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### Ways of increasing the efficiency of snow fences

Komarov, A. A.

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## PREFACE

Snowdrifts can be a major source of disruption in the operation of transportation services and a general nuisance in the normal wintertime activity of a community. Such drifts are formed whenever a wind, strong enough to transport horizontally a significant amount of snow, encounters a barrier which forces it to deposit some of this snow. The usual approach taken in defending an area or structure against snowdrifting has been to locate the structure properly so that the drift problem will be a minimum and to erect barriers, such as snow fences, to control where the snow will be deposited. The approach taken in the development of these defences has been largely empirical. Attention has been directed primarily to the character of the air flow with little attention being given to the material transported. In some circumstances, it would be an advantage to have a more complete defence against snowdrifting than is now available. In their attempts to develop this defence, engineers are giving more consideration to the theoretical aspects of the problem and in particular to the relationships between the air flow and the snow being transported.

It is one of the responsibilities of the Snow and Ice Section of the Division of Building Research to collect and make available information required for the solution of snow and ice problems encountered in engineering practice. The Division is pleased to offer to Canadian engineers the information contained in this Technical Translation on ways of increasing the efficiency of snow fences. This report is the fifth on Russian investigations on snowdrifting that has been published in the National Research Council Technical Translation series. The other four are: "Vertical Distribution of Solid Flux in a Snow-Wind Flow", by A.K. Dyunin, "Fundamentals of the Theory of Snowdrifting", by A.K. Dyunin, "On the Construction of Snow Fences", by A.K. Dyunin and A.A. Komarov and "Some Rules on the Migration and Deposition of Snow in Western Siberia and their Application to Control Measures", by A.A. Komarov.

The paper was translated by Mr. G. Belkov of the Translations Section of the National Research Council Library, to whom the Division of Building Research wishes to record its thanks.

Ottawa  
October, 1963

Robert F. Legget  
Director

NATIONAL RESEARCH COUNCIL OF CANADA

Technical Translation 1095

Title: Ways of increasing the efficiency of snow fences  
(Puti povysheniya effektivnosti raboty snegozashchitnykh  
zaborov i shchitov)

Author: A.A. Komarov

Reference: Trudy Transportno-Energeticheskogo Instituta, (4): 119-126,  
1954

Translator: G. Belkov, Translations Section, N.R.C. Library

## WAYS OF INCREASING THE EFFICIENCY OF SNOW FENCES

This paper notes the defects in the operation of existing snow fences and suggests ways of improving their construction and methods of arranging them on portions of roads that are subject to extensive snowdrifting.

At the present time snow fences are used to protect more than half of all roads subject to snowdrifting. For the roads of Siberia this means of snow control is even more important. In future, snow fences will be the basic method of snow control in regions where it is impossible to introduce forest strips and also for new roads during the first years after they are put to use. Therefore the development of measures intended to increase the efficiency of snow fences is an urgent problem.

The principal function of the snow fence is to retain the bulk of the snow that is transferred throughout the winter on the windward side of the road. On portions of the road subject to heavy snowdrifting the standard type lattice fences do not provide reliable protection because they do not hold back sufficient snow. They, as a rule, serve as an auxiliary means in conjunction with permanent fences or forest strips. Permanent lattice fences, although they are more efficient than the portable types, tend to become filled in towards the second half of the winter in areas where there are extensive blizzards.

According to the data of TsNII MPS (Central Research Institute of the Ministry of Transport) the snow-collecting ability of a single-row fence 6 metres high reaches  $300 \text{ m}^3/\text{pm}^*(1)$ . Moreover on the construction, repair and utilization of snow fences large funds are required. The high costs of snow fences prevent their extensive use on the road networks of the Soviet Union.

One of the measures intended to increase the efficiency of the fences is the elevation of the fence line above the surface of the ground<sup>(1)</sup>. In reducing the density in the lower part of the fence an important factor is the amount of snow transferred beyond the range of operation of the fence. Experimental investigations of the transfer of snow and its deposition in the area of the fence\*\* has established that the quantity of snow deposited from

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\* Translator's note:  $\text{m}^3/\text{pm}$  - metres cubed per linear metre.

\*\* See paper by A.A. Komarov, Some rules on the migration and deposition of snow in western Siberia and their application to control measures, Trudy Transportno-Energeticheskogo Instituta, (4): 89-97, 1954. (NRC TT-1094)

a snow-wind flux when the velocity of the wind is reduced by an obstacle can be expressed by the formula

$$\Delta q = q_1 - q_2 = 0.0065 (V_1^{3,5} - V_2^{3,5}) \quad (1)$$

where  $\Delta q$  is the quantity of snow deposited per unit of time or the difference in the rate of snow transfer in g/cm/min;

$V_1$  is the wind velocity on the windward side of the barrier measured at the height of 1 m in m/sec;

$V_2$  is the same beyond the barrier.

Using formula (1) we determined the quantity of snow deposited behind standard fences elevated above the surface of the ground.

From the wind velocity data and testing of model snow fences in wind tunnels, the wind velocity beyond a fence with 53% density is on the average 30% that of the open field velocity. Behind fences with an open space of 0.4 - 0.5 m at ground level, the wind velocity is on the average 45% that of the open field velocity. When the wind velocity is 15 m/sec the velocity beyond the fence measured at the surface of the ground is reduced to 4.5 m/sec and beyond the fence with an open space near the ground the wind velocity is approximately 7 m/sec. Carrying out calculations with the use of the formula (1) we obtained the following values for the quantity of snow deposited and that transferred beyond the range of the fence for the two types of snow fences (Table I).

As can be seen from Table I, the quantity of snow carried beyond the range of the fences, elevated above the ground at the beginning of their operation is insignificant and may be neglected. As the snowdrift increases, the wind velocity beyond both types of fences increases and the difference in the amount of snow transferred beyond the range of each fence type gradually decreases. Experimental observations carried out by TsNII (All-Union Central Research Institute) showed that the snow-collecting properties of fences elevated above the surface of the ground by 0.4 - 0.5 m increases by a factor of 1.5<sup>(1)</sup>.

Taking into account the efficient operation of snow fences raised above the ground we carried out an experimental investigation on snow fences of decreased density having 100% open space in the lower and middle part (Fig.1). By testing these model fences in a wind tunnel it was established that the optimum height of  $h_1$  should be 0.4 m and the height of  $h_2$  not less than 1.0 m.

With such values of  $h_1$  and  $h_2$  the wind velocity beyond the fence was on the average equal to 45% of the wind velocity in the open field (Fig. 2).

As seen from Fig. 2 the velocity curves at the fence raised above the surface of the ground and at the fence with reduced density are essentially the same. Consequently the snow-collecting property of these two fences can be assumed to be the same. To check the experimental investigation during the winter of 1952-53 some experimental observations were made and the results are shown in the graphs of Fig. 3 and 4 and in Table II.

From the graphs of snow deposit (Fig. 3, 4 and Table II) one can see that the snow-accumulating ability of the fence with reduced density is not less than that of a standard fence. On the contrary, behind fences with reduced density more favourable conditions are created for forming a high snow wall. Moreover one of the advantages of this type of fence is that in their construction the expenditure on lattice material is reduced by 30%, which reduces their cost substantially. Thus one of the methods of increasing the efficiency of snow fences is to provide an open space of about 0.4 m in the lower and middle part. This increases the snow-collecting ability of the fences and reduces their cost.

In choosing the type and size of a snow fence an important question is their space arrangement. When the snow deposition reaches  $300 \text{ m}^3/\text{pm}$ , official recommendations<sup>(3)</sup> and those of a number of authors<sup>(2)</sup> are to set up a single-row fence 6 - 7 m high. When the snow deposition is greater, the procedure is to set up a double-row fence or a single-row fence with a supplementary portable fence.

Let us consider briefly the conditions of forming a snow wall at snow fences of various heights and at different space arrangements. For a comparative estimate of the snow-collecting properties of a single-row fence one can use the known formula

$$Q_1 = kH_1^2 \quad (2)$$

where  $Q_1$  is the volume of snow at the fence in  $\text{m}^3/\text{pm}$ ,

$H_1$  is the height of the fence in m,

$k$  is an experimental coefficient equal to 6.

From this formula we get the obvious consequence that an increase in the snow-collecting properties of the fence can be achieved by increasing its height. The general shape of the snow wall at a single-row fence 3 m high is shown in Fig. 5. In addition to increasing the height of fences a substantial improvement may be obtained, as shown by TsNII, by installing a double-row fence. Experimental observations of TsNII have established that the most efficient distance between the two fences should be 30 times the height of the fence<sup>(1)</sup>. In such a case the space between the fences becomes filled with snow and much more snow is collected than with a single-row fence. On

the basis of these experimental data the total snow-collecting ability ( $Q_2$ ) of a double-row fence can be determined by the formula

$$Q_2 = \alpha H_2 l + k H_2^2, \quad (3)$$

where  $Q_2$  is the total volume of snow collected by a two row fence in  $m^3/pm$ ,

$H_2$  is the height of the fence in m,

$l$  is the distance between the rows of fences in m, equal to  $30H$ ,

$\alpha$  is a coefficient characterizing the extent to which the space between the fences is filled,

$k$  is an experimental coefficient which as in the previous case is equal to 6.

The profile of snow deposit at double-row fences 1.5 m high is shown in Fig. 6.

When  $H_2 = \frac{H_1}{2}$  (i.e. the height of the double-row fence is one-half that of a single-row fence) and  $\alpha = 0.75$  (i.e. the space between the rows is filled by 75%) we get  $Q_2 = 7H_1^2$ .

Thus calculation and experimental observation show that the snow-collecting ability of low double-row fences and high single-row fences is approximately the same (when the height of the single-row fence is twice that of the double-row).

In considering the two types of fences, i.e. high single-row fences and low double-row fences one should take into account a number of other important factors such as the expenditure of labour and material.

In constructing a single-row fence, the lattice work is arranged in such a manner as to reduce to a minimum the amount of snow that is carried beyond the limits of the fence. This is achieved, as shown by many experiments, by providing a density of from 57 to 63%. In constructing double-row fences, as shown by experimental data and field observations\* in the first row facing the open field the density may be reduced to 25%. In the first instant of operation of the two-row fence the volume of snow deposited beyond the first row having a density of 25%, calculated according to formula (1) reaches 30% of the total quantity of snow transferred by the wind. In constructing multiple rows of fences the density of each row with the exception of that nearest to the road being protected can also be 25%. In this case the snow wall initially forms behind the first rows of the fence and then as the snow accumulates it gradually extends to the row nearest to the road which should retain all the snow blown past the first fences.

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\* See our paper cited above.

Let us determine the approximate requirement of lumber to construct the lattice work of high single-row fences and low multi-row fences providing the same snow collecting ability. As a comparison let us consider two examples.

First example. A lattice type single-row fence 6 m high replaces a double-row fence 3 m high. The first row facing the open fields has a density of 25%. The fence facing the road being protected is of a design with reduced density of the type shown in Fig. 1. After carrying out some calculations we obtain the following quantity of lumber required for the lattice work (Table III). As can be seen from Table III, when a single-row fence is replaced by a double-row fence the requirement for lumber is reduced by 40%.

Second example. A double-row fence 6 m high (for extensive snowdrifting is replaced by a four-row fence 3 m high. By analogy with previous fences the row facing the road is of a construction with reduced density and all the others have a density of 25%. The expenditure of material for the lattice work is shown in Table IV.

As in the first case the replacement of high fences by low fences reduces the amount of material needed for the lattice work by 45%. Thus the investigations indicate that the designing of high fences (6 - 7 m) for sections of the road subject to extensive drifting is not advisable either from a technical or economical point of view. The most rational type of fence should be considered one with a height of not more than 3 m arranged at a distance of 30 times their height. The first row facing the road being protected is of a reduced density type of construction shown in Fig. 1 and the subsequent rows should have a density of 25%. The number of rows in each case depends on the extent of snowdrifting. Low fences arranged in two rows have as much snow-collecting ability as high fences but require approximately half the material for their construction.

It should be noted that when high single-row fences are replaced by low double-row fences the snow wall is wide and occupies a large strip. However, in designing and locating snow fences one should take into account the following possible cases:

(1) Fences should be used as a permanent protection for roads subject to snowdrifting in areas where the soil and climate conditions are unfavourable for planting forest strips for snow control.

(2) Fences should be used as a temporary means of snow control until newly planted forest strips are large enough to be effective.

In the first case when fences are constructed in regions with unfavourable soil and climate the width of the strip occupied by the fence is not a limiting factor in locating the fence. In the second case in order to protect

the newly planted trees it is desirable to locate the fence between the rows of trees. When the height of the fence is 3 m the snow wall beyond it does not have any detrimental effect on the newly planted trees if it is located between the rows of trees. Consequently even when these factors are taken into account it is preferable to use multiple rows of low fences.

It should be noted that a fence height of 3 m corresponds to a maximum design height of the functional part of the forest strip in determining the width of the area occupied by the snowdrift.

Therefore the area of land taken up by fences of the multi-row variety is about the same as that occupied by the forest strips.

On the railroads of Siberia where there is extensive drifting, forest strips and permanent fences are frequently supplemented by lattice-type snow fences. In setting up the supplementary snow fences on the windward side the density may be decreased by 25%.

Thus the investigations carried out on the efficiency of snow fences of various type show that in areas where there is extensive snowdrifting the construction of high snow fences (up to 6 - 7 m) is not expedient from either a technical or economical point of view. The most effective operation of snow fences can be achieved by constructing two or more rows of fences (depending on the extent of snowdrifting) to a height of not more than 3 m and arranging them at a distance of 30 times their height from each other. With this arrangement of snow fences all the rows, except the first one facing the road, can have a density of 25%. Such a system of snow fences has a high snow-retaining ability and reduces the consumption of lumber by one-half. One of the advantages of low multi-row fences is that the snow wall behind them is deposited in an even layer and removed from the road, which does not threaten the earth fill of the road bed.

#### References

1. Antonov, F.I., Pryadko, V.S., Mel'nik, I.M. Bor'ba so snezhnymi zanosami na zheleznodorozhnom transporte (Combatting snowdrifts in railroad transport). Moscow, Transzheldorizdat, 1951.
2. Danovskii, L.M. Snegozashchitnye zabory na dorogakh zapadnoi Sibiri (Snow fences on the roads of western Siberia). DopNITO Tomskoi zh. d. 1950.
3. Tekhnicheskii spravochnik zheleznodorozhnika (Railroad technical handbook), Vol. V. Transzheldorizdat, 1951.

Table I

Snow retaining ability of various types of fences  
(from theoretical calculations)

Type of fences	Field velocity of wind m/sec	Field velocity beyond fence m/sec	Quantity of snow deposited g/cm/min	Quantity of snow transferred g/cm/min	Magnitude of snow transferred %
1. Set up on surface of the ground.....	15.0	4.5	84.6	0	0
2. Elevated above surface..	15.0	6.7	81.0	3.6	3.5

Table II

Snow-collecting ability of various types of fences  
(from experimental observations)

Type of fence	Snow deposition in m <sup>3</sup> /pm on				
	27/XII	7/I	21/I	10/III	25/III
1. Standard type with 50% density.....	23	41	56	65	95
2. With decreased density.....	21	40	55	63	93

Table III

Amount of lumber required for the construction of the fence

Type of fence	Height of fence in m	Requirement of lumber in %	Observation
1. High single-row fences...	6.0	100.0	
2. Double-row fences.....	3.0	60.0	Distance between fences is 30 times their height

Table IV

Amount of lumber required for the construction of the fence

Type of fence	Height of fence in m	Requirement of lumber in %	Distance between fences
1. High double-row fences...	6.0	100.0	30 times height of fence
2. Low four-row fences.....	3.0	55.0	30 times height of fence

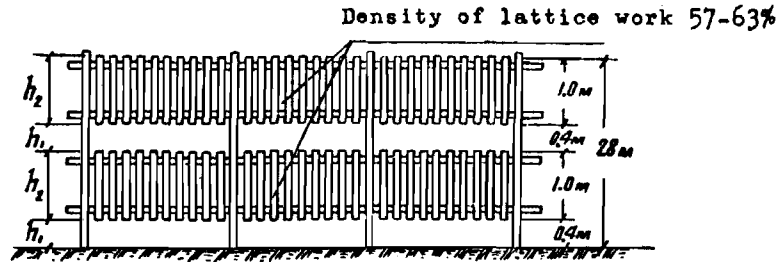


Fig. 1

A schematic diagram of a fence of light construction

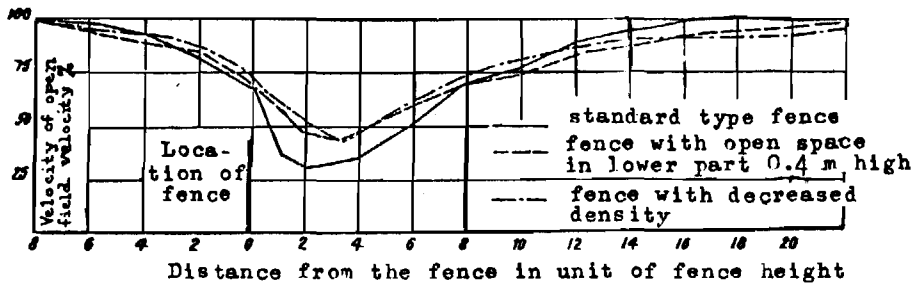


Fig. 2

Aerodynamic characteristics of snow fences of various types

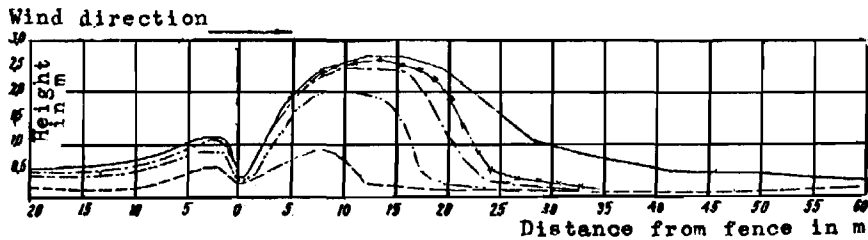


Fig. 3

Cross-section profile of snow deposit at fence with decreased density

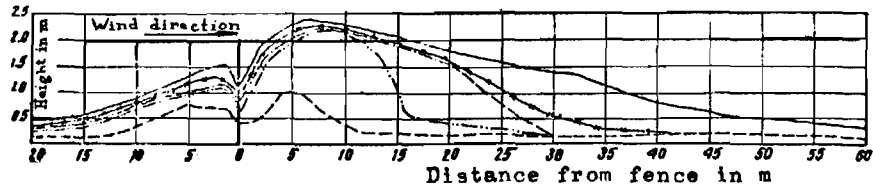


Fig. 4

Cross-section of snow deposition at a fence of standard construction

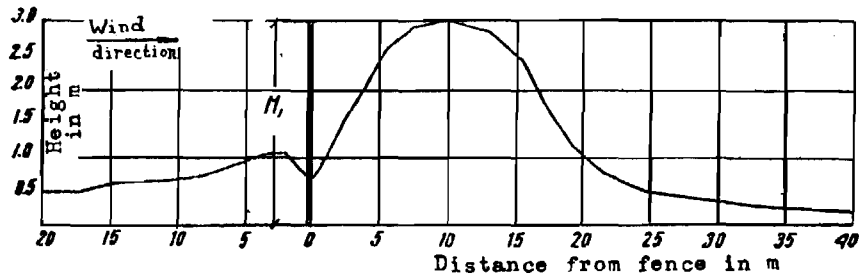


Fig. 5

Cross-section of snow deposition at a single-row fence 3 m high

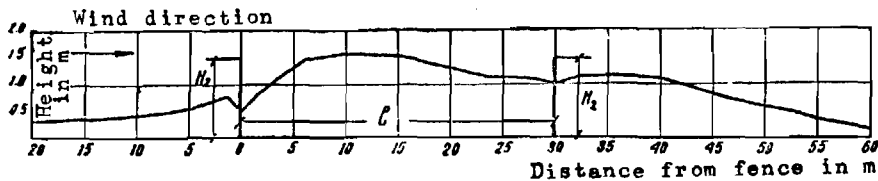


Fig. 6

Cross-section of snow deposition at a double-row fence 1.5 m high