Vegdirektoratet
Vegavdelingen
Drift, vedlikehold og vegteknologi
19.10.2017

Statens vegvesen

Labfasiliteter på Forsknings-senter vinterdrift (NTNU)

Etatsprogram vinterdrift (EVI)

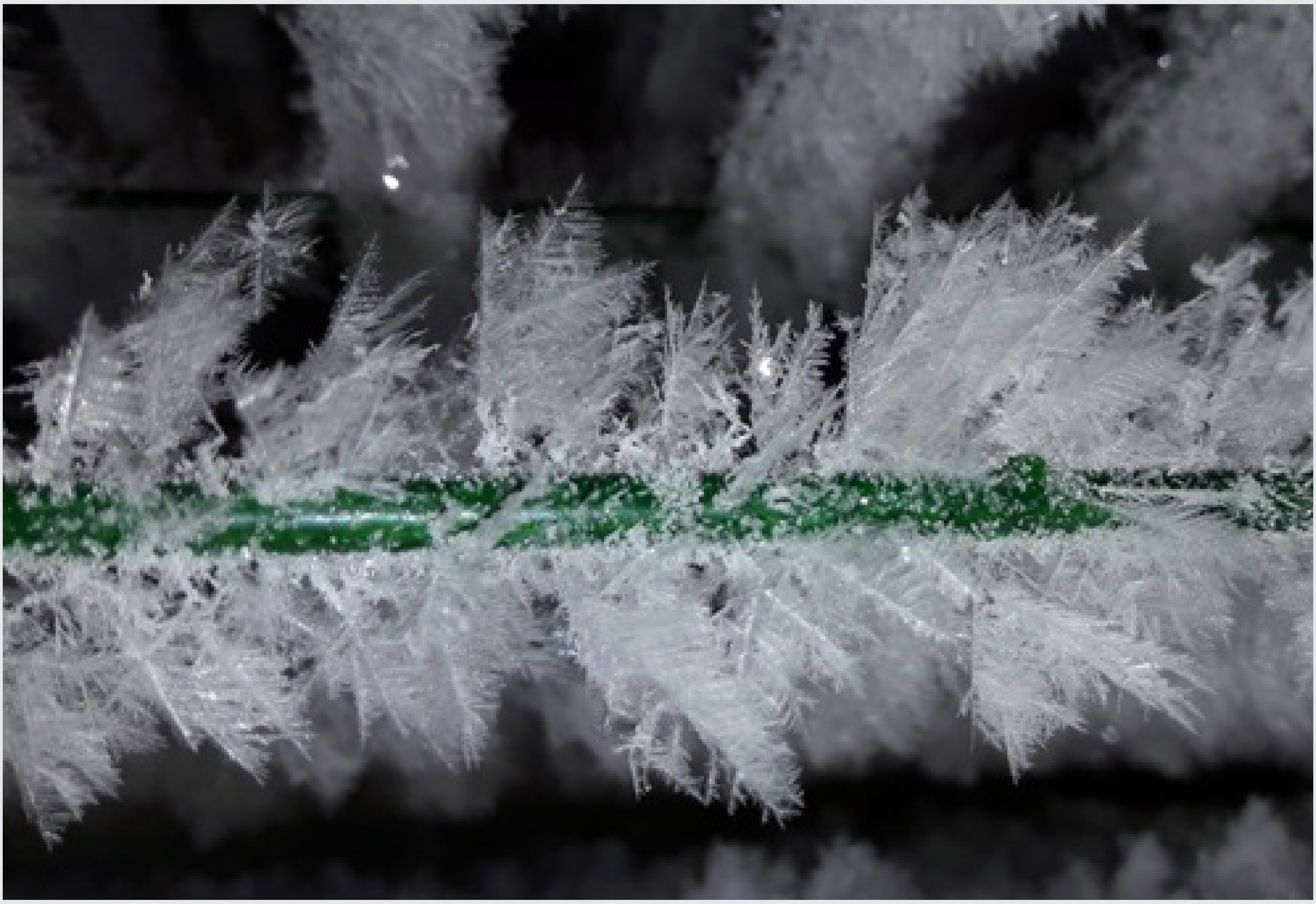

Foto: Mathis Dahl Fenre

Statens vegvesen

Laboratory facilities at the Norwegian University of Science and Technology (NTNU)

1 Background

Good quality winter maintenance of roads is important for getting people and goods safely transported in the winter. Ploughing, gritting and salting together with monitoring of road conditions require good knowledge and understanding of snow and ice properties, especially while interacting with a tire. A research group for winter maintenance at the NTNU has been established in cooperation with Norwegian Public Roads Administration (NPRA) to strengthen this field through research and building expertise. A central element of the research group's activities is the education of master's and doctoral candidates with specialization in winter maintenance that further contributes to higher level of knowledge in the sector.

Studying winter maintenance outdoors can be challenging, since weather conditions, such as precipitation, humidity and temperature, can vary rapidly and effect the test results. To secure good core expertise, such variables as weather, must be controlled. Therefore, there was a demand for new type of indoor laboratory facilities at the NTNU that would enable studies of snow and ice properties in controlled conditions. These facilities were develop in cooperation with the research group for winter maintenance at the NTNU and the NPRA and taken into use in January 2017. The description of these facilities are found in this memo.

2 Introduction

Steering, accelerating and braking a vehicle demands a certain amount of tire-pavement friction. Vehicle type and speed, among other factors, affect the amount of required friction. Snow and ice on a road surface reduce attainable tire-pavement friction, which results in longer braking distances or losing control of a vehicle. In order to avoid this, an adequate friction level on snow and ice needs to be achieved. Different winter maintenance actions, such as snowploughing, gritting and salting, are carried out in order to provide safe road conditions also in winter. To evaluate the quality of these maintenance actions, friction measurements are performed and those measurements (a friction coefficient) are often used as an indicator.

However, friction is not a simple phenomenon but rather complicated. In addition, the amount of required friction is dependent on vehicle and tire type and speed, as mentioned. Different tire properties are already well known, but we still lack the knowledge of snow properties in interaction with a tire. Therefore, insights in tire-snow interaction are needed, for example to improve the quality of friction measurement devices. The demand for new laboratory facilities to study tire-pavement interaction was recognized.

A linear analyser of road surface conditions (LARS) at the Norwegian University of Science and Technology (NTNU) is developed to respond this demand. Several facilities for studying friction mechanisms exists already [1 - 4], but most of them are focusing on tire properties. Facilities that allow high speeds usually are circular tracks where a test tire is rolling over same test surface several times. Linear tracks, on the other hand, allow single passages, but do normally not enable high testing speeds. Some of the existing facilities concentrate on testing tire tread blocks instead of pneumatic tires. In addition, ice is more commonly studied than snow, not to mention salted snow and ice. Combination of a rolling tire with relatively high speeds and an apparatus to make artificially new snow makes the LARS special.

3 Design

The laboratory facilities consist of three climate rooms, where temperature can be chosen between −25 °C and +25 °C. The temperature accuracy is ±0,5 °C. Two of the three climate rooms are laboratories for studying snow and ice properties and for producing artificial snow, whereas the third room is an entrance room to these two laboratory rooms. Room temperature laboratory facilities are located right by the climate rooms.

3.1 A Linear Analyzer of Road Surface conditions (LARS)

The LARS is a linear track with a total length of 8,8 meters from which 8 meters is the total free movement length. The test track is fitted in an aluminium frame (Figure 1). An electrical motor of 45 kW is driving a sledge along the track, and a test tire is attached to the sledge and rolled over a test surface. The tire is pressed against the track with a controlled normal force, 1500N at maximum. A tire with variable diameters can be tested, since the height of the test track is adjustable. A braking torque and rotation speed of the test tire is measured, which further enables to calculate the slip ratio.

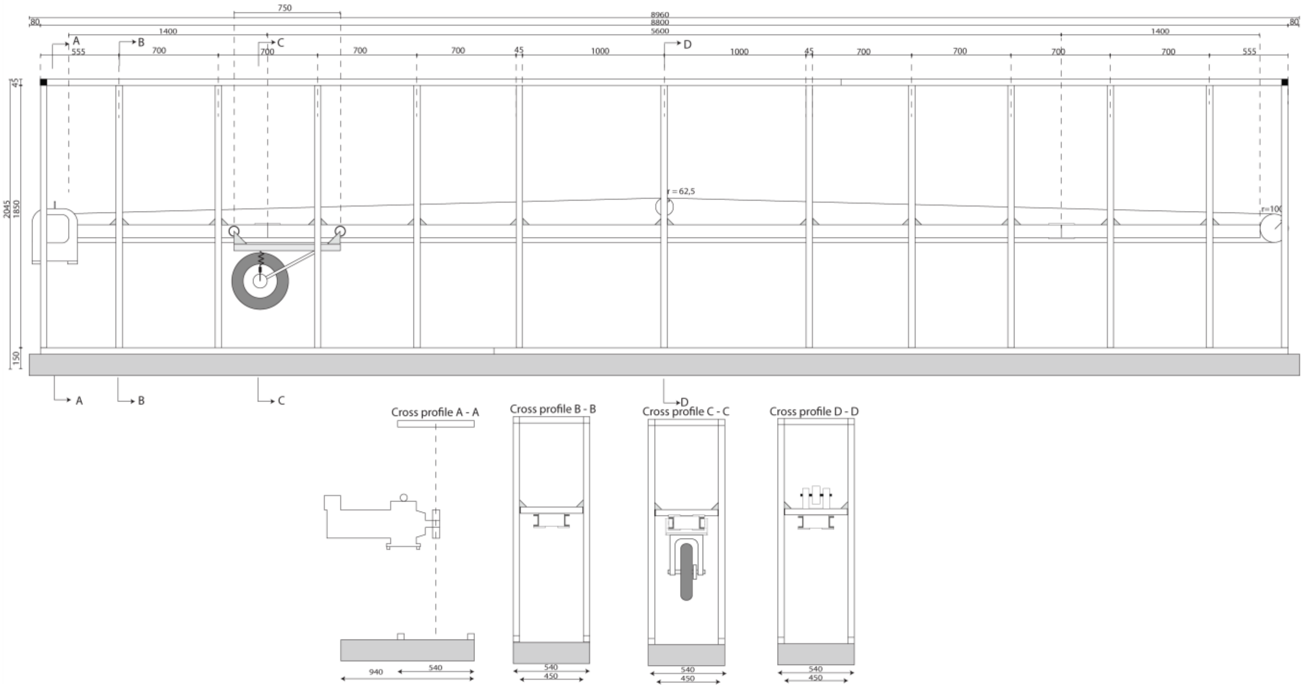

Figure 1. An illustration of the apparatus.

3.2 The snow machine *Lumi*

Lumi is a snow machine, which produces snow by blowing cold, humid air, into a nucleation chamber (Figure 2). When the air interacts with a plastic covered steel lattice (Figure 3), snow crystals starts growing. Every two hours, a vibration motor induces vibrations to the lattice and the snow crystals falls into the harvesting box.

Statens vegvesen

Figure 2: The snow machine Lumi.

Statens vegvesen

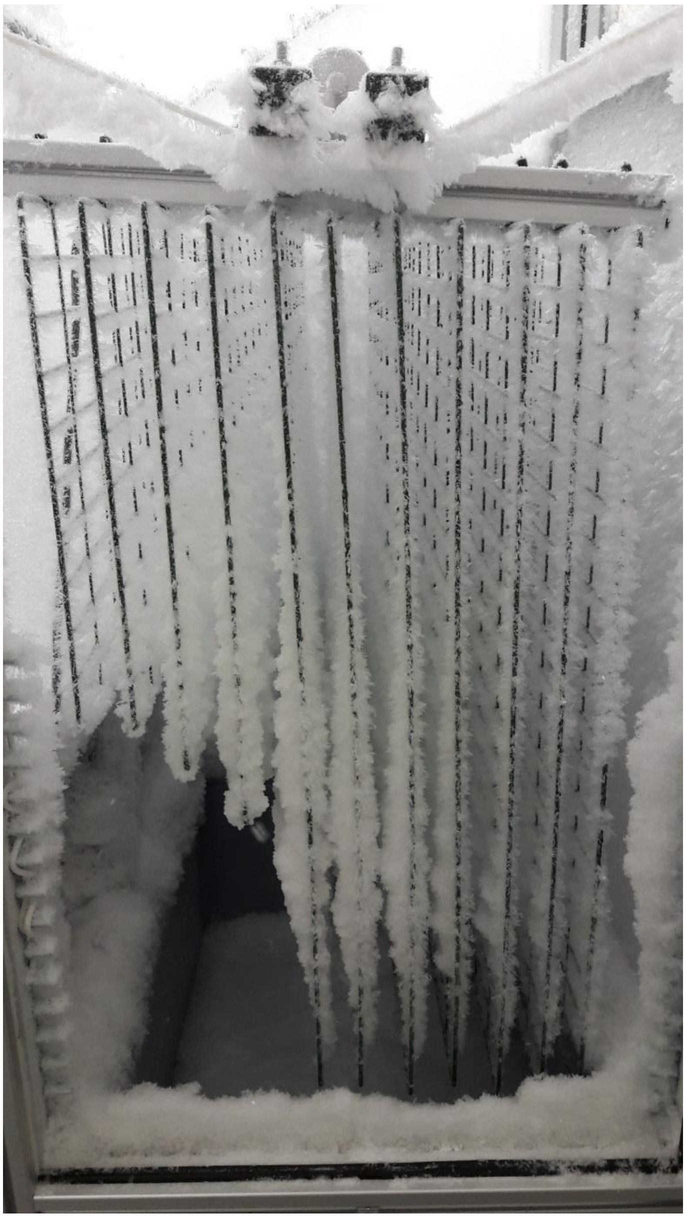

Figure 3: Plastic covered steel lattice inside of the Lumi where the snow gets created.

The humid air is provided by a temperature controlled water bath at 35 °C. The snow machine is placed inside a lab where temperatures are controlled down to −25 °C. The dimensions of Lumi are 2010 mm x 1430 mm x 970 mm (height x length x width).

Preliminary results show that Lumi produces 5,8 kg of dendritic snow crystals per 24 hours. The density is very low, around 40 g/L. By changing the water and air temperatures, Lumi can produce different types of snow crystals (Figure 4).

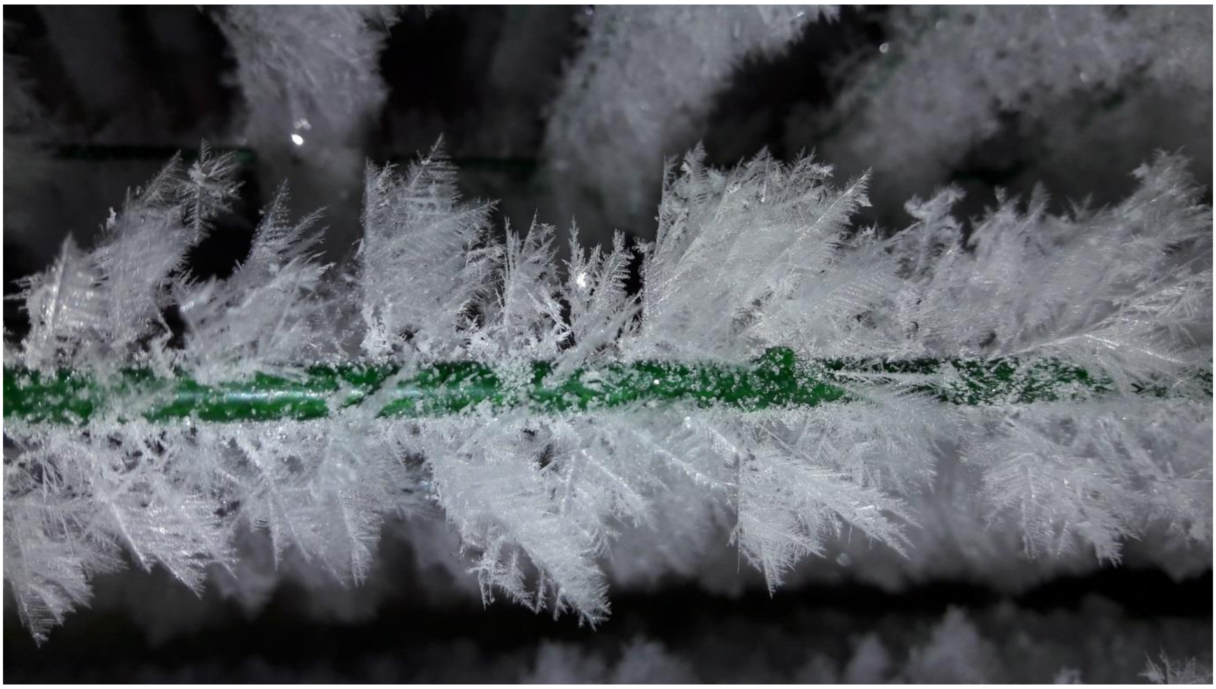

Figure 4. Close-up picture of artificially produced snow by the Lumi

3.3 Test settings

Three types of test settings are possible: 1) one-way friction test and 2) on-way or 3) back and forth traffic simulation test.

During a friction test, controlled braking force can be applied to the test tire and therefore a friction can be measured. In this test, a test tire is accelerated up to maximum 15 m/s within the first 3 meters of the track. Then the tire is rolling over the 2 meters long test area with controlled slip. Finally, the tire is braked down to 0 m/s. After the test, the tire can be returned to the start point. Hence, the test can be repeated with a new test sample.

During a traffic simulation test, a test tire is driven either one-way or back and forth over a test sample once or desired number of times. Tire can be braking or rolling freely over the test surface. In each test settings, different kinds of test tires can be chosen from a special test tire with diameter of 40 cm to a bicycle tire with diameter about 70 cm. The actual test area of 2 meters is positioned in the middle of the track. A summary of the three test settings is presented in Table 1.

Table 1. Test settings

Test setting	Slip-%	Test direction	Test target
1) Friction	Controlled slip	One way	Friction
2) Traffic simulation test	Free rolling or braking tire	One way	Snow and ice properties
3) Traffic simulation test	Free rolling or braking tire	Back and forth	Snow and ice properties

4 Time and resources

The NTNU was responsible of the tendering and carrying out the construction processes. The NPRA sponsored the process by financing 37,5 % of the total 4 MNOK investments costs and lending out 50 % position for supporting the project manager during the planning, tendering and construction processes from January 2015 to July 2016 (18 months).

The construction work of the laboratory facilities was started in spring 2015 and completed in summer 2016. Testing and adjustments of the facilities were carried out during autumn 2016. The facilities was finally taken into use in January 2017.

References

1. S. Ripka, H. Lind, M. Wangenheim, J. Wallaschek, K. Wiese and B. Wies. Tire Science and Technology. Investication of friction mechanisms of siped tire tread blocks on snowy and icy surfaces. 40, 1-24 (2012)
2. R. Mundl, G. Mesche and W: Liederer. Tire Science and Technology. Friction Mechanism of Tread blocks on Snow Surfaces. 24, 245-264. (1997)
3. M. Rantonen, A. J. Tuononen and P. Sainio. International Journal of Vehicle Systems Modelling and Testing. Measuring stud and rubber friction on ice under laboratory conditions. 7, 194-207. (2012)
4. O. Lahayne, J. Eberhardsteiner, R. Reihsner. Transactions of FAMENA. Tribological investigations carried out by a linear friction tester. 33, 15-22. (2009)
5. J. Wåhlin, S. Leisinger and A. Klein-Paste. Cold Regions Science and Technology. The effect of sodium chloride solution on the hardness of compacted snow. 102, 1-7. (2014)

Statens vegvesen
Vegdirektoratet
Vegavdelingen
Postboks 8142 Dep 0033 OSLO
Tlf: (+47) 22073000
publvd@vegvesen.no

vegvesen.no

Trygt fram sammen