DEVELOPMENT OF A NEW SANDING METHOD BASED ON A MIX OF SAND AND HOT WATER, AND IMPLEMENTATION AND CONSEQUENCES FOR THE ORGANIZATION OF GRITTING OPERATIONS

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1. Abstract

Recognizing that there is a need for increased knowledge of all types of friction measures, the Norwegian Public Roads Administration started a research program in 1997 with focus on winter management. The Winter Friction Project deals with practical, technical and economical problems arising in providing good friction conditions on winter roads. The final report is scheduled for 2002. One of the main activities throughout the whole project period is to carry out a testing program (scientific studies) to document performance of different friction improvement methods. The goal is to come up with a recommendation what the best method under different conditions is.

Aside from studying different salting methods, the project has dealt with different ways of applying abrasives. Both traditional and new sanding methods have been tested:

- Traditional methods: dry sand and sand with salt
- New methods: heated sand and warm wetted sand

The two new methods which were presented at the Xth PIARC International Winter Road Congress in Luleå in 1998 are principally different both in functionality of the truck and the method used for heating the materials. Heated sand means that the materials (crushed stone) are heated up to 180 degrees Celsius. The warm wetted sand method is based on adding hot water to the sand.

In particular, the method using a mix of hot water and sand produced promising results in the first winter test. Scientific studies conducted as part of the Winter Friction Project in Norway has revealed that measures carried out with the new method last considerably longer than traditional sanding methods. Under favorable road and weather conditions, satisfactory friction values have been found to be maintained for up to one week on roads with AADT 1,500-2,000 with the new method.

During the 1999/2000 winter season two new Norwegian prototypes were constructed on the basis of the experiences from the first winter test with a Swedish prototype. During the 2000/2001 winter season there was further development and refinement of the spreader and the heater system. Norwegian trucks have shown a very good performance both with a roller distributor and with a spinner. The warm wetted sand method is recommended for use on a larger scale for daily gritting operations as an alternative to traditional sanding methods.

In Norway, 88 percent of public roads, i.e. 47,300 km, are operated using the so-called white winter road strategy. Large quantities of sand are spread to improve friction on ice and snow. The limitations of this method are well known: The friction improvement is modest, and the effect of gritting is rapidly reduced by the traffic. For both practical and economic reasons it is not always possible to comply with the required standards.

The introduction of wet gritting means substantial improvement, both in regard to friction and in time of effect. The new method is expected to have a marked impact on winter road operations.

2. Background

Recognising that there was a need for increased knowledge of all types of friction measure, the Norwegian Public Roads Administration started a research project in 1997 with focus on winter management. The goals for the project are to a) come up with optimal methods that can be of practical use and b) come up with recommendations for snow plowing techniques as well as the type and amount of salt and sand to be used during various conditions.

One of the main activities throughout the whole project period is to carry out field studies. These field studies consist of the following parts:

1. Testing program (scientific studies) to document performance of different friction improvement methods
2. A follow-up study on roads in 10 counties to document existing winter maintenance practice both on salted and sanded roads

In part one of the field studies, the goal is to come up with a recommendation for the best method under different conditions.

Scientific studies have revealed that measures carried out with new sanding methods last longer than traditional sanding methods. While the effect of using cold and dry sand can disappear after the passage of 50 vehicles, it has been proven that by adding warm water to the sand it is easy to maintain a friction level above the standard even after the passage of 2,000 vehicles. Under favourable road and weather conditions, satisfactory friction values have been maintained for up to 3 to 7 days on roads with AADT 1,500.

3. Description of the Warm Wetted Sand Method

The first truck based on the warm wetted sand principle in Norway was called Friction Maker. This equipment, which was tested the first time in the 1998/99-winter season, was a re-constructed semi-trailer spreader with a dropside body, see Figure 1.

FIGURE 1 Swedish Prototype for Warm Wetted Sand.

A water tank holding 2.5 m^3 and a heater with a water pump is mounted onto the lorry body. The equipment is provided with a spreader mounted behind the dropside body. The method is based on

adding hot water to the sand and covering the sand particles with a film of water. When the sand that has been sprinkled with water leaves the spreader and lands on the roadway, the film of water has a short melting effect and then the mixture of sand and water freezes to the surface. This gives the roadway a kind of sandpaper texture, see figure 2.

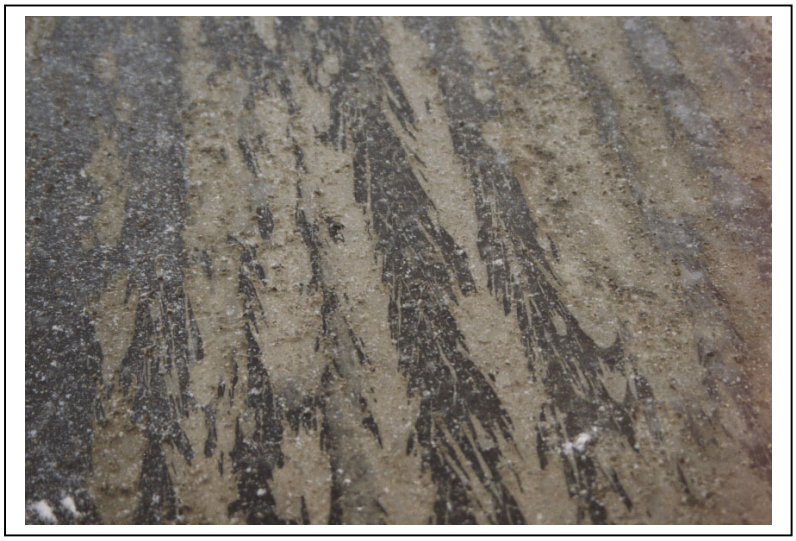

FIGURE 2 Road Surface Texture after spreading a Mixture of Sand and Hot Water on Ice.

The most significant factors in this method are the amount of water, the spreading speed and the water temperature. Hot water means that the water temperature is 90-95^0 C. The amount of water in the mixture of sand and water is approximately 30 weight percentage, and the normal dosage of sand used is equivalent to 200 grams/m^2 as an average.

Tests during the 1999/2000 winter season showed that the method used in combination with a spinner type spreader, gives almost as good results as the system combined with a roller distributor even though the spreader pictures are quite different, see figure 3 and 4.

FIGURE 3 Typical Pattern on the Road using Warm Wetted Wand and a Roller Distributor.

FIGURE 4 Typical Pattern on the Road using Warm Wetted Sand and a Spinner.

Field trials for the 1998/1999 and 1999/2000 winter seasons led to the conclusion that the further development of the method should be based on a spreader with a spinner, heater system for water and material box and transport of the sand ensuring sufficient way of handling the sand. A roller distributor can also be used depending on local conditions and needs.

4. Development of New Spreaders

During the last two winter seasons, the project has been concentrated on developing new spreaders and continuing tests with the warm wetted sand method to study the performance of the trucks and effects gained by different types if spreaders.

There has been a great change in the spreader concept and heater system during the project period. The Swedish prototype used in the winter season 1998/99 tests was based on placing a unit combining the water tank and heater system on the dropside body and using a roller distributor, see figure 1. This truck can only be used for spreading sand. The winter season 1999/2000 was an intermediate season and the development has continued in the 2000/2001 winter season. In the newest concept, the heater system and water tanks are separated, see figure 5. The new spreader type in combination with a spinner can be used both for spreading sand and salt with or without adding liquid.

FIGURE 5 New Concept for Warm Wetted Sand. The Truck to the left can also be used for spreading Salt.

There is still a long way to go, but continued tests this winter have confirmed the results from the previous winter seasons. Consequently there are 3 equipment manufacturers now offering units for the new sanding method for sale in Norway.

Figure 6 show spreaders based on the warm wetted sand principle from 3 different producers on the Norwegian market. All spreaders use a band to transport the sand, but there are some differences concerning both the types of spreader, heater system and water tanks.

FIGURE 6 Warm Wetted Sand Spreaders.

- Truck 1. The first truck in picture 7 is of the new concept. The heater system is placed behind the spreader cassette and the total heating capacity is 185 kW/h with 2 burners. The water tanks takes 3.2 m^3 and the truck can load 8 m^3 sand. The truck is based on using a spinner.
- Truck 2 is one of the Norwegian prototypes from the winter season 1999/2000 with the heater system built on the truck combining the water tanks and the heater system. This truck uses a roller distributor. The water is preheated up to approximately 40^0 C and then warmed up to the boiling point before spreading the materials.
- Truck 3 is of the new concept. The heater system is the same as on the first truck in picture 7, but the spreader type and the water tanks are of a different kind. The loading capacity is the same as for Truck 1. This truck uses a spinner also.
- Truck 4 is a new construction quite similar to truck 2. The heating capacity is 186 kW/h. The water tanks takes 2.4 m^3. Truck 4 is used with roller distributor here.

5. Testing Program to Evaluate New Spreaders

The winter season 2000/2001 has focused on testing new spreaders and gaining experience with the new method in daily operations. However there has been some delay in the delivery of the spreaders which has allowed less time to try the new spreaders in full scale in the daily operations.

There has been an emphasis on the importance of testing the spreaders under controlled conditions. The first test of a totally new construction revealed some minor deficiencies, which now have been modified.

Figure 7 shows the design of a test section from one of the trials on E136 with different sanding methods. The section is divided into fields of 1 km length each. The same measure is performed in each direction on the same field.

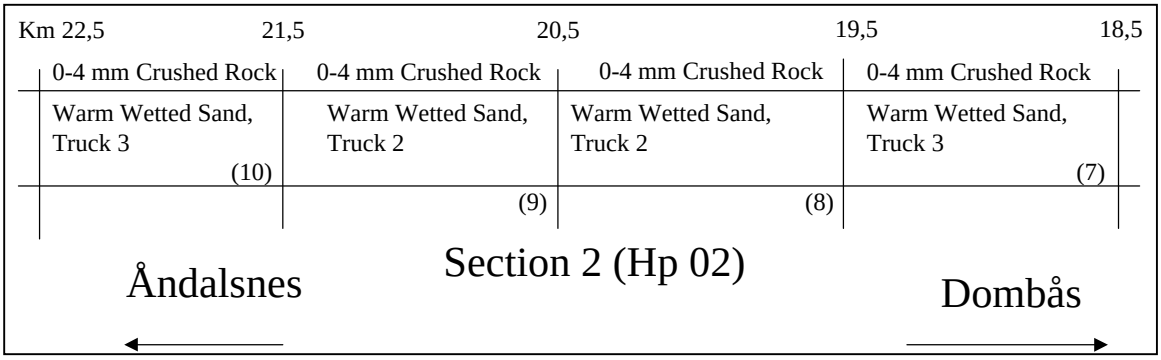

FIGURE 7 Design of a Test Section for Sanding Trials.

Two comprehensive scientific studies have been carried out through the winter season 2000/2001. These field studies comprise of 35 road sections strewn in each direction with a length of 1 km. The total study consists of 70 fields at a length of 70 km.

The effect is measured in two ways: 1) by how much the friction is improved and 2) by how long the added improvement lasts. Two different friction-measuring devices (OSCAR and ROAR) have been used to determine the friction level. Both devices are continuous measuring types with a variable slip test wheel. The friction measurements are done until the friction level on the field with the most durable effect is back to the original standard or the trial is disrupted by change in weather conditions. The evaluation system also includes the possibility of simultaneous video images every 20-meters together with the friction measurements. Road weather information is gathered and the number of vehicles is counted.

To evaluate the performance of the different spreaders, a thermo camera was used in two of the scientific tests. The camera is an Inframetrics SC1000 that operates in temperatures from -10 to +2000 degrees Celcius. The sensitivity is 0.1C. For picture analysis, the emissivity for a mixture of sand and water is set to 0.94.

6. Results the Winter Season 2000/2001

Figures 8 and 9 show pictures taken with the thermo camera of the four spreaders shown in figure 7. Figure 9 shows the Norwegian prototype built in 1999/2000 (Truck 2) to the left and the new spreader based on use of a roller distributor (Truck 4) to the right. Both spreaders show a good, almost identical, performance. There is an even temperature in the whole width of the spreader and there are almost identical temperatures on the road surface. Figure 10 (Truck 1) to the left and (Truck 3) to the right show the temperature using the spinner. The two spreaders with spinners show almost identical temperatures. Comparing the spinner with the roller distributor, it seems that the difference between the roller distributor and the spinner have diminished. There are only small differences in the distribution of the heat. This is also true for lower temperatures, see figure 10.

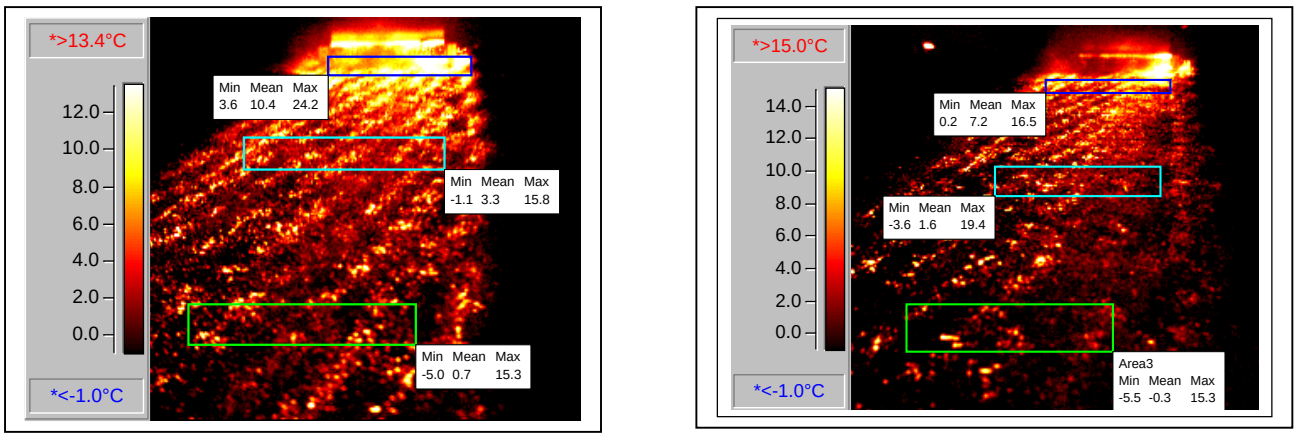

FIGURE 9 Warm Wetted Sand, Norwegian Prototype (Truck 2). Picture taken with Thermo Camera 13.02.2001, Air: -2.8^0 C, Road Surface: -3.5^0 C.

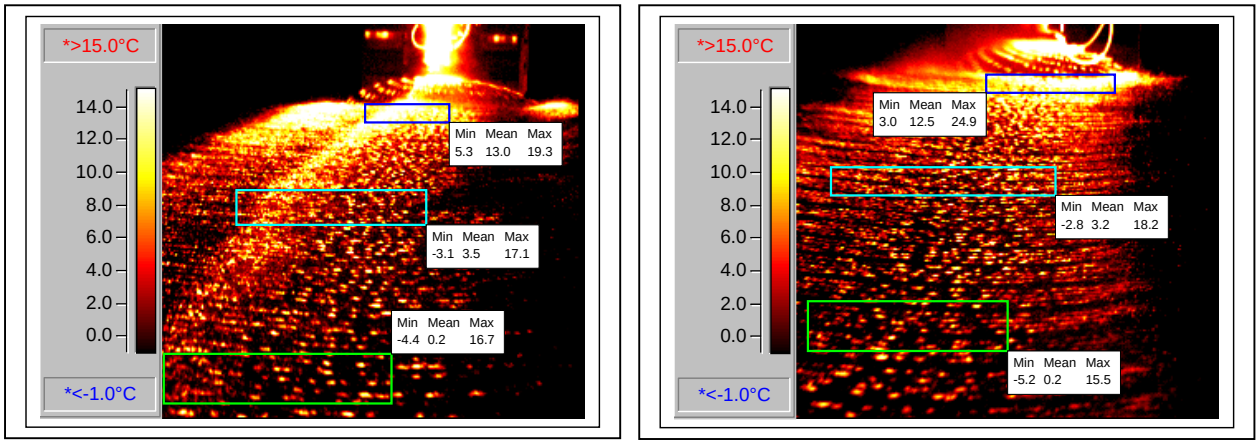

FIGURE 10 Warm Wetted Sand, New Spreader with Roller Distributor (Truck 1). Picture taken with Thermo Camera 13.02.2001, Air: -2.8^0 C, Road Surface: -3.5^0 C.

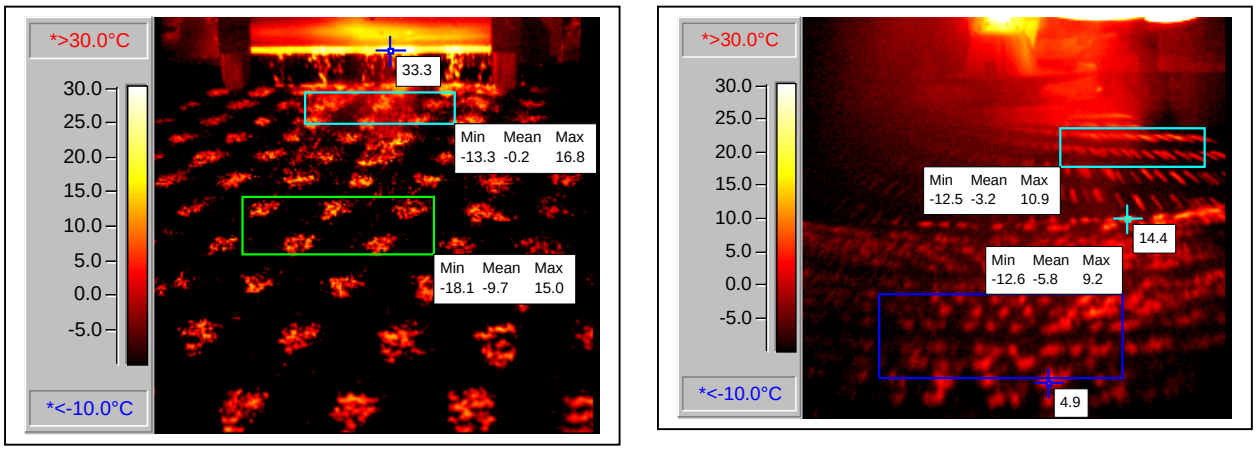

FIGURE 11 Picture taken with Thermo Camera 16.01.2001, Air: -18.0^0 C, Road Surface: -14.5^0 C. Truck 2 (Roller Distributor Type) to the left and Truck 3 (Spinner Type) to the right.

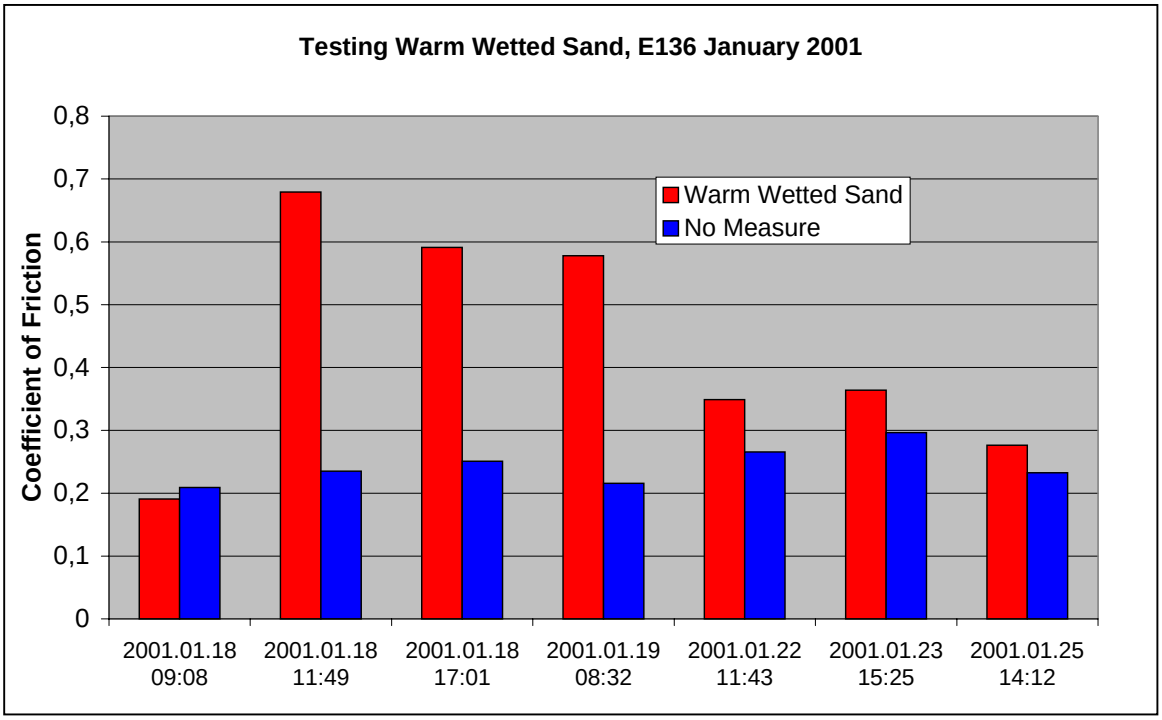

Figure 12 Results from Field Test with Warm Wetted Sand

Figure 12 shows the results from one of the trials on E136 with different methods. The second last friction measurement is made 5 days after sanding. Even if much of the sand is worn away (see figure 13) there is still enough sand on the surface to raise the friction above the background level.

Figure 13 Test Field strewn with Warm Wetted Sand 18th January 2001. Picture taken 22nd January.

Figure 17 show the results from testing the new spreaders against the Norwegian prototype developed in 1999/2000 (Truck 2). There are only small variations between the different trucks. There is no significant difference between trucks with roller distributor and trucks with a spinner when it comes to the rise in the friction level.

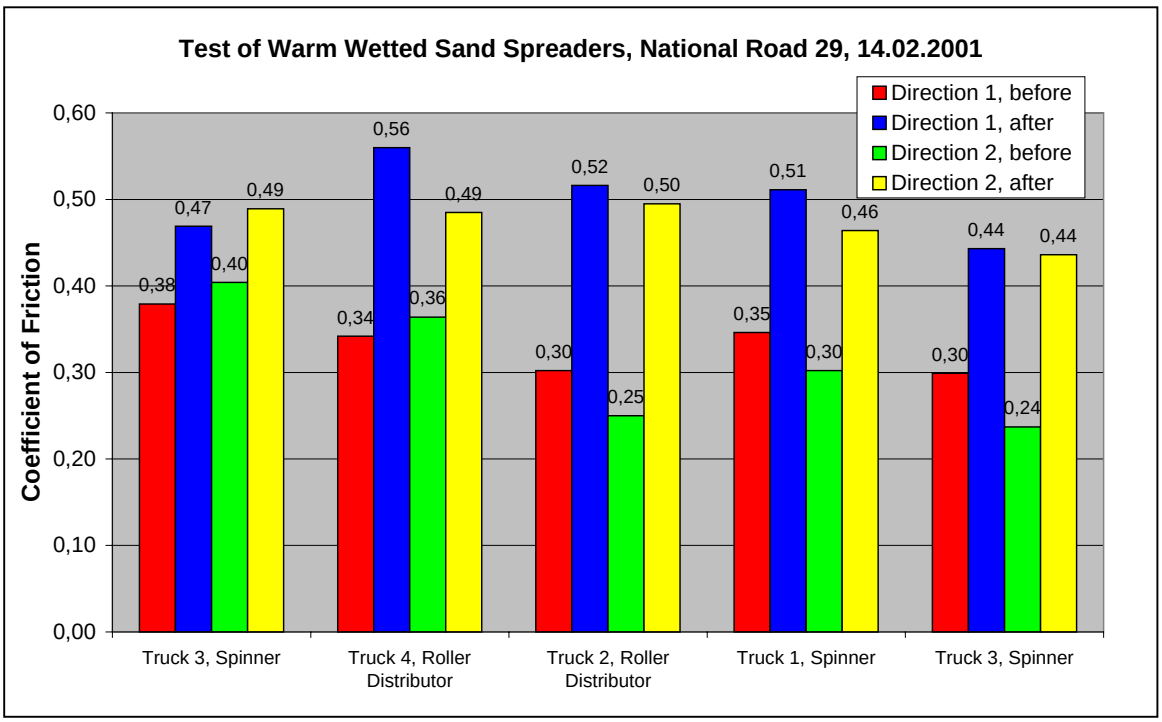

FIGURE 13 Field Trial on NR 29 in February 2001. Friction Improvement immediately following the Measure.

7. Implementation of the New Sanding Method

7.1 Summarizing the new method

The field tests carried out during the winter season 2000/2001 confirm the results from last season. Good results were achieved with the new trucks. From the experiments carried out, it is concluded that the wet-sand method, in particular, has a broad range of applications, and can therefore be recommended as a supplement to existing sanding methods. The main thing is the long-lasting effect, and friction improvement. It is important to emphasise that the wet-sand method can be used under conditions under which traditional methods have little or no effect:

- Hard “blue” ice
- Roads with a high percentage of heavy vehicles
- Thin ice or frost on asphalt

The new method also makes it possible to maintain the friction standard under conditions under which it is normal to spread sand less frequently than necessary to maintain the friction standard.

7.2 Description of existing organization

In Norway, 88 percent of public roads, i.e. 47,300 km, are operated using the so-called white winter road strategy. Large quantities of sand are spread to improve friction on ice and snow.
The total in an average winter is 400.000 metric tons, i.e. 8,5 tons per km. The limitations of this method are well known: The friction improvement is modest, and the effect of gritting is rapidly reduced by the traffic. For both practical and economic reasons, it is not always possible to comply with the required friction standards.

The normal practice in Norway is to organize the national road network into operational sections of 30-60 kilometers both for snow plowing, sanding and salting. The road length is adapted to the standards, the higher the standard the shorter length of the section. In total the national and county public network is served by 1200 sand spreader trucks. Out of these, 120 machines are of the spinner type, the majority are of the trailer type with roller distributors.

For sanding, which is used on roads with winter road strategy, the standard says that when the friction falls below 0.25, sanding should be done within 2 hours. For traffic below 1500 vehicles per day the requirement is within four hours. We have learned from feedback from road users that they are however not satisfied with these time limits. From the time action is to be taken, the truck must be loaded, and spreading completed. It is a major challenge to meet the requirement in due time in cases in which there is a need to spread on a continuous basis.

The problem, however, is that this sand is often gone after only a few vehicles have passed. In many cases, it will be difficult to maintain the friction standard by use of traditional sanding methods because it is not practically possible, to use the resources necessary to keep the standard. From the available documentation, it is known that, on a road with 2000 vehicles pr. day, approximately 12-40 measures of dry sand will be needed in a 24-hour period to meet the friction requirements, as opposed to only one measure of warm wetted sand. It is obvious that it is beyond the available resources to carry through with the level of measures required for traditional methods. The amount of measures can be 3-4 during a day with difficult driving conditions.

The existing sanding organization is insufficient in three respects:

1. The effect of sanding is only short lasting
2. Often fails to meet the time limit because of insufficient capacity
3. The road users are not satisfied with road administrations standards/action time, and lack of repeated gritting.

7.3 Analyzing the possibilities of the new method

The introduction of wet gritting means substantial improvement, both with regard to friction and duration time of effect, figure 14. Both controlled tests and reports from the counties confirm the effectiveness of the new method. Under normal and stable conditions without precipitation, the effect of a measure of warm wetted sand will last 10-20 times as long as dry sand, with the same traffic volume.

The method is now so well documented that it can be recommended as an alternative to traditional dry sanding. With fine gradation, the water and sand slurry evenly sticks to bare pavement if the surface temperature is below 0 degrees Celsius.

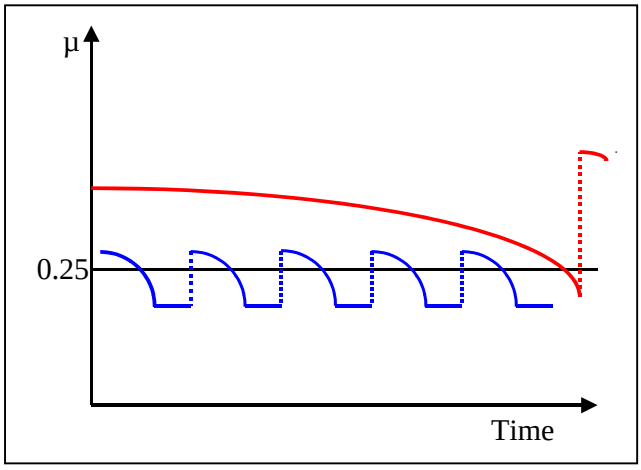

FIGURE 14 Diagram Friction – Time

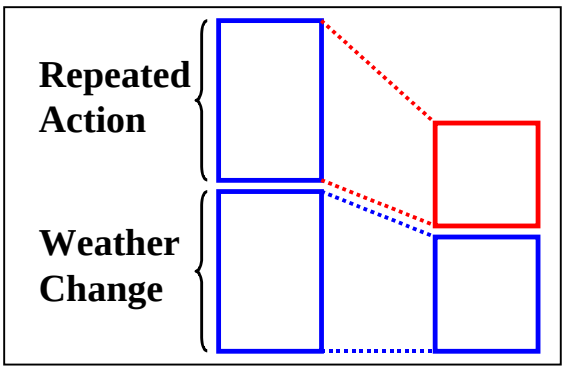

Figure 15 Evolution of Production Quantity by use of Wet Sanding

In addition to a better and more lasting effect, the warm wetted sand method will also have a favorable environmental impact, by reducing in the quantity of sand used. Preliminary calculations indicate that it is possible to reduce the sand consumption by 40-50 percent.

The new method is expected to have a marked impact on winter road operations, in three respects:

- The action range (capacity) of each wet spreading truck will be markedly increased, making it possible to improve the organization of the entire spreading services.
- Wet spreading can under certain conditions be carried out as a preventive measure, implying that the work can be planned ahead and, to a large extent, be completed during regular working hours, thus reducing readiness and labor costs.
- The increased friction improvement must be evaluated in relation to the required standards.

This new characteristics call for a redesign of the gritting organization. Spreading that can be done in advance as a preventive measure, will be done with new wet sand spreaders. In midwinter this is expected to be a significant part of the total spreading production. At this stage we anticipate a wet sand truck will cover a road network of 300-500 km. The long lasting effect of warm wet gritting will markedly reduce the need for repeated spreading measures, figure 15. The wet sanding production will replace traditional sanding. The need for traditional spreading trucks will be reduced. How much depends on the rate of wet sanding which is possible as a preventive measure. To take care of rapid weather changes we will however still need a fleet of traditional spreaders, but the daily sanding with these equipment will be replaced by wet sanding to a large extent.

7.4 Plan for organization and operation winter 2001/2002

During the winter season 2000/2001, 4 out of totally 19 counties have started using the new method in the daily gritting operations. We regard this to be an important step towards a wider use of the method. Expansion of the new method depends on the further development of good working machines. The spreader manufacturers seem to take the challenge, but at this moment we are not able to predict how many additional wet sand spreaders we will get for the winter 2001/2002.

Based on experiences from winter 2000/2001 we will make a change in the organizing set up, as a test during winter 2001/2002. Instead of a combined task of snow plowing and spreading, we will set up a truck for wet spreading exclusively. This is to make maximum advantage of the property of wet spreading as preventive measures.

7.5 Outlook

We are in the initial phase of implementing wet spreading. The current challenge is to move from the experimental phase into large-scale production. During the 2000-2001 season we have provided several spreading trucks with wet spreading equipment. As yet, the manufacturers of the equipment are at somewhat different stages of development. At the same time, we would like to gain some more experience to use for the future organization of spreading services. One hypothesis might be that one wet spreader unit will replace 3-5 ordinary spreading trucks.

The new possibilities inspire to formulate a vision: develop a gritting service that is effective for the road users and efficient for the road administration. To implement wet sanding is to be defined as a primary goal. And we have at the moment developed the following strategies to reach the goal: 1) Wet sanding as largest possible part of gritting. 2) Preventive sanding. 3) Truck unit exclusively for wet sanding.

It is expected that the organization of the sanding operations will go through important changes during the next 2-3 years.

Advantages of implementing the new method:

- Improved friction and winter driving conditions
- Easier to meet standard requirements
- Less sand consumption
- Developing the efficiency of winter service

8. References

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