Tool and Method for Testing the Resistance of the Snow Road Cover to Destruction

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Tool and Method for Testing the Resistance of the Snow Road Cover to Destruction

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Abstract. The paper presents the design of the tool for efficient determination of the hardness of the snow road coating. The tool increases vertical positioning of the rod with the tip through replacement of the rod slide friction of the ball element by roll friction of its outer bearing race in order to enhance the accuracy of determining the hardness of the snow-ice road covering. A special feature of the tool consists in possibility of creating different impact energy by the change of the lifting height of the rod with the tip (indenter) and the exchangeable load mass. This allows the study of the influence of the tip shape and the impact energy on the snow strength parameters in a wide range, extends the scope of application of the durometer and makes possible to determine the strength of snow-ice formations by indenters with various geometrical parameters depending on climatic conditions.

1. Introduction

During rapid reclamation of the northern regions in Russia in order to increase the extent of the hydrocarbonic raw material production, the intensity of traffic (vehicular, aerial) is enhanced, and as a consequence, the transport network is to be developed. Due to remoteness of the reclaimed areas from industrial centers and navigable rivers, poor infrastructure, bad weather and natural conditions (swamps, strong watering of the soil), the most efficient and a cost-effective way to deliver necessary cargoes is roads (snow roads) and airfields with compacted snow cover [1–10].

The snow roads depending on the duration of the season usage could be divided into:

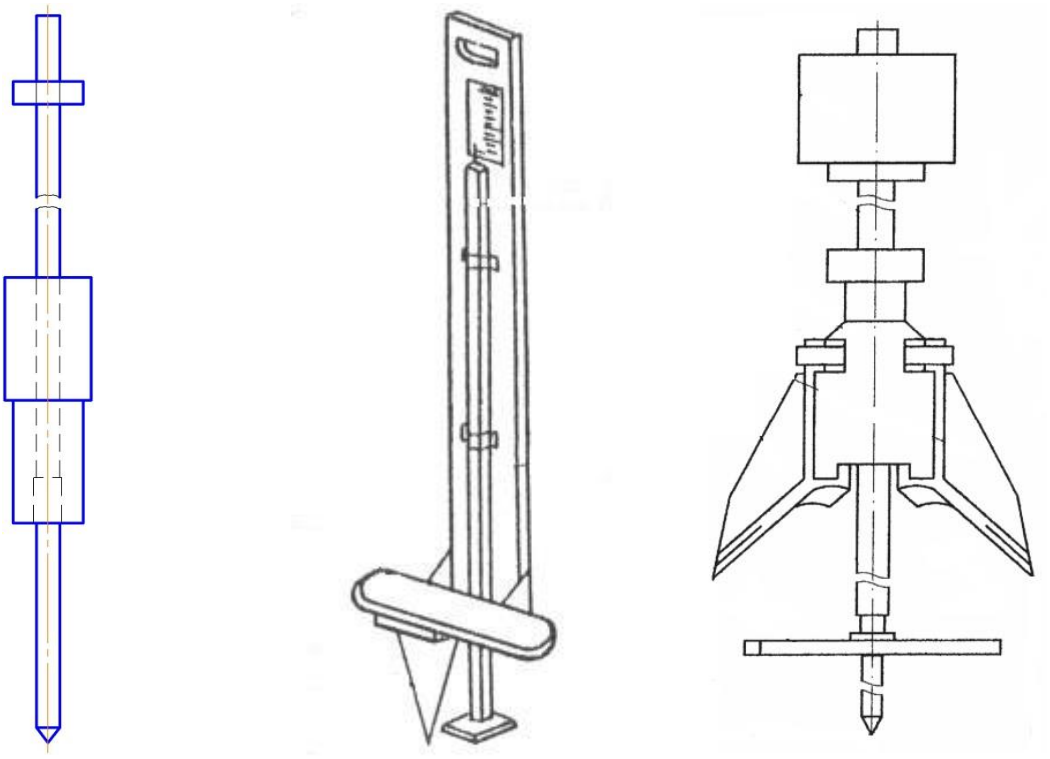
- general, intended for operation only during the period with stable negative air temperatures;
- snow roads with a longer lifetime providing transportation during the winter and part (or all) of the summer.

The requirements to be taken into account to ground the design decisions for snow roads are as follows:

- rapidly constructed from local materials with a maximum construction work mechanization;
- withstand the estimated loads of all types of vehicles (wheeled, caterpillar, sledge train) and to ensure their performance with the estimated speed for the required period of service;
- easy to recover from the destruction and environmental factors [11].

It is necessary to consider that in operation of roads and airfields with a compacted snow surface, in order to ensure the projected the intensity of vehicle traffic and a traffic volume, it is essential to continuously monitor the snow strength.

The tool by Soyuzdornii [11], tool NIAS [12] and tool KISI are used to determine the strength of the snow road cover [13] (figure 1). V.Z. Iofik [14] and a Japanese researcher Kinoshita [15] offer different types and geometric parameters of the indenter in contact with snow.



a b c

Figure 1. Tool controls the strength of snow cover: a) tool of Soyuzdornii; b) tool of NIAS; c) tool of KISI.

The main source of error in determining the strength of the snow cover hardness in NIAS is lack of the gauge (it is virtually impossible to put hardness vertically), and the weight determination test is inconvenient when measuring and affect the accuracy of determining the strength of the snow cover. Furthermore, when measuring the strength, the center of gravity is displaced relative to the tester rack, and to balance the longitudinal axis it is necessary to tilt the rack, and along with it, the longitudinal axis of the cone. In this case, the point of the contact of the cone with the surface of the snow cover is broken parallel to the base of the surface cone, wherein part of the energy is wasted on sliding friction of the contact surfaces of the rack with board-focusing and cramps.

2. Results and Discussion

In order to avoid these drawbacks, a device was designed and manufactured (figures 2 and 3). Tool 1 consists of body base 2. The housing is provided with ball bearing 4 (with a split outer race) having a ball head and a through hole in which it is fixed to guide tube 5 installed in the rod with a conical tip 6, 7, exchangeable load 8 and ruler 9 attached to the outer surface of the pipe. In the upper and lower parts of pipe 5 through three equally spaced openings of rectangular diameter 10 are made. Each of the openings 10 is supplied with plug 11 to move longitudinally therein. One end of each plug roller bearing 12 is mounted in contact with the surface of the outer race and the rod being a guide for the movement of the rod along its longitudinal axis. The other end of the plug is made with a thread and is mounted in cylindrical hole 13, and bracket 14 is rigidly secured to guide tube 5. At the end of the threaded plug, nut 15 is installed for adjusting the gap between outer ring rolling bearing 12 and rod 6. To fix the ball head bearing outer split 4, the ball bearing cage is mounted in a slotted body with two arms connected by a stopper. The stopper bolt consists of the brackets and nuts 16 along the longitudinal axis of guide tube 5 and longitudinal groove 17 with transverse shoulder 18. Longitudinal slot 17 includes arrow pointer 19, mounted on rod 6. It indicates the amount of immersion of the conical tip in snow cover.

Figure 2. The appearance of the tool.

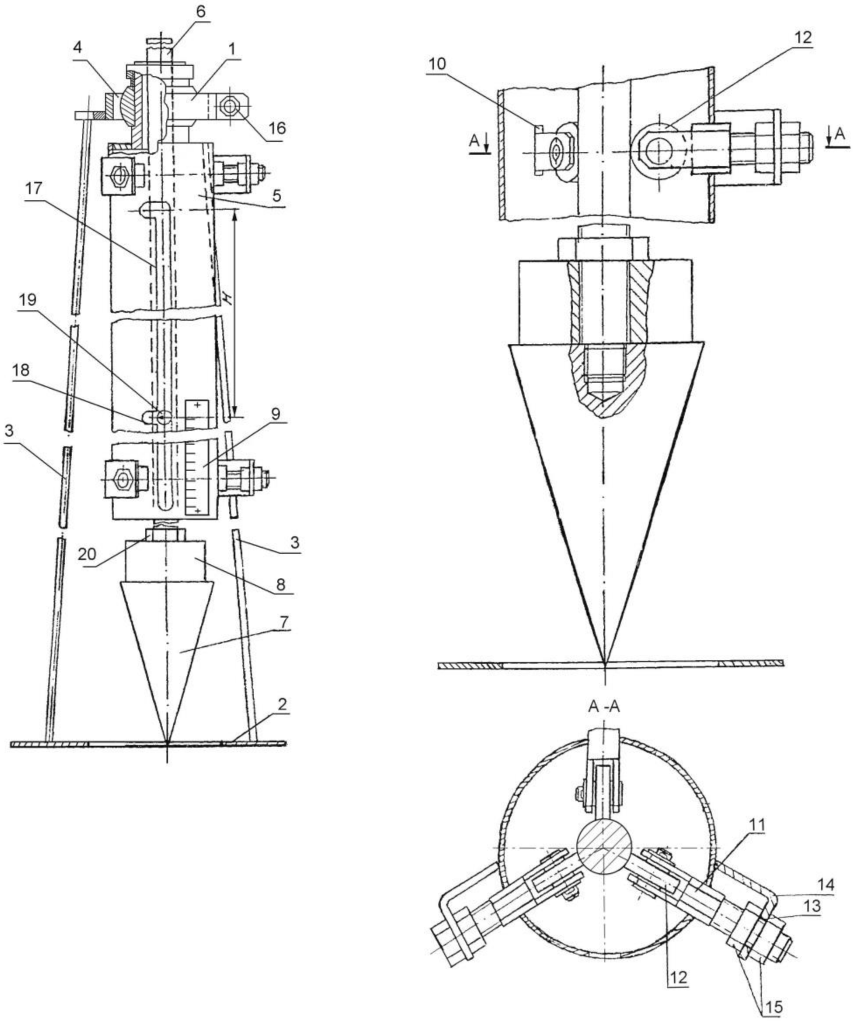


Figure 3. Design of the device 1 – framework; 2 – base; 3 – support; 4 – ball bearings; 5 – the guide tube; 6 – pin; 7 – the conical tip (indentation); 8 – change freight; 9 – ruler; 10 – rectangular opening; 11 – male; 12 – rolling bearings; 13 – cylindrical hole; 14 – bracket; 15 – the adjusting nut; 16 – nut retainer; 17 – longitudinal groove; 18 – cross the ledge; 19 – pointer arrow; 20 – nut.

The tool operates as follows. Framework 1 at bottom base 2 is mounted on a pre-aligned snow cover, with arrow pointer 19 mounted in the lower transverse shoulder 18 of guide tube 5. In this case, the top of conical tip 7 should be in the plane of base 2 in contact with snow, and guide tube 5 under the influence of its weight, the weight of rod 6, conical tip 7, removable load 8 and nut 20 mounted in framework 1 and a holder with vertically split ball. To fix this position, guide tube 5 and framework 1 by rotating nut 16 under the action of the axial force of the bolt stopper contracts the split ball holder that clamps the ball head and keeps it in that position when determining the snow strength. After that, arrow pointer 19 together with rod 6 and conical tip 7 rises up through longitudinal groove 17. The rod is released from this position. Under the action of its own gravity it moves down and in contact with the surface of the conical tip enters into snow. The value of the tip immersion is measured on the scale of the gauge shown in figure 4.

Figure 4. The scale of the ruler.

The strength of the compacted snow depending on the applied load and the depth of the cone is determined by the formula:

$$\sigma = \frac{m \cdot g \cdot H}{\pi \cdot h^2 \cdot tg^2 \cdot \frac{\alpha}{2}}. \tag{1}$$

where σ is snow strength index kPa; m is mass of the rod with a conical tip, [kg]; H is height of the fall of the rod with a conical tip, [m]; h is depth of immersion of the cone, [m]; α is cone angle of 34°12'.

3. Conclusion

The novelty of the proposed technical solution is confirmed by the patent [6]. The feature of the tool is that its design has different impact energy changed by the pitch of fixed lifting rod 6 with a tip 7 (indentation) and changed weight of load 8. This allows the study of the influence of the tip and the energy of the impact on the values of the snow strength in broad limits, extends the scope to determine the strength and hardness of snow and ice formations with indenters of various geometrical parameters depending on climatic conditions. In addition, the use of the device will allow operational services of roads and unpaved airfields to carry out operational testing of the snow compaction degree on the carriageway of roads (winter roads), elements of the airfield grounds and enables efficient control of the parameters of the sealing equipment operation in the construction of winter roads and development of the method of sealing unpaved airfields.

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