Determination of equivalent cohesion for snow and ice samples in the cold laboratory of the Geography Faculty of MSU

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Abstract. This paper examines the use of snow and ice as construction materials in polar regions, emphasizing their environmental benefits. Rapid climate change in the polar regions necessitates the maintenance of sustainable infrastructure, and snow becomes a promising option due to its mechanical properties at low temperatures. Technologies such as the production of snow blocks and pipes for use in buildings and thermal insulation are described. Snow compaction plays a key role in the creation of winterized roads and runways, using the ball stamp method to control strength. The results showed an equivalent cohesion for ice at around 0.04, and for compacted snow at 0.01-0.025.

1 Introduction

Polar Regions with their unique geographical value and potential resources are in the focus of international research [1, 2]. At the same time, rapid changes in polar glaciers create an urgent need for research in the polar regions [3, 4]. It is crucial to build environmentally friendly and sustainable infrastructure in Polar Regions. For instance, the problem of carbon emissions from traditional building materials such as asphalt and concrete will have a serious impact on the environment, and many scientists have worked on researching building materials with reduced environmental impact such as lower carbon emissions [5, 6].

Ice is a readily available material in polar regions. Due to its good mechanical properties at low temperatures, ice can be used as a building material in engineering structures needed by polar researchers to reduce the environmental impact of building materials in Polar Regions.

The construction of winter roads, runways and other structures using snow is possible thanks to special technologies and engineering solutions that make it possible to use snow and ice as a building material. One such method is the use of snow blocks for construction. In order to do this, the snow must be dense and wet to easily form blocks. The blocks are usually cut from snowdrifts and used to build walls and roofs. To strengthen the blocks, metal or wooden reinforcements are placed between them. Another method is the use of snow pipes, which are filled with snow and pressed in a special machine. The tubes can be

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used to build runways, roads and other structures. Also, snow cover can be used as a material for insulation of buildings and structures. Snow packed tightly on roofs or walls can be an excellent insulator that keeps heat inside a building.

The peoples of the North, adapting to the harsh natural conditions, have learned and successfully used snow for the construction of housing and auxiliary buildings. Eskimos achieved special skill in building snow igloo huts. These buildings serve as a sample of witty and skillful use of snow as a building material [K.F. Voytkovsky]. In addition, in 1930, engineer M.M. Krylov developed a project for the construction of cold warehouses made of ice. From the outside, the warehouses were protected with thermal insulating materials such as sawdust or peat to preserve the negative temperatures.

Vehicles in northern countries with large amounts of snow precipitation are more difficult to move, as the pass ability of machinery in snow is reduced by a factor of one compared to the surface of asphalt or non-swamped dirt roads. To overcome distances in the snow, people have long used snow or snow-ice roads. Snow roads require the most serious and in-depth studying, as they depend on them to provide supplies to populations in hard-to-reach areas, logging operations, and the possibility of transporting devices for mining and fuel resources. Back in the 1950s in Canada about 50 thousand kilometers of snow roads were used for logging operations every winter. Vibratory compactors and chain rippers in conjunction with sheet compactors were used to bring the mass density of snow down to 0.5 g/cm^3. Even at this density, however, heavy vehicles damage the pavement. A density of at least 0.55 g/cm^3 and a 2-3-day “seasoning” period, as well as several passes of heavy caterpillar tractors, are required to make the snow road surface suitable for uninterrupted vehicular traffic [7-11].

The properties and characteristics of snow roads, the techniques used to make them, and their purposes can vary widely. There is no single established method for classifying different types of snow roads. The fact is that different roads are made for different traffic, traffic congestion, and different types of vehicles. For instance, snow roads for heavy vehicles and trucks require a much denser, more stable and reliable surface than those for cars, small airplanes or airplanes with ski landing gear. In addition, the terms “snow road” and “snow runway” are not precise enough, as even within these terms there are differences in the type of equipment to create and use them. “Snow track” is generally only used by tracked modes of transportation or low-pressure vehicles on the roadway.

2 Materials and methods

Snow compaction is used in the process of building winter roads and runways under snow cover conditions. Snow compaction can be monitored using the ball-stamp method. The device for snow compaction and the ASIS installation with a ball-stamp device (Figure 1) were tested on the snow compaction device located in the arsenal of equipment of the cold laboratory of the Geography Department of MSU (Figure 1).

Fig.1. Cold laboratory of the geography department of MSU. Sealing device and installation of ASIS with the ball stamp device.

On the prepared samples of ice and snow compacted with the help of a press, ball-stamp tests were performed. The research results are shown on the graphs in Figure 2.

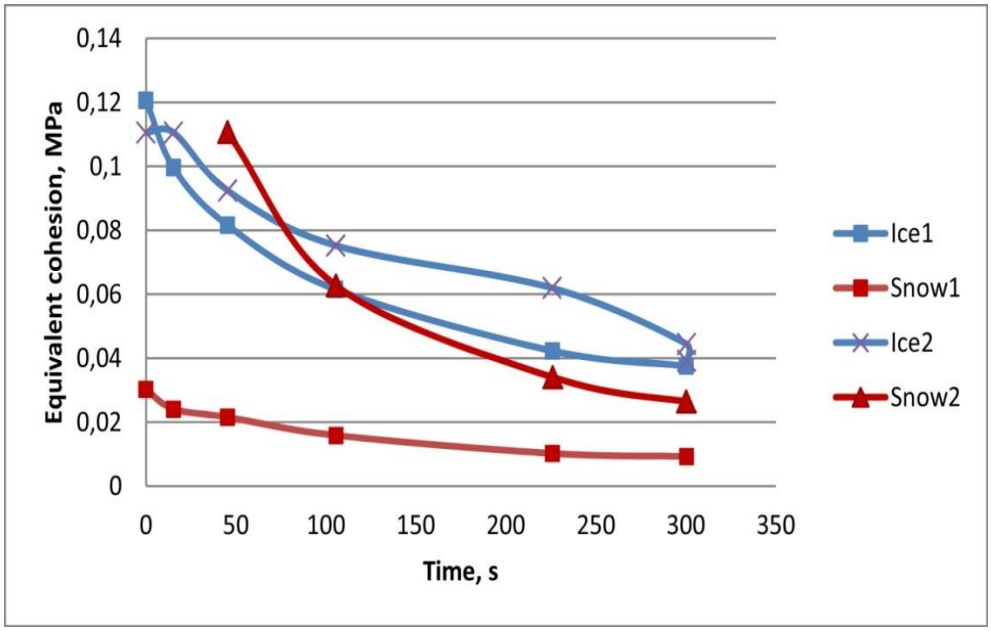

Fig. 2. Results of testing samples of compacted snow and ice by the ball stamp method.

It can be seen from the experiments in particular that the final value of equivalent cohesion for ice is approximately or greater than 0.04, and for compacted snow it is 0.01-0.025.

3 Results and conclusions

The considered use of snow and ice as construction materials in polar regions emphasizes their ecological advantage for reducing environmental impact and as traditional materials. Ice and snow have good mechanical and thermal insulation properties and at low temperatures can be used in the construction of winter roads, runways and insulation of buildings.

Snow roads are particularly important and their creation and properties are given special attention, as they are necessary to ensure transportation of goods under snow cover conditions. To improve the pass ability of such roads, snow density control is required, which is accomplished using various technologies, including the ball stamp method. Model research on the strength of compacted snow cover by ball stamp method was conducted in the cold laboratory of MSU. Experimental results showed an equivalent cohesion of 0.04 for ice and 0.01-0.025 for compacted snow.

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