RELATIONSHIP BETWEEN THE DEVELOPMENT OF A SNOWDRIFT AND SNOW TRANSPORT RATE ON A ROAD SECTION WITH A CUT ON ONE SIDE – OBSERVATION IN TESHIKAGA-CHO DURING WINTERTIME IN FY2016 AND FY2017-

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1. Introduction

In recent years, stranding of vehicles in snowdrifts and other traffic hazards have been reported in relation to road sections with a cut during snowstorms. Therefore, it is important to predict the formation of snowdrifts on such cut road sections on a real-time basis and to carry out more effective wintertime road management, which involves snow removal and road closure. However, it has been unclear what kind of impact the structure of the cut road section and weather conditions have on the process of snowdrift development. This study examines the relationship between the depth of snowdrifts on a cut road section and the transport rates in order to propose a snowdrift prediction method for cut road sections.

2. Research method

The authors investigated the process of snowdrift development on a cut road section with a height of approximately 2 m and a grade of 100 % located in a suburb of Teshikaga-cho, Hokkaido Prefecture (N43°30', E144°27'). **Fig. 1** shows a photograph of the investigation spot and the position of the measurement equipment. The investigation spot has a fetch of 500 m or more, which is enough for blowing snow to accumulate on the windward side. This investigation assumes that there is a two-lane Type 3 Class 1 road on the lee side of the cut. The depths of snowdrifts on the measurement lines shown in **Fig. 1** were measured. Measurement was conducted during wintertime over two years, namely from November 20, 2016, to January 17, 2017 and from November 20, 2017, to March 30, 2018.

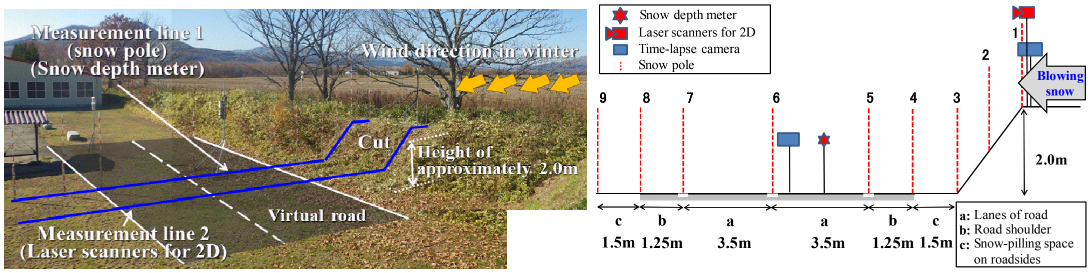

Fig. 1. Investigation spot and Measurement method

For measurement, we set nine measuring sticks (snow poles) and took photographs with a time-lapse camera every 20 minutes from 6 a.m. to 4 p.m. We also set a snow depth meter in the middle of the lanes on the windward side and measured the snow depth every hour. From November 20, 2017, we also measured the depth of snow on the road's cross-section with a laser scanner every hour.

3. Analysis method

This paper analyzses the following three periods during which blowing snow formed a snowdrift on the lanes of the virtual road where there had been almost no snowdrift before the blowing snow.

[Event I] : December 9 to 12, 2016

[Event II] : December 13 to 14, 2017

[Event III] : January 3 to 4, 2018

Since the transport of snow greatly contributes to the formation of a snowdrift, we estimated the transport rate by the following method. First, we determined whether or not there was blowing snow. If blowing snow was occurring, we estimated the snow transport rate during such event using Formula (1), which was proposed by Matsuzawa[1], et al. With reference to The Highway Snowstorm Countermeasure Manual[2] , we determined whether there was blowing snow based on Condition 1 or 2, depending on whether it was snowing or not.

$$Q = 0.005\, U_{1.2}^{4} \qquad \text{Formula (1)}$$

[Condition 1 (snowing)] : $T \leq -5°C$ and $U \geq 5 ms^{-1}$ or $-5°C < T < 0°C$ and $U \geq 6\ ms^{-1}$

[Condition 2 (not snowing)] : $T \leq -5°C$ and $U \geq 10\ ms^{-1}$ or $-5°C < T < 0°C$ and $U \geq 11\ ms^{-1}$

Q is the snow transport rate ($gm^{-1}s^{-1}$), $U_{1.2}$ is the average wind velocity (ms^{-1}) at 1.2 m high, T is the temperature (°C), and U is the maximum instantaneous wind velocity (ms^{-1}) at 10 m high. We used observation values (ten-minute values) obtained by the AMeDAS located near the investigation spot for the calculation of transport rates. Wind velocities at individual heights were calculated according to the logarithmic law (snow surface roughness was set at 1.5×10^{-4} m).

4. Analysis results

Fig. 2 shows the relationship between the depths of snowdrifts and the accumulated snow transport rate. The results show that snowdrifts are formed earlier and the development speed as a ratio to the snow transport rate is larger on the windward side near the cut slope.

Fig. 3 shows the relationship between the depths of the snowdrift and the accumulated snow transport rate on the middle line of the lanes on the windward side for individual events. In Events I and II, the depth of the snowdrift reached 15 cm, with which it is said to be difficult to start a car, when the accumulated snow transport rate reached approximately 1000 kgm^{-1} (**Fig. 3** a)). Meanwhile, in Event III, the depth of the snowdrift reached 15 cm earlier than in Event I or II, when the accumulated transport rate reached 300-700 kgm^{-1} (**Fig. 3** b)). In Event III, a snowdrift had already been formed on the cut slope before the blowing snow started. It is considered that the difference in the accumulation of snow on the cut slope on the windward side has an impact on the development speed of snowdrifts.

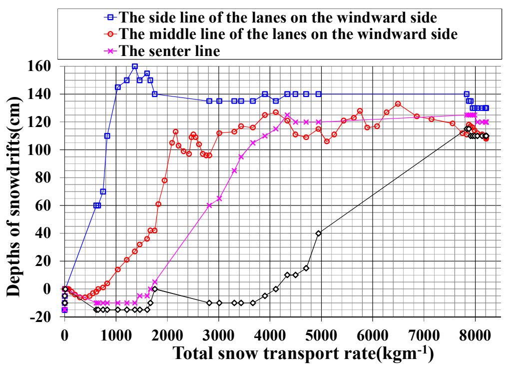

Fig. 2. Relationship between the depths of snowdrifts and accumulated snow transport rate (Event I)

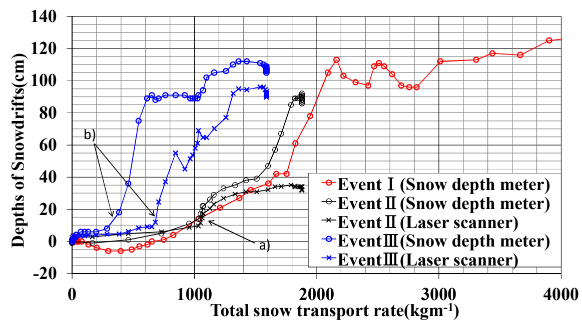

Fig. 3. Relationship between the depths of snowdrifts and accumulated snow transport rate on the middle line of the lanes on the windward side

References:

1. Masaru Matsuzawa et al., **2010**, A study on experimental relationships between wind velocity and snow transport, Cold region technical papers and reports, vol.26, 45-48

2. Civil Engineering Research Institute for Cold Region, **2010**, The Highway Snowstorm Countermeasure Manual