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Tymchenko Olga, Candidate of Engineering Science (Ph.D.)

DETERMINING SNOW CAPACITY OF SNOW PROTECTION FACILITIES ON ROADS IN THE MOUNTAINOUS AREA

Анотація. У статті розглядаються засоби захисту від снігу. Метою даної роботи є визначення снігового потенціалу засобів захисту снігу на дорогах у гірській місцевості. Для проведення теоретичних досліджень були застосовані аналітичні методи. У статті представлений загальний вигляд формул для визначення снігозатримуючої спроможності та снігомісткості снігозахисних засобів за допомогою добре відомих геометричних параметрів і були запропоновані захисні засоби проти заметів.

Ключові слова: снігомісткість, снігозатримуюча спроможність, снігозахисний засіб, сніговідкладення, автомобільна дорога у гірській місцевості.

Аннотация. В статье рассматриваются средства защиты от снега. Целью данной работы является определение снежного потенциала средств защиты снега на дорогах в горной местности. Для проведения теоретических исследований были применены аналитические методы. В статье представлен общий вид формул для определения снегозадерживающей способности и снегоемкости снегозащитных средств с помощью хорошо известных геометрических параметров и были предложены защитные средства против заносов.

Ключевые слова: снегоемкость, снегозадерживающая способность, снегозащитное средство, снегоотложение, автомобильная дорога в горной местности.

Abstract. The article deals with the snow capacity of snow protection facilities. The purpose of the given work is to determine the snow capacity of snow protection facilities on roads in the mountainous area. To carry out theoretical studies there were applied analytical methods. The article presents a general form of formulas for determining the snow-retaining capacity and the snow capacity of snow protection

facilities through well-known geometrical parameters and there were offered protective means against snowdrift.

Keywords: snow capacity, snow-retaining capacity, snow protection facility, snow sediment, road in the mountainous area.

1. Introduction

An effective method of snow control on the roads is preliminary snow retention. For example, one forest belt with four lines can hold up to 150 m³ of snow. Wind breaks on the roads are often arranged close to the roadbed, so contributing to snow drifts on the roads. The road in such cases is within the zone of intensive formation of snow deposits.

To resolve this problem, it is necessary to reconstruct the existing snow control landscaping, which is associated with the allocation of land, the value of which is growing rapidly. This puts temporary facilities that do not require land on the forefront of the snow-drift control.

2. Analysis of research and publications

The most common way of snow-drift control is temporary wooden latticework panels that in the course of a 120-year period of application have outdated by all indicators. They have a number of significant drawbacks. It is a small snow capacity and snow drift, which determines a great complexity in their operation. For a long time, the use of such tools have proved to be ineffective due to insufficient development of the theory of formation of snow deposits because of the high complexity and low scrutiny of the process of high-drag barriers interaction with one- and two-phase gas flows. Despite a large number of studies, up to the present moment there has not existed a theoretical way to determine the basic operational performance of snow protection facilities such as snow-retaining capability and snow capacity that can be determined only experimentally (Goncharenko 1999).

It is known that formation of snow deposits is due to the braking action of obstacles against the oncoming snow-wind stream. This action takes place on a particular part of the length and height of the flow on both sides within some limits of the zone of aerodynamic effects. The larger the zone is, the longer the length of the stream will be where the speed is reduced, and the more snow deposits will be formed around the obstacles (Bileush 2000, Byalobzheskij 1983).

To identify the space and evaluate the frequency of avalanches is only possible owing to characteristic signs that they leave behind them if the chutes, on which avalanches occur, are devoid of vegetation and have distinct shapes.

In the case of gentle slopes and small pools snow mass gathering can be prevented using the transverse defensive walls and stone outfitting (Byalobzheskij 1983). In some cases, if there is a favorable terrain, the avalanche can be directed to one side of the road, using protection walls, avalanche-breakers. Avalanche dams are constructed in the form of mounds with securely fenced slopes from 10 m to 15 m.

Capital structures that securely protect the roads from snow avalanches are galleries (Kungurcev 1961). Galleries are designed on steep slopes. The roof of the gallery is designed in the form of a lean-to roof equal to or greater than the downhill slope. This design provides free skidding of snow mass on the roof without effort.

Galleries are mainly constructed closed made of prefabricated concrete elements.

The work purpose - to determine the snow-capacity of snow retaining facilities on the roads in mountainous areas. To carry out theoretical studies there were applied analytical methods.

3. Research of snow capacity of snow retaining facilities

According to the theory of turbulent stream, the length of the windward zone and the leeward zone of aerodynamic performance is a function of the square of the mid section of the obstacle, which can be expressed in terms of height (Kungurcev 1961).

In accordance to the experimental data collected during numerous studies, the length of windward deposits in the proximity of any snow-retaining facilities approximately equals 10 heights of the obstacle (Kungurcev 1961). This allows to consider with sufficient accuracy

$$l = C_1 H_0, \quad (1)$$

where l – length of the windward part of snow deposits, m;

$C_1=10$ – dimensionless constant factor;

H_0 – height of snow-retaining facility, m.

Regarding the leeward zone, where a larger part of the joint volume of snow deposits is formed, until recently there has not been a consensus about its size even according to experimental data.

The process of obstacle interaction with a biphasic snow-wind flow over time is accompanied by the solid snowfall phase, i.e. formation of snow deposits on both sides. Increasing the height of windward snow deposits defines proportional reduction of the obstacle that interacts with an oncoming flat snow-wind flow. This pattern can be written in the form

$$d(F_0 - F) = Zdh_n, \quad (2)$$

where F_0 – mid sectional area of the obstacle, m^2 ;

F – area of interaction of the obstacle with the flow, m^2 ;

Z – unit of length, m ;

H_n – height of snow deposits on the leeward side, m .

At a constant speed of the blizzard the deposited amount of snow per unit of time or increase of the volume of snow deposits is permanent. For each meter of the snow-protection line length there is brought a certain amount of snow, which is equal to the total flow of the blizzard Q_{max} , m^3/s .

According to numerous experiments the longitudinal profile of snow deposits before snow accumulation by barriers has the shape of a triangle (Bileush 2000, Kungurcev 1961). Increase of the volume of snow retention therefore spreads over slightly extending space of formed snow deposits. In addition, over time the amount of snow that moved past the barrier due to reducing of F increases, so the process of snow deposits heightening can be written in the form of the following dependence

$$h(T) = a_3T^3 + a_2T^2 + a_1T + a, \quad (3)$$

where h – height of snow deposits, m ;

$a...a_3$ – constant dimensionless coefficients;

T – time, s .

For snow protection it is recommended to use barriers that are flushed from below with a clearance space of 0.3 - 0.5 (Byalobzheskij 1983). According to the authors' data and (Goncharenko 1983), barriers with smaller of the given values of clearance have a higher snow capacity and greater sparsity of the bottom of the midsection area. In these cases, the following dependence is typical

$$dh_n = dh_p, \quad (4)$$

where h_p – height of the leeward side of snow deposits, m.

According to the theory at a constant speed the length of snow deposits from the downwind side of barriers do not change over time (Bileush 2000). In accordance with the experimental data obtained by the authors and other researchers, the length of snow deposits remains virtually unchanged in the range of velocities of 6-15 m/s. In view of this and the triangular form of the profile of snow deposits, using expressions (2) - (3) we present the formula for determining the snow-retaining capacity of barriers:

$$N = C_3 F_0 \frac{dh}{dT}, \quad (5)$$

where N – snow retaining capacity, m^3/s ; $C_3 = C_1 + C_2$ - dimensionless constant coefficient.

Integrating formula (5), we obtain a formula for determining the snow capacity of snow-retaining facilities:

$$W = C F_0 \int_0^T dh, \quad (6)$$

According to the theory (Byalobzheskij 1983) and the data obtained by the authors the height of snow deposits at the final moment of time $T_c=T$ of the process of snow deposits formation equals the height of the snow-retaining facility, that is

$$h_e = I_0. \quad (7)$$

This makes it possible to submit a general form of expressions for determining the snow-retention capability and the snow capacity of snow protection facilities through the known geometrical parameters. Substituting in formulas (5) - (6) $\frac{dh}{dT}$ for $\frac{dF}{dT}$ in accordance with formula (2), after some transformations we obtain

$$N = C_5 F_0 \frac{d(F_0 - F)}{dT}, \quad (8)$$

where $C_5 = \frac{5}{Z} \left(\frac{1}{1-P} + 22,5 \right)$ - dimensionless coefficient;

P – clearance space of the snow protection facility in fractions of a unit.

Then

$$W = C_5 F_0, \quad (9)$$

The validity of expression (9) is confirmed by experimental data obtained by the authors and other researchers. Thus, according to the expression (9) the maximum snow capacity of wooden lattice shields with $P = 0.3$ is 36.16 m^3 , and according to the majority of authors, it is 36 m^3 (Bileush 2000, Kungurcev 1961).

Avalanche protection structures rely on vertical and horizontal components of the pressure from the impact and weight of snow slide (Kungurcev 1961).

To determine the approximate estimated speed of an avalanche they use formula:

$$v = \sqrt{2qz}, \quad (10)$$

where z - the distance that is determined, using the dependence

$$z = H_A - \frac{H}{L} l_A, \quad (11)$$

The parallel pressure angle, N/m^2 on the surface of the avalanche-breaker, blasting dam or the direction wall is determined by the formula:

$$P_r = \frac{\gamma v^2}{2q} \sin^2 \alpha, \quad (12)$$

where γ - the proportion of snow, N/m^3 ; for snow that has just fallen, $\gamma = 0,3 \cdot 10^4 \text{ N/m}^3$; for old snow $\gamma = 0,4 \cdot 10^4 \text{ N/m}^3$; for wet snow $\gamma = 0,5 \cdot 10^4 \text{ N/m}^3$;

α - the angle between the direction of avalanches and surface structures, deg.

Avalanche pressure on the roof of galleries is determined by the formula:

$$P_b = \gamma h_b \cos \beta, \quad (13)$$

where h_b - the thickness of the avalanche layer;

β - gallery roof angle to the horizontal plane.

4. Conclusions

1. To develop effective recommendations for protection of roads in the mountainous area from snowdrifts it is necessary to determine the snow capacity of snow protection structures.

2. According to recommendations (MR R B.2.3-218-02071168-776:2010) we will adopt the following protective measures against snowdrift: placement of walls and other structures to prevent blowing of snow from the surrounding areas into basins that prevents the accumulation of snow on the slopes and in ravines; afforestation of snow retention pools, placing ditches, walls, retaining walls along the movement of snow to prevent its replacement; snow mass removal by guide walls sideward away from the structure to be protected.

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Рецензенти:

Павлюк Д.О., д-р техн. наук, Національний транспортний університет.
Гончаренко Ф.П., канд. техн. наук, ДП "Укрдипроддор".

Reviewers:

Pavliuk D.O., Dr. Tech. Sci., National Transport University.
Honcharenko F.P., Cand. Eng. Sci. (Ph.D.), "Ukrdiprodor".

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