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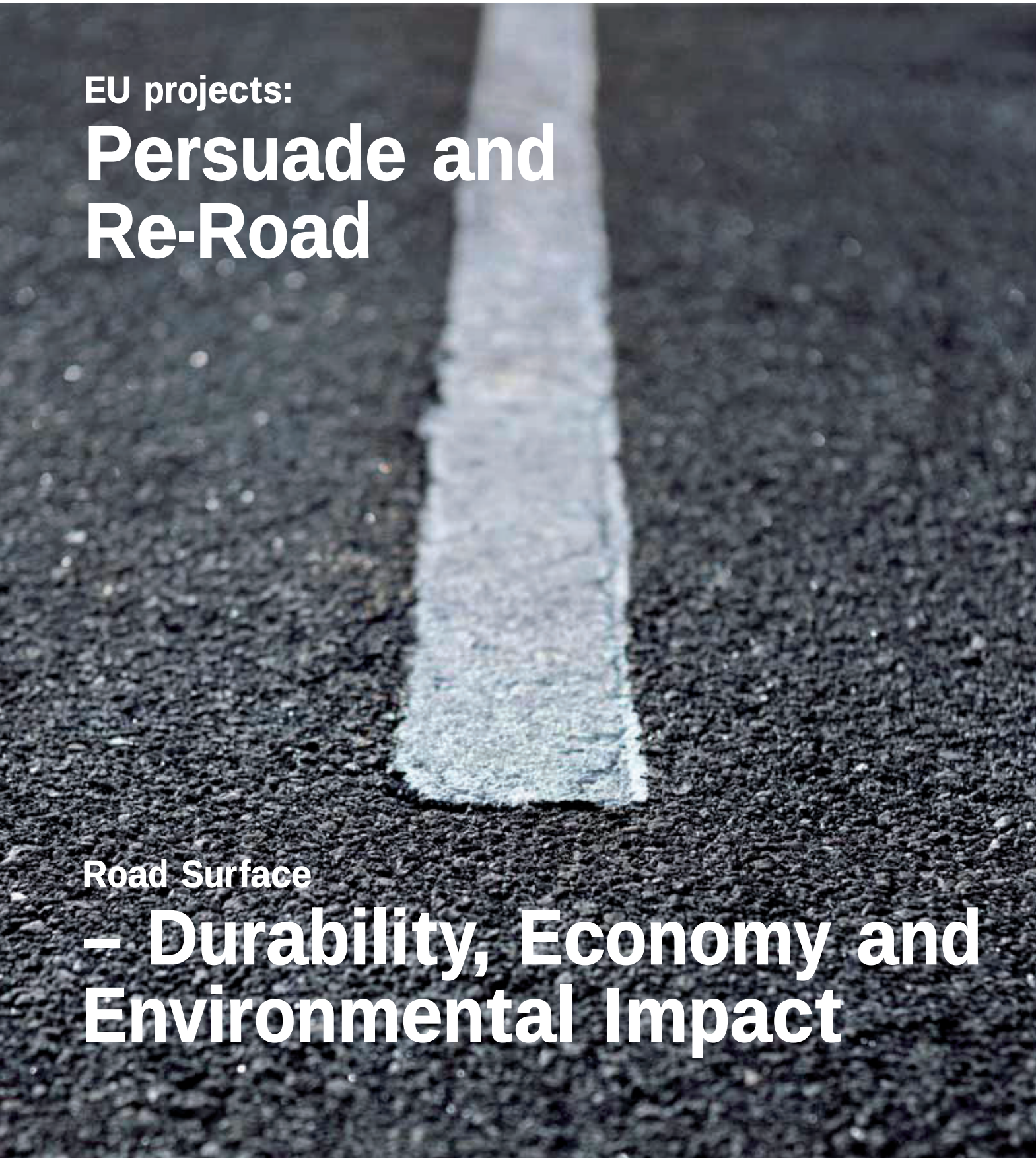

EU projects:

Persuade and Re-Road

Road Surface

– Durability, Economy and Environmental Impact

News from

Swedish National Road and Transport Research Institute (VTI)

VTI is an independent, internationally established research institute which is engaged in the transport sector. Our work covers all modes, and our core competence is in the fields of safety, economy, environment, traffic and transport analysis, public transport, behaviour and the man-vehicle-transport system interaction, and in road design, operation and maintenance. VTI is a world leader in several areas, for instance in simulator technology.

Danish Road Directorate (DRD) Danish Road Institute (DRI)

The Road Directorate, which is a part of The Ministry of Transport, Denmark, is responsible for development and management of the national highways and for servicing and facilitating traffic on the network. As part of this responsibility, the Directorate conducts R&D, the aim of which is to contribute to efficient road management and to the safe use of the network. The materials research component is carried out by the Danish Road Institute.

Technical Research Centre of Finland (VTT)

VTT Technical Research Centre of Finland is a contract research organisation with a staff of 2,800. In this joint publication, the VTT expertise areas cover research and development of transportation, logistics and road structures. The work is carried out in five research groups employing a staff of 60.

Icelandic Road Administration (ICERA)

The ICERA's mission is to provide the Icelandic society with a road system in accordance with its needs and to provide a service with the aim of smooth and safe traffic. The number of employees is about 340. Applied research and development and to some extent also basic research concerning road construction, maintenance, traffic and safety is performed or directed by the ICERA. Development division is responsible for road research in Iceland.

Norwegian Public Roads Administration (NPRA)

The Norwegian Public Roads Administration is one of the administrative agencies under the Ministry of Transport and Communications in Norway. The NPRA is responsible for the development and management of public roads and road traffic, as well as the Vehicle Department. This responsibility includes research and development of all areas related to road transport and the implementation of R&D results.

Institute of Transport Economics (TØI), Norway

The Institute of Transport Economics is the national institution for transport research and development in Norway. The main objectives of the Institute are to carry out applied research and promote the application and use of results through consultative assistance to public authorities, the transport industry and others. The Institute is an independent research foundation employing about one hundred persons.

Editorial notes

Nordic Road & Transport Research is a joint publication of six public road and transport research organisations in the Nordic countries, Denmark, Finland, Iceland, Norway, and Sweden. The main objective of the publication is to disseminate research results and news from the institutions, especially to researchers and decision makers. Each institution is responsible for the selection and presentation of the material from its own scope of activities.

Nordic Road & Transport Research is published three times a year. It is regularly sent out, free of charge, to recipients selected by the six joint publishers. Free sample copies are also sent out on special request.

Correspondence about the contents of the publication:

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Addresses: see back cover.

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Contents

Determining the Spreading Accuracy of Equipment for Winter Maintenance Services

A salt spreader runs over the measuring field with plates.

The objective is to develop a method to document the ability of a given salt spreader to achieve accurate dosage and distribution across the road – for the sake of road safety, the environment and the economy.

Tine Damkjaer, DRD, Denmark,
Krister Persson, Engineering Centre Bygholm, Denmark

In the period from 2006 to 2009, the Salt Spreader Development Group of the Danish Road Directorate worked on the development of methods to assess the use of spreading materials to maintain road passability in snow and ice conditions.

The SUG works in the context of the so-called Winter Committee, and consists of a broad range of representatives from the Danish Road Directorate, the local authorities and the Sund&Baelt Partner Ltd, with occasional participants from the Danish Association of Consulting Engineers and the private sector. The group's objective is to make recommendations for requirements for spreading equipment.

Besides establishing standards for dosage and distribution accuracy, the group aimed to develop methods to assess such parameters. This was done in cooperation with the University of Aarhus' Engineering Centre Bygholm (ECB) in Horsens. The ECB has Europe's largest spreading laboratory, and is built to meet the existing standards for the test of commercial fertilizer spreaders used in agriculture.

Distribution and spreading

Distribution and spreading tests are carried out by collecting spread material in funnels situated across the path. When the material is dry salt, the amount spread is registered by an electronic scale placed under each funnel. When the material being spread is moistened salt or brine, the quantity is determined by a conductibility measurement, which has proven to be sufficiently accurate, and will be recommended in order to achieve quick results.

The tests show that the distribution image of a given spreader is narrower when the material is collected in the funnels at the testing facility than it is in real life conditions. This is due to the fact that on a real road, salt bounces towards the edge after hitting the surface. To ensure as realistic conditions as possible, plates with a tarmac-like surface have been laid before and after the measurement field, so the material being spread can bounce outwards. The use of such plates gave satisfactory results.

The spreading tests were conducted at different speeds. In the beginning, the speed was between 40 and 60 km / h, which corresponds to real life conditions. It has been decided that future tests will be conducted at 10 km / h, as this will ensure conditions that are easy to reproduce, and at the same time minimise the risk of accidents during the tests.

Dosage tests

Dosage tests have been carried out by collecting the salt, moistened salt or brine directly from the spreader, without any spreading actually taking place. After being collected, the material has been registered by an electronic scale. The results are most accurate when the spreading disc is not used, as this produces considerable vibrations that can be perceived as noise. Dosage tests are used to provide documentation of dosage precision and of the response time elapsed when changing from a dosage level to another. It is expected that the actual dosage does not vary more than 6% in relation to the desired amount.

Collecting container on weight cell.

The tests have been carried out with the materials most commonly used in Denmark, i.e. vacuum salt, sea salt and mineral salt.

Criteria for test results

The criteria used to assess test results were established with the purpose of ensuring maximum coverage of the road surface and were set up to reduce salt consumption in general, and to reduce the amount of salt being spread outside the road, which is an unnecessary hazard to the environment. The criteria are still being discussed, but the general objective is to achieve an even distribution across the whole width of the road with the least possible loss to the surroundings.

A positive development in spreading equipment has been noticed during the test period. It is important, however, that a final decision is made regarding these criteria so that all involved parties, such as equipment producers, have a goal for their development work.

Current status of the project is that the basic aspects of test and measurement methods seem to be ready. These are some issues to be taken care of in the near future:

- Establishing final requirements for equipment/certification criteria
- Preparing test protocols for certification procedures.
- Reviewing instruction manuals in order to ensure that they are intelligible to the staff using the equipment
- Developing procedures for testing GPS-guided spreaders.

The first steps towards cooperation with the other Nordic countries have been taken. The aim is to develop common methods, as well as conducting common tests of equipment.

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Retired after more than 40 years

After more than 40 years as one of the leading experts in Norwegian transport planning, Tore Knudsen has now retired and is wrapping up his professional career. Having earned a PhD in transportation planning from the University of California, Berkley, he was a professor at the Norwegian Institute of Technology (NTH) from 1966-1980 and 1995-1996. During the 1980s Knudsen was head of and leading consultant for transport planning in the consulting company Asplan. In 1996 he was appointed head of the Transport Research division at SINTEF.

His main professional interest has been in transport modelling and cost-benefit analysis. Many Norwegian transport planners have had the privilege of experiencing Tore Knudsen as an enthusiastic and inspiring lecturer. He has now retired from his position at SINTEF, but is still actively advising others on transport study issues. On 15 April SINTEF and NTNU hosted an honorary seminar to mark Tore Knudsen's retirement.

Dr. Tore Knudsen (Photo: SINTEF)

Dear Subscriber of the Nordic Road & Transport Research

Through the magazine we wish continuously to supply you with the latest results of the Nordic transport research. Now we would greatly appreciate if you could help us to define the best current way to do it by filling this **Reader Survey.**

This year it is exactly twenty years since Nordic Road & Transport Research was published for the first time. A lot of research done in the Nordic countries in the field of transport during these years has, through the magazine, reached out to readers all over the world.

As you know, the magazine is published as a paper issue as well as on the website nordicroads.com. We now wish that you could let us know which way of publishing you value most by answering the reader survey you will find on the website **nordicroads.com.**

Please, take some minute or two and let us know your opinion! Thank you!

The editorial board of the Nordic Road & Transport Research

Which Pavement Lasts Longest?

PHOTO: VTI

There is a large number of different road pavements today, all with different capacities to stand up to rutting due to abrasion by studded tyres and deformation caused by heavy traffic. For future planning and investments in technical solutions that are correct for the purpose, the different pavements must be evaluated. To make measurements on a road and evaluate its qualities, it is necessary to have recourse to a large number of different methods, an area where VTI has made a lot of progress.

Magdalena Green,
VTI, Sweden

The Swedish road network has gradually been subjected to increasing loads. Most newly constructed roads in Sweden have bitumen pavements but some also have concrete pavements. For a comparison of the different constructions in a long-term perspective, European route E6 to the north of Halmstad was constructed as a test road when it was upgraded to motorway standard.

Test road

When E6 was converted into a motorway, the Fastarp-Heberg setion was constructed as a test road with pavements of different structural design. VTI was commissioned by the Swedish Road Administration to document the construction and to monitor the changes in condition on the 19 different observation sections. The test road which has a total length of 21 km, one third of which has a bituminous surfacing and two thirds a cement concrete surfacing, was opened to traffic in the autumn of 1996.

Apart from rutting, longitudinal evenness and the properties of the different wearing courses were studied, with the intention to highlight the differences between the different pavements with regard to stability, rut wear, deformation resistance, maintenance costs, friction and noise.

High traffic load over 10 years

Over a period of ten years, 1996–2006, VTI has monitored the condition of the different pavement types which are designed to stand up to what is a high traffic load for Swedish conditions. The evaluation shows, inter alia, that pavements with concrete surfacing have good wear resistance and thus good resistance to rutting. As regards friction and noise, there is little difference between bitumen and concrete surfacings.

Changes have been monitored by a comprehensive measurement programme with the emphasis on measuring the transverse profile of the road. Other surface properties which have been measured are friction, surface evenness and noise. The structural condition of the observation sections has been monitored by falling weight measurements and visual inspection of the condition of the sections with regard to damage. Other parameters which have been measured are temperature, traffic and the use of studded tyres.

Transverse profile measurements

The transverse profile has been measured using two different equipments, the laser profilometer Primal and a RST (Road Surface Tester) vehicle.

The laser profilometer Primal measures the profile of the surface by means of a wheel mounted on a self propelled carriage which measures the distance between the measuring wheel and a laser plane. Measurements with Primal were made both in spring and autumn, a total of 20 measurements.

The most recent transverse profile measurement showed that, after ten years' traffic, there is still little rutting on the concrete sections. The rutting found on the concrete sections has been caused by studded tyre wear.

Rut depth measurements have also been made with Laser RST on eight occasions. RST measures surface regularity both longitudinally and transversely, roughness of the surface and road gradient at the speed of traffic.

Stud wear is measured with a special laser profilometer, Primal, developed by VTI, which measures the transverse profile of the road over one metre long sections. The laser profilometer is fixed to the wearing course by fixtures installed in the metre section concerned. The surface is measured in the autumn and spring with high precision, and the difference between the profile measured in the autumn and spring corresponds to the amount of surfacing abrasion worn away by studded traffic in the winter.

Friction

Friction has been measured on all observation sections with the VTI Saab Friction Tester. Measurements have been made in the spring and autumn at a speed of 70 km/h on an irrigated surface. On all sections except one, friction improved during the first winter.

The pavement

The structural condition of the test sections has been documented through load tests with a Falling Weight Deflectometer and visual inspections.

For measurements in and between the ruts, the VTI falling weight deflectometer has applied a load of 50 kN . The values give an indication of the deflectometer stiffness of the pavement and of the elastic properties of the subsoil. Generally speaking, lower values indicate better conditions, i.e. a lower risk of cracking in the sur-

facing owing to fatigue, and a lower risk of deformations.

The sections are also inspected visually with respect to cracking and other damage such as loose aggregates.

Laboratory experiments

Parallel with the measurements made on the different observation sections, in the form of measurements of different surface properties, laboratory analyses have also been performed on cores drilled on various occasions. It was mainly functional properties that were analysed, but the thickness of courses and voids ratios have also been determined on all cores to provide background data. On bitumen recovered from the cores, relatively comprehensive studies of both traditional and functional properties have also been made. Some preliminary tests were also made initially, inter alia in the VTI circular road simulator with respect to wear resistance, in order to verify that the surfacings satisfy the requirements.

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Environmentally Friendly Pavements in Norway

Results from five years of research and development in Norway on how to reduce tyre noise and dust emissions from road traffic are now available in the final report from the Environmentally Friendly Pavements programme.


Jostein Aksnes, NPRA, Norway
Ragnar Evensen, ViaNova Plan og Trafikk AS

The Environmentally Friendly Pavements programme was conducted by the Norwegian Public Roads Administration (NPRA) during the period 2004–2009 in close collaboration with research institutions and the road industry. The main focus of the programme was to optimise the environmental properties of road surfaces with respect to low road tyre noise and road dust emissions. The research results show that:

- The noise level of new low noise asphalt pavements is 3–9 dB(A) lower than the reference (SMA11, older than one year).
- The noise reducing effect decreases relatively rapidly for all types of pavements that have been investigated. The annual increase in noise levels measured on Norwegian pavements is considerably higher than what is reported from a number of other countries. This increase is particularly great during the first winter. Natural explanations for this phenomenon are the wear from studded tires and their influence on the pavement surface texture.
- The friction levels of environmentally friendly pavements do not differ from traditional asphalt types and do not require special attention with respect to winter operations. Porous asphalt pavements most likely have better friction properties than traditional asphalts.
- It is difficult to develop pavements with considerably higher wear resistance than those we have today without compromising other important properties such as stability and friction. However, through adjusted requirements for material quality and mix design, it is possible to maintain the durability of low noise pavement alternatives.

Thin asphalt layers yielded the most promising results in the cost-benefit analysis. Experience from other countries indicates that there is a potential for developing more durable thin layers with longer lasting noise reducing properties than what has been achieved in the field tests in this programme. Those types of low noise pavements should be regarded as a good alternative where the conditions are favourable.

Traditional asphalt pavements (SMA and AC) with reduced aggregate upper sieve size (8 mm or less) also have favourable properties with respect to noise. The cost-benefit ratio is not quite as good as for the thin asphalt layers because of the limited wear resistance and the generation of dust. However, with more focus on optimising the wear resistance of this type of mixes (better quality of fine aggregates, polymer modified binder, optimum mix composition) the applicability of these pavements may be increased, in particular in areas with a low percentage of cars with studded tyres in the winter.

Restricted use of porous pavements is recommended. Experience with their use under Norwegian climate and traffic conditions is still very limited. Clogging of the pores is still considered to be a problem. The cleaning of porous surfaces with the equipment that is currently available is not very efficient. Another negative factor for porous pavements is the limitations in their applicability. The volume of porous pavements is likely to be quite small for many years, making it difficult for contractors to develop the special workmanship that is required to ensure a porous asphalt of good quality.

Facts: The R&D programme "Environmentally Friendly Pavements" of the Norwegian Public Roads Administration (NPRA) was conducted by the Road technology section of the Technology Department in Trondheim during the period 2004-2009 in close collaboration with other units within the NPRA and external partners.
This article is based on the final programme report: Statens vegvesen, Teknologirapport nr. 2578
Contact person: Jostein Aksnes. E-mail: jostein.aksnes@vegvesen.no
Read more: www.vegvesen.no/Miljovegdekke (Download English report under <Sluttrapporter fra prosjektet>)

Persuade – a New EU Noise Project

"Development and testing of poroelastic road pavements with high noise reductions without sacrificing safety and durability are the challenges in the EU project PERSUADE"



Tine Damkjær, Danish Road Directorate, Denmark
Hans Bendtsen, Danish Road Directorate, Danish Road Institute DRI,
Ulf Sanberg, VTI, Sweden

In September 2009 a new EU project on innovative noise reducing road pavements started. Representatives from twelve European research institutes and companies met for a kickoff meeting at the Belgian Road Research Laboratory (BRRC). BRRC has the role to coordinate this new project which has been named PERSUADE, an abbreviation for ”Poroelastic Road Surface: an innovation to avoid damages to the environment”.

Concept and purpose

The main purpose of PERSUADE is to develop and test new road pavements with very high noise-reducing effect. The pavements will be based on an aggregate of rubber material instead of the traditional stone aggregates; they will also be designed with a high proportion of air voids. The air voids will make the pavement porous, which in combination with the elastic rubber granules will make it flexible, both of which contribute to reduce noise from the tyre/road contact. By using rubber granulate from used vehicle tyres, the environmental aim of the project is two-fold: to reduce noise from road traffic and at the same time to give a considerable amount of used tyres in Europe a second lifecycle. The final mixtures produced in PERSUADE might include also a certain amount of sand or stone aggregate; mainly to increase friction. The EU Commission and its project reviewers found this so interesting that a support of 3.4 million euros was obtained for this project in hard competition with other project proposals.

The poroelastic road surface is originally a Swedish invention from the 1970s which was tried in Sweden in the 1980s, but without success. The Japanese adopted the concept in the 1990s and started comprehensive research which still goes on after about 15 years. In 2000–2005 VTI conducted a project, sponsored mainly by Vinnova, which was similar to PERSUADE but was of a much smaller scale [1]. This project ended with a test of three poroelastic materials on a street in Stockholm, which failed due to break-up of the too weak asphalt under the rubber surface. Before this happened, people were enthusiastic about the dramatic noise reduction experienced on the street. The experience from the VTI and the Japanese projects now constitute the basic level from which PERSUADE starts. When the Swedish and Japanese activities were most intensive, in 2000–2005, several common workshops were organized and one or two study trips were made each year; these continued annually after 2005. In 2005 also people from the Danish Road Institute took part in a study tour to Japan [2].

The purpose of the PERSUADE project is to develop and test poroelastic materials, first in the laboratories, later on roads under traffic. The pavements shall provide substantial noise reduction and acceptable operation over a reasonable lifetime, while at the same time, meet requirements on friction and other traffic safety issues. Some might suspect that a flexible pavement might cause much higher rolling resistance and thus energy consumption and CO_2 emissions but, in fact, it is hoped that low losses in the material will provide similar rolling resistance as conventional asphalt, and in the best case even reduce the rolling resistance.

In the first instance, the poroelastic road surfaces will primarily be considered for use on ”black spots”, which is the term used for limited areas where noise exposure is very high, and where it is not possible or desirable to use noise barriers etc.

Performing the project

The project will run for six years. This is unusually long for an EU project but makes it possible in the first years to work on development and testing of new materials in the laboratory after which full-scale tests of the new pavements will be carried out. It is the intention to test pavements in five European countries, including Denmark and Sweden. The materials and the laying processes might vary between the countries and in Sweden special concerns apply for severe winter conditions. A comprehensive

Figure 1: Overview of poroelastic road surface test sections laid in Stockholm in 2004, which gave tyre/road noise reductions of 10 dB(A) [1]. In the winter, the old asphalt pavement onto which the rubber pavement was glued separated from a lower asphalt layer, forcing the experiment to finish.

Figure 2: Overview of poroelastic road surface laid in Mie in Japan in 2004. This experiment had to be interrupted when, a few months later, wet friction failed to meet the Japanese standard.

measuring programme will be set up which will include noise, friction, rolling resistance, etc. Furthermore, cost-benefit analyses will be carried out where poroelastic road surfaces will be compared to other ”traditional” types of noise reduction measures, such as façade insulation and ”conventional” noise-reducing pavements. Life cycle analyses will also be included.

From Denmark, the Road Directorate, Danish Road Institute and NCC Roads will take part in the PERSUADE project and from Sweden the partner is VTI. Recently, a state-of-the-art report was prepared by VTI and BRRC [3], which can be downloaded from the project website. The PERSUADE website [4] will present the results from the project and some other relevant information and will be updated frequently during the entire project.

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4. The PERSUADE website; see http://persuade.eu.com or http://persuade-project.eu (both addresses work equally well).

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Read more:
http://persuade.fehrl.org/

A New Approach in Research on Bituminous Mixtures

Research opportunities with new European test methods and testing equipment.

Pétur Pétursson,
Innovation Center Iceland

The production and laying of hot bituminous mixtures is an expensive and precise process that demands that great care is taken at all stages. It is therefore important to have knowledge of the raw materials and the predicted ability of the mixtures to endure external forces on the surface of the road.

The Icelandic Innovation Center has recently received new equipment to measure properties of bituminous mixtures. This includes a new roller compactor to make sample plates, a wheel track machine (small device) to measure deformation, and a Prall machine to measure abrasion from studded tires. Testing of bituminous mixtures has in the past been mostly limited to the much debated Marshall stability method and the Icelandic asphalt industry has relied on traditional receipts, developed in the past or imported from other Nordic countries.

Now, after the implementation of the European Standards for bituminous mixtures, the Icelandic Road Administration (ICERA) will switch over to the new test methods in their road guidelines, as well as replace old requirements with new ones for different asphalt types. It is therefore important to gain experience with the new test methods by testing the traditional mixtures as well as designing and testing new and improved mixtures.

New test methods – new requirements

The Innovation Center is working on several research projects concerning hot mix asphalt. Deformation and abrasion properties of traditional mixtures have been measured, both on laboratory compacted samples and on sample plates from the road surface. Also, mixtures that have not been in use in Iceland can be tested and developed, i.e. mixtures with different aggregate grading and filler types, different paving grade (PG) of bitumen, new additives such as polymer modification, wax, etc. The results in the long run will be reflected in longer lasting pavements with all the advantages involved; less maintenance and rehabilitation, less pollution, less use of raw material and more comfort for the drivers and passengers.

The Icelandic Road Administration, Municipality of Reykjavik and two asphalt plants have supported the purchase of necessary machinery and the research fund of the Icelandic Road Administration supports the present research projects.

Is dust from bituminous surfacings overestimated?

The airborne dust in urban areas with high traffic rate is of increasing concern. It has been rightfully stated that abrasion from studded tires is the major cause for the production of harmful airborne dust. On the other hand, when estimating the quantity of dust from various sources, the total rut depth of wheel tracks has been considered to be entirely caused by abrasion. This is however not always the case and it has been demonstrated that deformation on hot summer days does occur. Harmful dust estimations should therefore take summer deformation into account, but wheel track testing indicates that deformation of traditional Icelandic asphalt mixtures could prove to be considerable.

External changes and new materials

With time, many parameters affecting asphalt pavement behavior and durability have changed. The total traffic load is increasing and heavy vehicle loads and air pressure in tires have also increased. The type of studs in studded tires and proportional use of such tires has also changed with time. Moreover, there are indications of changes in the weather, including high temperature records on warm summer days, which may add to the deformation of

The author with the new wheel tracking machine (left) and roller compactor (right).

Sawn section through sample plates which have been tested in the wheel tracking machine.

A close-up of the Prall abrasion machine.

traditional asphalt mixtures in asphalt surfacings. Additionally, the identification of harmful airborne dust from pavements is relatively recent and was not of much concern some decades ago. In fact, it can be reasoned that in the old days, when asphaltic surfacings took over and dusty gravel streets disappeared, everyone was very happy to get rid of the dust.

It is normal that changes occur with time in our environment, such as traffic related factors and climatic changes, but also new technology, development and new materials are being introduced. All these changes call for development and re-evaluation of receipts for bituminous mixtures, where both resistance to deformation and abrasion will be optimized.

It should not be forgotten that some 30 years ago, the results from extensive and successful research projects were used to set up the traditional receipts for asphalt concrete in Iceland. Later stone mastic asphalt was introduced to the market, also in a successful way. Those receipts have served well in the Reykjavik area, at least while the traffic rate and volume were less than today.

Research and implementation

Iceland, as well as many other European countries, is currently in the process of implementing harmonized European test methods and product standards for bituminous mixtures. The Innovation Center is now well prepared to take part in international research projects on the properties of bituminous mixtures. An informal Nordic technical mirror group for European standards in the field of bituminous mixtures does exist, and may proof to be a good scientific platform for ideas concerning research needs and areas.

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Read more: Two interim reports (in Icelandic) have been published, see
http://www.nmi.is/files/NMIS0905_188551803.pdf
and
http://www.nmi.is/files/NMÍS1002_972470607.pdf

Road Surface Measurement – a Journey over Many Years

Every year, the road surface condition in Sweden is monitored. Tens of thousands of kilometres are surveyed to collect data that provides an up-to-date, detailed, complex, and almost completely objective picture of the condition and change in condition. This data is one of many parameters used when determining the need for road maintenance.

Magdalena Green,
VTI, Sweden

Monitoring of the road condition has been carried out for many years. As early as 1975, road surface condition measurement technology became an important part of VTI's work. Development of this technology has been going on for more than 30 years.

Friction and surface evenness

In the 1970s, VTI, in collaboration with Saab, began the development of a road surface friction tester - the Saab Friction Tester. Further developments included the fitting of road wear measurement sensors, 25 small wheels and an accelerometer for measurement of surface evenness. This was, in fact, the beginning of the development of VTI's Road Surface Tester (RST) equipment.

Mechanical wear and the need for frequent calibration caused a major problem with the measuring wheels – a problem that was solved with laser sensors. Intensive development work began with the use of laser sensors – sensors that were world leading in terms of technology for a long time and still remain among the best performing in this field. The first RST with lasers was ready in 1980. Laser RST consisted of a beam, mounted at the front of a Chevrolet vehicle, equipped with eleven laser sensors that could, at normal traffic speed, remotely measure a 3.1 m transverse profile and simultaneously calculate rut depth and ride comfort index. At this time, investment and efforts, driven by the Swedish Road Administration, were at the fore front of world research.

VTI has so far been involved in the construction and delivery of around 30 RST vehicles to countries such as Saudi Arabia, USA, Australia, UK, Hungary, Spain and Sweden.

Data acquisition

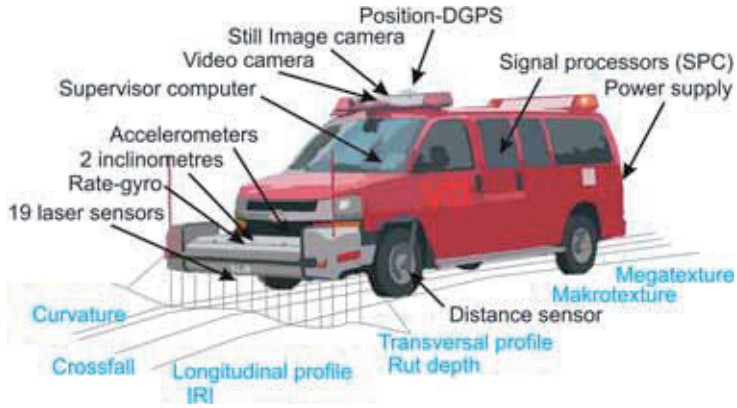
Information collected from road surface measurements provides a basis for managing the maintenance of paved roads.

At the beginning of the 1980s, the personal computer and Microsoft concept had not yet been introduced, however, intensive technological research was in progress to develop a data collection computer system. Since memory capacity was minimal compared with that of today, it was essential that programs should be extremely effective and make the best possible use of available memory. The VTI hive off company,

Primal Data AB, soon delivered a data collection computer system, highly competent for that time, which was installed in the Laser RST vehicle.

Knowledge of road surface condition is an important part of data provision for the Pavement Management System (PMS) used by the Swedish Road Administration. A PMS is a tool and support system used to reach an optimal level of road maintenance, and is based on national economic assessments. A PMS performs systematic planning of maintenance and operations, and also acts as a tool for the determination of where, when and how certain treatments should be carried out. For a PMS to function, information is needed on: traffic load, construction/structural condition, road type, climate, geology, drainage system condition, related costs, and data on road surface condition.

PHOTO: VTI/HEJDLÖSA BILDER



Bearing capacity and cracking

To achieve effective road maintenance planning and be able to determine different treatment strategies, it is necessary to have a good knowledge of the road network condition and its required standards. Planning ensures the correct treatment, at the right location and at the right time. To achieve this, it is essential to have a correct and sufficiently comprehensive description of, not only the roads surface condition, but also of the structural condition. Therefore, to complement and add further information, the development of road condition measurement systems continued.

Around 1990 the activity reached its peak and a real effort was made to develop further measuring systems that were needed to complement Laser RST. Hive off companies were formed and measuring equipment was developed; the Laser Road Deflection Tester (RDT) measures, at normal traffic speed, pavement strength and bearing capacity, and PAVUE measures the presence of cracks in the road surface. Both these systems were designed to assess the structural state of the road. For various reasons, the Swedish Road Administration decided to terminate investment, and equipment and associated patents were sold off.

Foundation for specifications and requirements

Today, VTI's role in this field has changed. There is only minor technical development, and VTI instead provides support and expertise to the Swedish Road Administration on specifications and requirements for condition measurement with survey vehicles. Thanks to the investments in technical development, a market has been established where several companies carry on commercial activity. Condition measurements carried out at present are procured through competitive tendering by the Swedish Road Administration, with VTI as an important partner for specifying requirements and selecting the contractor.

VTI has at its disposal advanced road surface monitoring equipment based on the Laser RST concept. The equipment comprises of sensors and technology which enable the properties required by the Swedish Road Administration to be measured such as rut depth, IRI (International Roughness Index), and macrotexture, MPD (Mean Profile Depth). Measurements are carried out at normal traffic speed, located with DGPS (satellite support) and complemented with digital photographs of the road environment. VTI's Laser RST is primarily used for research but also for consultancy tasks. A bright future lies ahead for the technology that started at VTI 30 years ago, and with further concentration on focus, attitude and discipline (FAD) it is likely to become a competitive and successful activity in achieveing the objectives of road maintenance.

FAD was formulated by a prominent American researcher; it is an abbreviation for

- Focus – concentration on the intended goal
- Attitude - motive and determination to reach the goal
- Discipline – make considered efforts and monitor these.

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Re-Road – Optimizing the Potential in Recycling of Asphalt

In a former number of this magazine (Nordic No. 1, 2009) there was an appetizer concerning the start of a European project "Re-Road – End of Life Strategies of Asphalt Pavements" running from 2009–2012. The project consortium involves eighteen partners of which four originates from the Nordic countries. Apart from the VTI, which also holds the role of project coordinator through Björn Kalman, the Swedish Geotechnical Institute, Peab Asfalt AB and Danish Road Institute participate in the research project which is funded by the EU Commission under the 7th framework programme.

Erik Nielsen, DRD, Denmark

The technical part of the project is divided into five work packages:

- WP1 Sampling and Characterization of Reclaimed Asphalt (RA)
- WP2 Impact of RA quality and characteristics on mix design and performance of asphalt containing RA
- WP3 Environmental performance of RA
- WP4 RA processing and RA management at the mixing plant
- WP5 Performance modelling of RA.

In the initial reference to Re-Road in this magazine we had just passed the "kick-off" meeting, but now the first interim reports to support the further activities of the project are in the tube for review and the last quality check before publication outside the consortium. As work package leader of WP4, I will here mention specifically an interim report in the format of a small survey which WP4 performed to provide background information of WP2.

The tasks for WP4 are closely related to practical application in the road sector, and the partners of that work package have good connections to asphalt producers and contractors. WP2 was involved in developing an optimum laboratory mixing procedure to obtain the best possible characterization of impact of reclaimed asphalt on mix design. As an initial starting point – apart from the European standard for laboratory mixing EN 12697-35 – WP2 was interested in the present experience for performing laboratory mixing – especially when reclaimed asphalt was introduced. By drawing on the industry contacts of the partners of WP4, a small survey was put together for practise of laboratory mixing to establish an appropriate mix design for materials including reclaimed asphalt. The deadline was rather tight as an initial sampling of practise was to be presented to WP2 12 May 2009 though the sampling was continued until October 2009 to harvest additional contributions.

The report contains more than 22 responses from six countries (Belgium, Denmark, Germany, Slovenia, Sweden and United Kingdom). The number of responses does not on the surface reveal the coverage in each country, but in general a major, if not a total market share, is represented by the responses, so the report gives a reasonable trend of the present state of the art.

The responses cannot be taken and summarized over the total range as some points are dependent on type of plant (batch plant or drum mixer and how the reclaimed asphalt is introduced), the market situation in which the company operates, availability to RA and local acceptance of RA in mixes – especially surface layers. But certain lessons can be learnt from the survey and 13 statements are highlighted in the report. A few of them will be mentioned here, yet it will be necessary to go through the responses to the questionnaire for a more thorough examination of the individual items.

- Marshall mix design is still the predominant method of performing mix optimization.

Reclaimed asphalt – slabs from utility works ready to be processed and re-used.

- Almost all companies use heated and predried reclaimed asphalt in laboratory mixing irrespective if they use cold feed addition of RA in the asphalt plant.
- Almost all companies aim for a homogeneous mixed asphalt material in the laboratory even though it means longer mixing times in the laboratory than in the asphalt plant.
- A few companies do not use laboratory mixing for mix design at all, but optimize mix design through full scale production based on experience and knowledge of the characteristics of the constituents.
- Only a very few responses claim that their laboratory mixing procedure is linked closely to the conditions of the local asphalt plant.
- In general, mixing temperatures – both in laboratory and in the plant – are selected based on binder viscosity or preselected from experience depending of the grade of binder.

Asphalt plant equipped for recycling.

Road User Requirements and Experiences Regarding Road Surface Conditions

PHOTO: MAGDALENA GREEN, VTI

The condition of our state-maintained roads is regularly monitored by the Swedish Road Administration, both by objective road surface measurements and by collecting the views of those who drive on state roads through questionnaire surveys. The agreement between the objective measurements and the views expressed by road users is not particularly good. In order to understand the disagreement between the two methods of assessment it is necessary to review the indices and the methods employed in collecting data.

Magdalena Green,
VTI, Sweden

The primary objective of the project "The demand of road users regarding road conditions" is to find out a) how to ask questions regarding road conditions in order to receive valid and reliable subjective data, and b) to find out what objective data that should be collected in the future in order to obtain a better agreement between subjective and objective data.

Regular monitoring

At present, the Swedish Road Administration routinely assess the condition of state-maintained roads by means of road surface condition measurements. It is mainly rut depth and surface roughness, expressed in terms of IRI (International Roughness Index) that forms the basis for road condition assessments. These objective measurements show that the condition of roads has neither improved nor deteriorated over the years.

At the same time, the staff of the Swedish Road Administration annually interview private and professional drivers to find out how pleased or displeased they are with the maintenance of the state-maintained roads. Road users are asked what they think of the maintenance of roads in general, and also more specifically about their views regarding rutting and surface roughness, i.e. the factors that are monitored. The results show that professional drivers are less pleased than private drivers. The general tendency, with the exception of the latest year, is that the proportion of pleased road users is decreasing.

The agreement between the measurements of road condition and the views of road users, according to the surveys, is thus not very good. It is therefore necessary to investigate the reason for this discrepancy to understand which objective measurements are needed to be developed in order to also gain insight about road users' experiences of road surface conditions.

Increased understanding

The project which is financed by the Swedish Road Administration has been carried out in the form of three independent stages, 1) a study of the literature, 2) focus groups and a subsequent questionnaire study, and 3) a driving simulator study.

The aim of the project was to enhance the understanding of what requirements, needs and expectations road users express in the relation to the surface condition of roads, and to formulate questions that will elicit valid and reliable subjective data. By understanding the demands of the road users, it will be possible to find out the objective indices needed to describe road conditions from the perspective of road users. This will result in better utilisation of the data collected at present and indicate what the measures are for tomorrow.

The study of the literature reveal that an increasing number of road management authorities wish to find out how well they manage to satisfy the wishes of road users regarding various aspects of the road network. The results from the focus group interviews indicate that the wish of all the participants was to have a road surface that was smooth, quiet and preferably recently surfaced, as well as wide without any unexpected narrow portions.

Damage types included in the questionnaire study such as, patching and repairs, as well as rutting, were perceived to be the most common while uneven/weak road edges and large rough areas were seen to occur less often. Generally, acceptance of damage was low, and it was lowest for potholes, followed by large areas of rough surface and uneven/weak road edges. Drivers had the highest degree of acceptance for patches and repairs. It was rutting in wet conditions and potholes which were per-

ceived to the greatest extent to result in harmful consequences for driving, and it was considered that there was an increased risk of an accident or that the driver had to concentrate more on driving. However, the results also indicate clear differences between different road categories, between different groups of drivers and between drivers in different regions.

Simulator study

In the third stage of the project, the VTI driving simulator was used to study how the road surface affects road users' perception of comfort and safety.

In a driving simulator, the environment under study can be gradually altered in order to pinpoint which changes give rise to an effect such as changed driver behaviour. Since there are many factors apart from the condition of the road surface which affect road user comfort and a feeling of safety, it is necessary to have stretches of roads that are homogeneous in all respects apart from the road surface properties, whose effect is to be studied. This is something that can only be achieved in a driving simulator. The fact that the appearance of the road surface is coupled with realistic sounds and realistic vibrations at the level of detail employed in this study is however unique and has required extensive development.

In the first part of the simulator study, tests were made to find out how impressions such as visual impression, sound and vibrations from the road surface affect road user perceptions regarding comfort and safety.

On the basis of driving data such as speed and lateral position, together with the test subjects' estimates of how comfortable and safe the road surface was to drive on, the conclusion could be drawn that the visual impression, on its own, does not affect speed, but has an effect on lateral position. Sound affects variance in speed, and vibrations affect variance in lateral position. Finally, vibration and sound also have an effect on speed in interaction with the visual impression. Hence, all three impressions affected different measures of driver behaviour on its own or in combination.

In order to elicit the drivers' subjective perceptions of different road surfaces, simulator driving was combined with a semi-dynamic questionnaire that the drivers had to respond to while driving. Estimates of comfort and safety reveal a clear pattern of how different impressions affect the drivers' perception of the road surface. This implies that visual impression, sound and vibrations, both individually and in combination, affect the subjective perception of safety and comfort. Hence, in order to affect road user's experience of the road surface all three impressions (one by one or in combination) can increase road user's satisfaction, or dissatisfaction, with the road surface (in terms of comfort and safety).

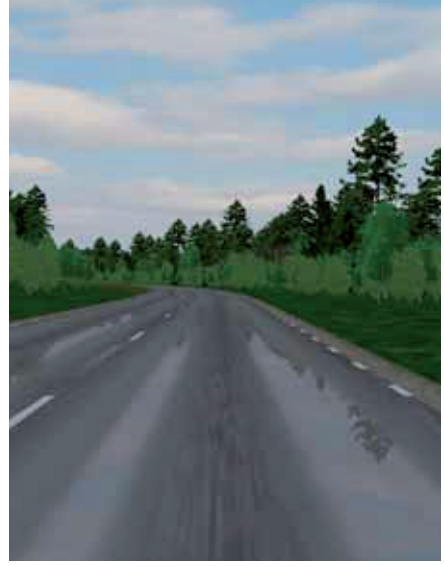

PHOTO: VTI DRIVING SIMULATOR

The second simulator experiment comprised eight road surfaces with different properties such as patches, ruts with and without water, and rough surface. On the basis of participants estimates the different types of damage/ properties were ranked. Road surfaces with ruts full of water stand out and were perceived to be least safe. The rough surface was considered as one of the least comfortable in addition to ruts full of water, but it was not perceived to be as unsafe. The estimates were completed before the driving session in the simulator, during the driving session and after the driving session. Participant estimates were very reliable and indicate that participant estimates can be used when the participant knows and understands the surfaces discussed.

There was a strong relation between perceived comfort and perceived safety, i.e. a road surface that is perceived to be safe is also perceived as comfortable. However, this relation is not so strong that it provides an expression for the same thing, i.e., there is an obvious and strong relation between experienced comfort and safety but, nevertheless, they do not explain the same thing.

Visual impression, sound and vibrations

Visual impression, sound and vibrations all contribute, both individually and in combination, to a reduced perception of comfort and safety. It is however not possible to state clearly which impression has the greatest impact; this varies depending on the type of damage to the road surface.

The experiments also reveal that there are great and clear differences between different types of road surface. For example, road surfaces with ruts full of water are perceived to be both less comfortable and less safe to drive on compared to road surfaces with dry ruts. This implies, in turn, that the condition index "rut" that is used today is insufficient to obtain the perceptions of road users regarding the road surface. A condition index that describes where water collects after rain is even more important.

Sound was found to be an important factor for road user perception of comfort and speed, i.e., sound could be captured in future by a condition index such as texture, for example.

One evident example of what creates a perception of a poor road is the patched road. Even the visual impression of a patched road reduces drivers' perception of comfort. If the noise generated by the texture and roughness of the patches is added, the perception of comfort deteriorates more. If, finally, the vibrations caused by poorly laid patches, with protruding joints and other roughness, are added, comfort is further reduced. One interpretation of this is that it is possible to minimise the negative effect of patching on driver perception provided that protruding joints and rough areas are avoided and that the texture and colour of the patch are as similar to the rest of the surfacing as possible.

Generally, the conclusion that can be drawn is that the greatest effort should be made to ensure that the road surface has a uniform colour, generates little noise and has a uniform noise level, and that it is as smooth as possible, in order to obtain that the road users should perceive it as comfortable and safe.

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Extreme Weather Impact on European Transport Systems

It is possible to both predict and mitigate disruptions in the transportation of people and goods. EU has launched a research project which studies the effects of extreme weather events on the safety and reliability of traffic systems. The EWENT project, which is coordinated by VTT Technical Research Centre of Finland, will also estimate the cost effects of weather-related disruptions. The project is motivated by the concern over the increase in extreme weather events caused by climate change.

Pekka Leviäkangas, VTT, Finland

The EWENT project supports ways of mitigating the effects of extreme weather events on the transport of people and goods. The study will focus on the safety and reliability of air, ground and water transport as well as on the cost effects of traffic disruptions.

The project will identify dangerous extreme weather events and estimate their probability and effects. It will also estimate the cost effects of traffic disruptions, such as costs associated with human casualties, material damages and discontinued supply chains. A lot of information exists about the effects of weather events, but this is the first project which intends to estimate their cost effects methodically.

The main purpose of the project is to support adaptation to climate change. In addition to the authorities, the project results may be useful for businesses, project financers and insurers. The results can be leveraged in various ways, such as in creating sizing criteria of infrastructures, pointing out needs for enhanced maintenance capabilities, development of cooperation between authorities and preparedness for exceptional conditions. The pre-engineering of co-European and national risk management methods and processes is one of the project's key tasks.

The project will be carried out between 2010 and 2012. The total project budget is approximately 2 million euros. The participants of the EWENT project coordinated by VTT are: German Aerospace Center (Germany), Institute of Transport Economics (Norway), Foreca Consulting Ltd (Finland), Finnish Meteorological Institute (Finland), Meteorological Service in Cyprus (Cyprus), Österreichische Wasserstrassen GmbH (Austria), European Severe Storms Laboratory (Germany) and World Meteorological Organisation (UN).

The Consultative Board of the project consists of representatives from the Finnish Ministry of Transport and Communications, the European Investment Bank, OECD, insurance company Allianz and the Polytechnic University of Turin.

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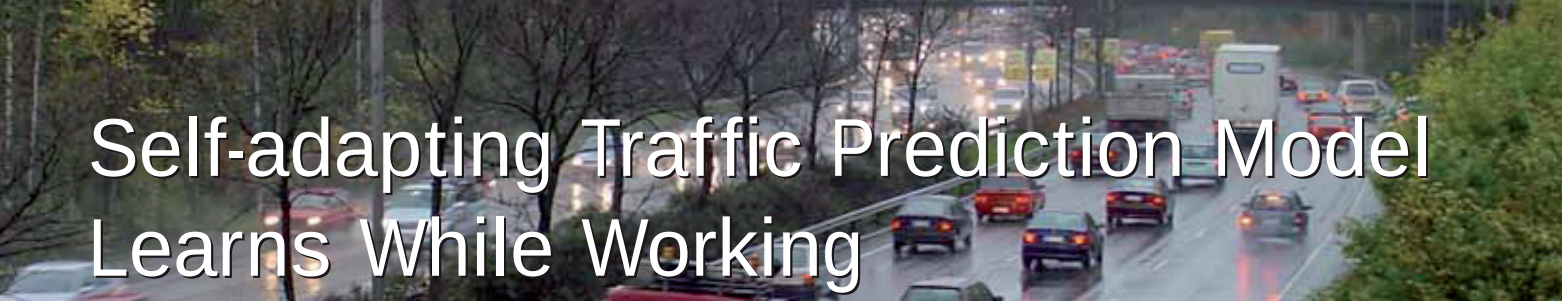

Self-adapting Traffic Prediction Model Learns While Working

PHOTO: FINNISH TRANSPORT AGENCY

There is often too little time to collect data for creating traffic models, leading to a small number of samples that represent random incidents and consequently poor ability to predict their consequences. The ability to learn while working online could improve this. The purpose of this doctoral dissertation was to develop a method for making a self-adapting short-term prediction model for the flow status that would also be practical for long-term online use.

Satu Innamaa, VTT
Finland

Road users benefit more from accurate travel time information when there is great variability in travel times. However, without short-term prediction, real-time information on travel time cannot be given. Much research has been done over the past 15 years in the field of travel time prediction. However, most of the models developed so far have been static and cannot deal with new types of situations, regularly requiring new man-made calibration and fresh data. Unfortunately, there is often too little time to collect data for creating such a model, leading to a small number of samples that represent random incidents and consequently poor ability to predict their consequences. The ability to learn while working online could improve this but there is a lack of knowledge on how to develop a practical, self-adapting prediction model.

The purpose of the study was to develop a method for making a self-adapting short-term prediction model for the flow status (i.e. a five-step travel speed-based classification). Specifically, the objective was to find a method that (1) could predict the flow status on a satisfactory level, (2) would learn by itself during online operation, and (3) would also be practical for long-term online use. The model was based on field-measured travel time data and self-organising maps. The test site was Ring Road I in the Helsinki metropolitan area. The road was regularly congested. Models were based on travel time and road weather data. Travel time data was collected by a license plate recognition system. Models were based on data collected during an 8-month period. The prediction performance of the models was tested during a separate 8-month period.

The forecasts were based on the outcomes of previous occasions when the traffic situation was similar to the present (Figure 1). The forecast was set to the most common outcome in the cluster of these similar samples. Forecasts were made for vehicles entering the road sections within the next 15 minutes on the basis of weather and road condition and travel time information. The forecast was given at 5-minute intervals for 5-minute periods. To make the model learn while working online from the traffic situations it encountered, the distribution of outcome classes was updated in the cluster used for making the forecast as soon as the "correct" answer was measured in the field. Consequently, there was no need to restore the samples to a database; rather, all that was needed was to increase the number of matches in an outcome distribution table. This table was as big as the number of clusters times the number of outcome classes.

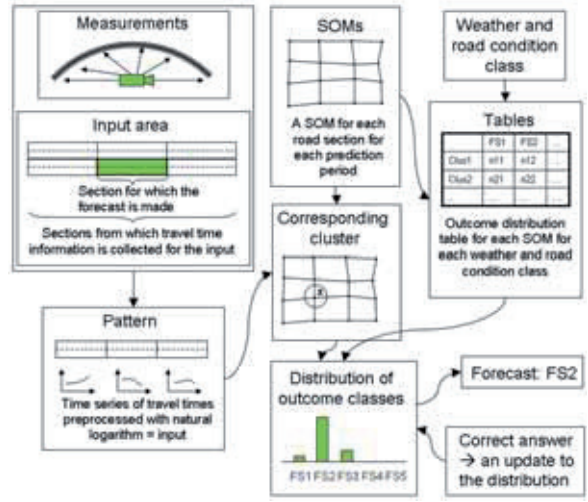

Figure 1. Principles of the prediction model.

The model was allowed to work online and its performance was studied as a function of time for a 250-day period. The proportion of correct forecasts was 93.8% over the entire trial period and 80.9% in congested conditions for the first test section (A) in normal weather and road conditions. Corresponding proportions were 96.3% and 82.3% for the second test section (B). The average daily change in the proportion of correct forecasts was positive over the whole trial period: +0.4% for road section A and +0.3% for road section B. Two naïve comparison models were made. The first one based the forecast on average travel time for the 5-minute period and day of the week in question for each road section. The second one used the latest measurements directly as forecasts. Both comparison models performed considerably worse than the self-adapting model.

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Read more: Innamaa S (2009). Short-term prediction of traffic flow status for online driver information. Doctoral dissertation, VTT Publications: 708. VTT, Espoo. 79 p. + app. 90 p.
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E6 Trondheim–Stjørdal, Mid-Norway:

A Pilot Project Using Competitive Dialogue

For the first time the Norwegian Public Roads Administration (NPRA) has chosen a contractor using the procurement procedure "competitive dialogue". The project chosen to pilot this procedure is the construction of a complicated tunnel in quick clay underneath buildings in the Møllenberg district in Trondheim. This project is part of the E6 Trondheim-Stjørdal highway project.

Thorbjørn Chr. Risan,
NPRA, Norway

"Competitive dialogue", a procurement procedure governed by the Regulations relating to public acquisitions, may be useful when awarding particularly complex projects. The objective of this pilot project is to develop guidelines for the use of this procurement procedure, as well as to carry out the construction work.

The process

In October 2008 the E6 Trondheim-Stjørdal highway project held an information seminar about the project itself, the upcoming contracts and the procurement procedure known as "competitive dialogue". As competitive dialogue is a relatively new procedure, there are few projects where it has been implemented in the European Economic Area.

Due to little response from the construction industry early in the process, the NPRA felt a need to give the contractors a greater understanding of the procedure, its possibilities and responsibilities. Three contractors participated in the dialogue phase. They were asked to use the summer of 2009 to draw up their offers, but at the opening of tenders in September, only two of the participating companies, NCC Construction and AF Group/Züblins, chose to submit a bid package for this part of the E6 Trondheim-Stjørdal highway project.

Both offers were better than the original plan sketch. The offer from AF Group/Züblins was considered more professional, but the cost was almost double compared with the bid from NCC. As this vast price differential outweighed the other considerations, the NPRA and NCC Construction signed the 70 million euro contract in November 2009.

The construction work will go through and under the district of Møllenberg along the northern main road out of the city of Trondheim. Large residential buildings in Møllenberg must be relocated temporarily and some, including a church (white building), must be demolished and rebuild when the tunnel construction work is finished. (Photo: NPRA)

The challenges

The contract is for the construction of approximately 500 metres of new four-lane highway between Pirbrua (the Pier Bridge) and the district of Møllenberg, of which about 300 metres is a concrete tunnel through uncompacted material prior to transition to tunnel in rock. A 120-metre stretch of the tunnel passes through quick clay. The quick clay is basically quite weak, with firmness like wet clay before agitating (Su 30–50) and like motor oil (0.5 kPa) after it has been agitated. This is 10 percentage points above the floating limit for clay, which means that it must be disturbed as little as possible.

The building pit will be below sea level and will reach solid bedrock 20 metres below the ground. Its biggest building pit will be 20 metres deep and about 24 metres wide.

The NPRA has signed a contract with NCC Construction for 500 metres of new four-lane highway through the district of Møllenberg in Trondheim, including a 300-metre tunnel to be built through uncompacted material. Using NCC's solution, six of the twelve buildings inside the blue area will not be affected. (Photo: NPRA)

The tunnel will be built along a main road which is heavily trafficked. The district of Møllenberg has many historical and protected wooden buildings which are close to and above the tunnel. In the original plan 12 buildings were to be moved to a parking area nearby for storage during the three-year building period, but with the solution of the NCC only six buildings need to be moved.

In addition, a new railroad underpass will be built, which involves removal of the main railway line (Nordland Line) during part of the building period.

The building method

NCC Construction has chosen a traditional solution for constructing the tunnel. The quick clay will be stabilised with lime and concrete piling to make it resistant to movement. Then steel sheet pile will be used to stiffen the walls of the building pit and to prevent the clay from moving. Throughout the construction period the groundwater level will be maintained. The building pit will go all the way to the collaring, where the rock will be separated by a cut and slip operation.

By reducing the distance between the two lines towards the tunnel opening, the method of NCC Construction will save 6 of the 12 buildings which were scheduled to be moved.

This winter NCC has been busy doing sampling, rigging up and carrying out detailed planning. In the middle of March the Nordland Line was moved temporarily beyond the local station at Lademoen in order to build the new railroad underpass.

Construction work will be in full swing after Easter 2010. The entire project is scheduled to be completed in June 2013.

Article based on different information from NPRA.
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Environmental Damage Caused by Road Salting – a Literature Review

Salt SMART is a four-year research and development project initiated by the Norwegian Public Roads Administration. The motivation for the project is an increasing focus on the environmental consequences related to the use of salt (sodium chloride) on roads in wintertime. A key objective is to document the environmental damage caused by road salt and other relevant alternative de-icing chemicals. This article summarises the main results of a literature review.

Kjersti J. Wike, NPRA, Norway

There have been numerous investigations into the use of road salts and their environmental impact. A literature review has been conducted which surveys both national and international literature focusing on the effects road salting has on surface water (flora and fauna), groundwater, terrestrial plants and soil. Two main groups of de-icing chemicals are considered in this report: chloride-based and organic-based. An assessment is given for estimations of critical load for species and natural environments. Bioforsk performed the Salt SMART-financed literature review in cooperation with UMB (University of Life Sciences), with researchers from Denmark, Sweden and Finland as a Nordic reference group.

Microorganisms and fauna in soil

Sodium chloride alters the soil structure and the composition of cations during ion exchange in soils. The washing out of calcium and magnesium from the soil as a result of sodium chloride use leads to increased potential for colloidal transport in soil, with a possibility of reduced hydraulic conductivity if pores become blocked with particles. Increased mobility of organic and inorganic colloids results in the increased mobility and wash out of heavy metals such as lead and copper, while the addition of chloride will increase the mobility of substances such as cadmium and zinc due to the release of chloride complexes.

Calcium magnesium acetate contains calcium and magnesium, both of which stabilise clay particles and improve drainage and aeration of the soil. Degradation of acetate and other organic-based de-icing agents can result in a lack of oxygen in soil because oxygen is used during degradation. This can mean an increase in the transport of iron, manganese and other metals because a precipitated oxidised binding of iron and manganese is reduced, released and becomes more mobile.

Microorganisms in soil near heavily trafficked roads can be harmed by sodium chloride. Chronic effects on soil springtails (Collembola) are proven at concentrations of 280 mg Cl/l. As for aquatic organisms, both chronic and sub-lethal effects occur when salt concentrations are considerably lower than the concentrations where acute effects occur. Microorganisms, flora and fauna are dependent on each other in the soil ecosystem, and it is unclear how this ecosystem is affected by different de-icing agents.

Plants

Salt can cause damage to plants as a result of uptake through soil and by spray. Numerous studies have shown that the deposition of airborne sodium chloride declines exponentially with increasing distance from the road. The greatest spray damage is usually found within a zone of approximately 10 metres from the road. Local soil variation, roadside forests and climate determine the magnitude of salt damage to vegetation.

Salt damage as a result of uptake through soil is a serious problem. It can take a long time before symptoms of salt damage disappear. Changes in species composition and losing out areas to other species along roads are a natural consequence of the use of road salt.

Determining critical loads that are applicable in a field situation is difficult,

PHOTO: KNUT OPEIDE, NPRA

because the extent of damage is dependent on a number of factors. Sodium chloride damages plants both by uptake through the roots and directly through spray; there is not necessarily a link between tolerance to uptake through the roots and tolerance to direct spray.

Alternative de-icing agents also affect plants, but a number of studies indicate that the effects are less than when using sodium chloride.

Surface water

Lakes in Norway which are affected by the use of sodium chloride during winter maintenance have developed salt gradients (difference between water in the upper level and bottom level > 10mg C/l). In the bottom levels of salt affected lakes, oxygen depletion gives higher concentrations of iron and manganese in the water. Use of chloride salts can also lead to an increase in the concentration of heavy metals and base cations (such as Ca and Mg) in the surface water.

Natural chloride concentrations in Norwegian lakes are usually between 1-10 mg/l. Acute effects of exposure < 4 days, acute effects of exposure for 1 week and chronic effects arise at Cl-concentrations of respectively (ca.) 6000 mg/l, 1100 mg/l and 560 mg/l if we allow effects on 50% of organisms (EC50) (fish, shellfish, algae). If effects are based on only 5% of the organisms, then chronic effects can arise at concentrations of ca 200 mg/l. Changes in species composition and physiological changes in certain species (chronic effects) arise at much lower concentrations than acute effects. The general trend in a number of studies shows that the chloride-based de-icing agents are less toxic to aquatic organisms (fish, shellfish, and algae) than those based on acetate.

Groundwater

Since chloride is difficult to remove, the most important way to avoid an unfortunate influence on groundwater is dilution.

Decomposition of organic de-icing agents increases with temperature and nutrient contribution (N and P). It is important to ensure enough residence time in the unsaturated zone to ensure that chemicals are broken down before reaching groundwater. Organic de-icing agents have different oxygen consumption, but in general, decomposition of these often results in increased iron and manganese concentrations in groundwater and sometimes also poisonous mercaptan.

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Read more:
http://www.vegvesen.no/en/Professional/Research+and+development/SaltSMART

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