrost, designers will be able to use the approaches developed to determine the geometry of the drainage system and the optimal number of passages, as well as the proportions of the embankment slope where wind and alignment favour snow accumulation. Designers will also benefit from optimizing the design criteria of two techniques used to extract heat from soil by air convection: heat drain and air convection embankments.

The results of the research program will have a significant impact on the quality of Northern roads and runways, therefore contributing to social and economic sustainability in Northern Canada. The knowledge and research results developed can be exported since the problems affecting development in Canada are also encountered in other Northern territories.