Searching for the perfect road salt

January 10 2014

Ph.D student Kine Nilssen conducting an experiment on ice adhesion. Provisional data indicate that ice binding is significantly weakened when salt is present, although so far, no-one knows why. Credit: SINTEF

Each winter, Norway spends NOK 1.6 billion keeping its roads fit for use. Researchers have many reasons for wanting to get costs down.

The Norwegian Public Roads Administration maintains 55,000

kilometres of roads in Norway, of which about 9,000 kilometres are salted in winter. "This means that we 'salt Norway' from north to south about three and a half times", says SINTEF researcher Kine Nilssen, who specialises in winter road maintenance.

The use of salt on roads has given both motoring and environmental organisations cause to criticise the authorities. Salt causes cars to rust. It kills roadside vegetation and may contaminate groundwater. Even so, according to Nilssen, salting is essential to keep traffic flowing and maintain safety.

According to figures from SINTEF (Report STF63 A95004), road accident numbers are reduced by 20 per cent on salted roads, and most of this reduction is linked to the most serious types of accidents.

Most of the salt is used on the busiest roads in and around towns and cities – more that 200,000 tonnes in total, and this figure has doubled in the last ten years.

How much is enough?

But how much salt is really necessary? And how can we get the best out of it in different situations? Answers to these questions will be invaluable, both from an environmental and socio-economic perspective. This is why NTNU and SINTEF are currently bringing the issue into the lab.

But first of all – a brief explanation as to how and why we use salt on our roads.

Salt is used for three main reasons. We use it to prevent ice forming on road surfaces (anti-icing) and to prevent snow and ice compacting when it snows (anti-compaction). This makes snow easier to plough away. If,

on the other hand, thin films of ice develop on the road, salt will help to melt these away (de-icing).

"In many places in Norway most salt is used when it is snowing. For this reason it's important to optimise the use of salt under such conditions", explains Nilssen.

Nilssen and her colleagues are going to re-create different snow conditions and test systematically how salt achieves its optimal effect.

"Not least of our aims is to find out how much is enough when it comes to the different applications of salt", she says. "We need consistently stable snow conditions, and we can't re-create these outdoors", says Nilssen, who has started her doctorate studies in this field.

Cold, hard facts

Some of the controlled experiments will be carried out in a frost laboratory where researchers have installed a snow machine which they have designed themselves. This can manufacture real snowflakes tailored to the freezing temperature and water content parameters required. It is the need to meet these requirements which has made inventors of the researchers – the machine they have designed and constructed is no bigger than a domestic freezer.

"When you make real snow, it's not enough simply to freeze small water droplets like the big machines on the alpine ski slopes do," says Nilssen. "You have to imitate what goes on in the atmosphere. The water must first evaporate to form a vapour, and then we must introduce cold air to help form the snowflakes", she says. "In order to produce consistently stable snow, this process must be controlled very precisely. This is what we mean by a controlled experiment," says Nilssen.

How and why does salt work?

Alex Klein-Paste, who heads the winter roads maintenance centre at NTNU, explains that salt works differently under different conditions.

In the case of anti-icing, or ice prevention, salt lowers the freezing point of water so that the water won't freeze even if the temperature drops below zero. But if it freezes anyway, the salt will still act to weaken any ice which does form. "Ice can be weakened so much that vehicles using the road will manage to clear it themselves," says Klein-Paste.

When salt is used to melt ice which has already formed, it acts by making it more attractive for water molecules to exist as a liquid rather than a solid. The salt encourages the ice to turn into water, which then remains liquid because its freezing point has been lowered.

"This process is well known, but we still need better test procedures in order to record rates of melting and the melting capacity linked to different types of salt," adds Klein-Paste

"Salt prevents snow particles from binding together, and this makes snow-ploughing easier during snowfalls", he says. "However, we still understand very little about the physics behind this process, and this is why we are working to improve our detailed knowledge. Our aim is to find the best type of salt for each and every situation," he says.

Searching for the best salt

Researchers have now developed a series of laboratory experiments which will give us answers about melting capacities linked to different salts, their ability to prevent snow particles from binding together, and studies looking into what happens when water freezes and how salt

influences the structure of ice.

"Tests and microscope work help us to observe such things as how salt affects water freezing on a road surface," says Nilssen. "The ice is formed by crystals surrounded by a concentrated salt solution", she says, and asks me to look down the microscope. Unlike the ice sample without salt, this one exhibits a fine, mesh-like pattern.

"This pattern means that the ice will break down more easily when it is exposed to mechanical stress", says Nilssen. "If no salt is present, a hard layer of ice will form," she says.

The compressibility of the snow will also be influenced by salt. "As well as helping to melt the snow, we have seen that salt water also inhibits snow crystals from binding together", says Nilssen. "Salt changes the structure of the snow – it isn't transformed into ice, and this indicates that it might be a good idea to use a salt solution instead of dry salt under snowy conditions," she says.

The hope is that the researchers will be able to produce better research-based guidelines for salting, to understand how road salt additives work and discover other, better chemicals.

The road as laboratory

However, the code can't be broken using laboratory experiments alone.

"It's the snow plough contractors out on the roads with their experience and local knowledge who hold the key to producing good winter roads", says Nilssen. "Combining empirical data from the contractors with our lab results will thus be a very important element of this project," she says.

Provided by SINTEF