world road association
uk national committee

2018

International Winter Road Congress
Lessons for the United Kingdom

CIHT

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- Alan Chambers, Amey, UK representative on World Road Association Winter Committee
- Matt Evans, TRL, National Winter Service Research Group (NWSRG)
- Martin Thomson, Transport Scotland, UK representative on World Road Association Winter Committee.
- Carol Valentine, Kent County Council, NWSRG
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Table of contents

Executive Summary

The International Winter Road Congress took place from 20-23 February 2018. The UK had a number of experts attending who have shared their key insights into what they found interesting and useful for winter service operations in the UK.

This report provides key insights, information and knowledge gained from the UK delegation that attended the Congress. There is immense value in the UK's attendance and involvement with the International Winter Road Congress.

Martin Thomson and Alan Chambers, members of the PIARC Technical Committee B2 Winter Service, were heavily involved in preparing for Gdansk: reviewing abstracts, papers, developing and agreeing the programme. They were also actively involved in the Congress by chairing/co-chairing sessions and presenting at sessions. Active participation in the PIARC Winter Service Technical Committee brings benefits and being a member provides direct access to a diverse range of winter specialists and offers opportunity for innovation

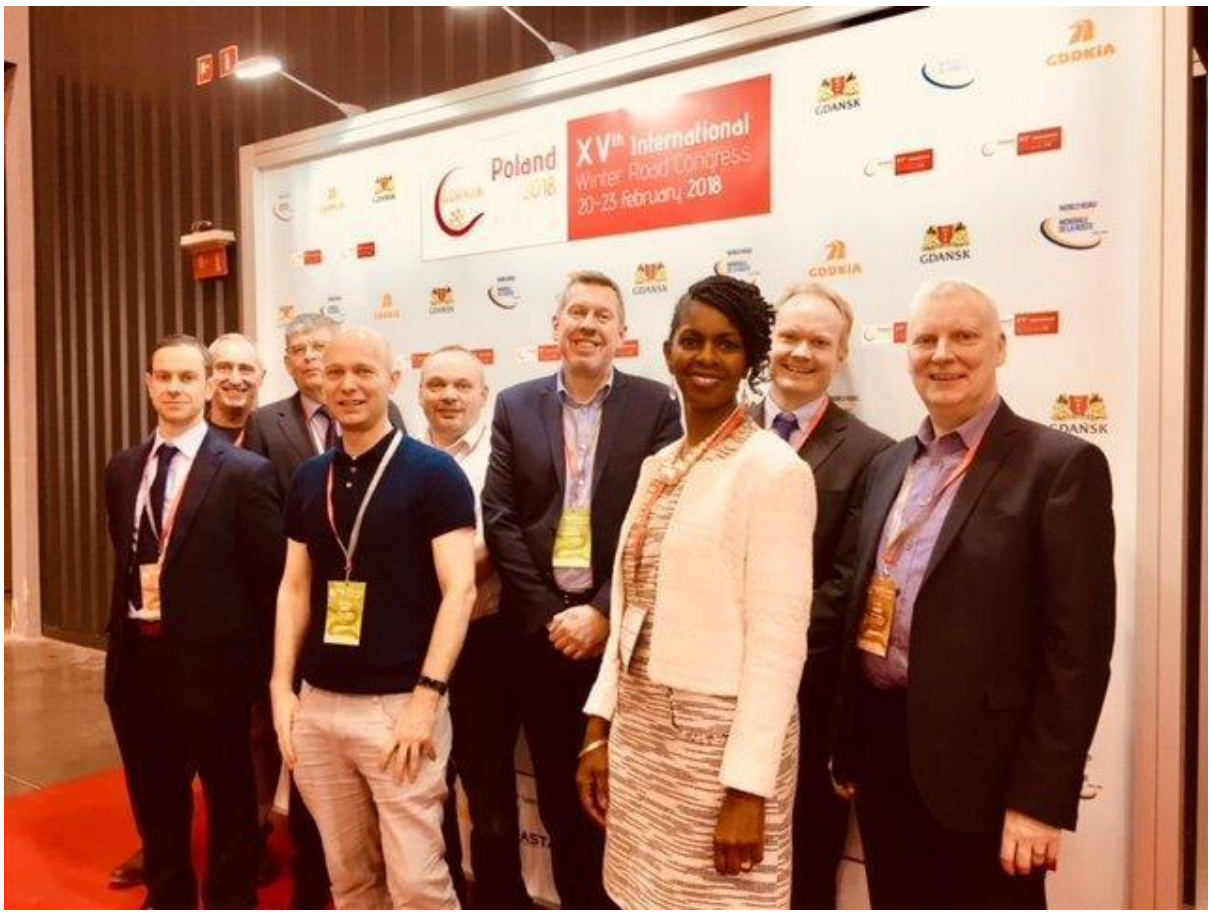
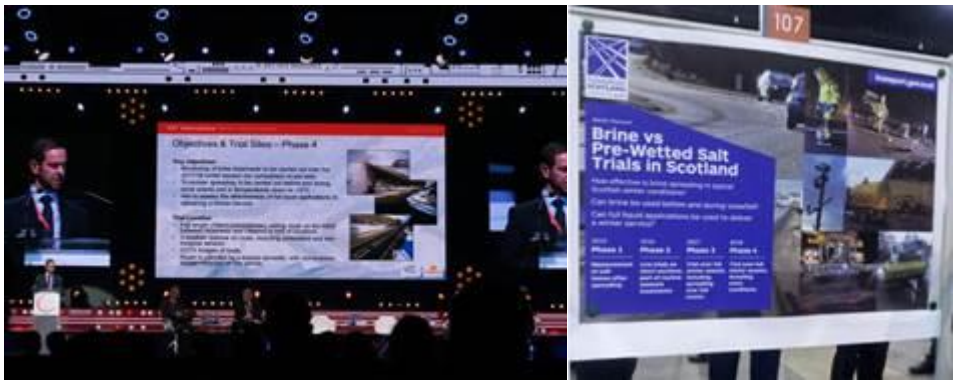


Photo of some of the UK delegation

The knowledge gained is vital to winter service operations in the UK. Following the 2014 International Winter Road Congress in Andorra the UK undertook a number of trials on liquid brine spreading.

The lessons are also relevant to the National Winter Service Research Group (a sub Group of the UK Roads Board that sits within the UK Roads Liaison Group (UKRLG) and for the supply chain who actively presented (Amey, BEAR Scotland and Scotland TranServ). Highways England have also taken innovations back to their respective organisations for consideration.



Martin Thomson from Transport Scotland presenting at the International Winter Road Congress 2018 in Gdansk

In terms of some key lessons for the UK the following were of particular interest, but it is recommended reading the full report as the list below is not exhaustive:

- Creation of enhanced road weather observations network using lower cost sensors, battery powered, data on demand, CCTV weather classification and mobile sensors fitted to buses, public service vehicles.
- Move to enhanced pre-wet using greater ratios of brine to dry salt. Reduced losses and delivers higher performance.
- In snow events efficient route treatment times are important as are methods for managing traffic to keep the network running.
- Increasing amounts of road weather and forecast data leads to a greater need for automated systems and the reduction in experienced staff will further drive the take up of automated decision support systems.
- Climate change leads to more marginal conditions further increasing the challenges associated with decision making and forecasting.
- Techniques for measuring / modelling residual salt are evolving. This will feed into improving maintenance decision support systems / de-icer management systems. [This demonstrates the value of the research by the NWSRG into residual salt].

- New road surfacing innovations and asphalt additives may lead to more self-de-icing roads and pavements better able to withstand severe climates.
- Specialist vehicles can deliver improved performance and capability at vulnerable and critical road sections.
- New software tools and forecasting capability will likely lead to dynamic route forecasting. This will see on-the-fly treatment routes tailored to suit each daily road forecast.
- Joint research collaboration opportunities with Netherlands, Swedish VTI, Denmark and the Nordfou (Scandinavian) research group. Networking with industry and supplier experts and a range of winter research organisations has proved extremely beneficial.

Road weather sensors – both on road and on vehicles

China is creating a denser network of road weather sensors. Focus on lower cost and more sensor site flexibility using wireless sensor technology to target black ice formation in particular, which is becoming more frequent than snow events. Battery has a one year life span but looking at solar option to extend life.

The picture of the wireless ice sensor buried underground

Sweden presented knowledge transfer from academia (Gothenburg) resulting in the development of a non-invasive 2D Road sensor, which can provide a surface condition and temperature "image" using near infra-red. Provides the benefit of much larger road surface view (6m x 6m). Highways England and Transport Scotland are to trial this sensor on the M8 on-road sensor and weather station test facility.

Finland (Teconer) are installing mobile sensors (which can measure Grip) on public service vehicles (buses) to provide infill and route road surface weather data to support the limited number of fixed weather stations. Expansion of road weather observation network will support improved decision making and provide verification of treatment effectiveness, based on grip measurement. The cost per bus to install the system is 3000 EURO. This works out to be an annual cost of around 60 EURO/km compared to fixed weather stations, which are around 200 EURO/km per annum.

Mobile road condition monitor installed in a bus

Andy Fraser of Transerve Scotland presented benefits (performance, environmental and economic) of moving to Route Based Forecasting from domain based forecasting. The next step is to better understand residual salt levels in order to optimise (reduce) spread rates.

By David Batchelor

Sensing – machine learning and data on demand

South Korea is developing a project focussing on road surface temperature change patterns using machine learning. Utilise on-board spreader vehicle ambient temperature data to establish the relationship with the road surface temperature. The aim is to compare patterns of air and road surface temperature (RST) and develop a model to achieve a low cost effective solution for estimating RST's.

Richard DeVries and Rachel Adams from Vaisala provided an interesting presentation on new ways of obtaining road weather data. "Data on Demand", where the weather station is provided by Vaisala for "free" and the customer is charged on a monthly basis for accessing road weather observation data. The data would be owned by the authority and data availability (>95%) and quality would be provided to an agreed Level of Service. This may assist in overcoming one of the financial hurdles to expanding or renewing the weather station network in an authority area. This would be based on a multi-year contract deal and could be based on a single sensor / weather station to a complete system. They have a number of clients (mostly US based) who are adopting this model and have interest from many more. To put some scale on this the UK has some 1,200 Vaisala weather stations across the local authority and government road networks.

Matt Evans: "[This is] analogous to a mobile phone contract where the customer does not pay for the phone but has a multi-year contract'

Carol Valentine: "This presentation provided information on a project undertaken in West Des Moines in Iowa. They wanted to install a fixed system but did not want to bring a capital program forward nor did they want to wait multiple years to get a system installed. The city of West Des Moines was the first city in the United States to enter into the new offering and installed their first fixed RWIS station in 2014 (with more sites following). The city does not own the sites where the RWIS are located but they are on the city streets and provide real time observations. The case study demonstrated that the information collected proved useful to decision making through the arrangement with Vaisala for the provision of weather stations across the county"

A fixed RWIS system installed on a West Des Moines street

South Korea is attempting to leverage more benefit from the network of CCTV video images they have around there network. The aim is to develop automatic detection of weather conditions such as snow, fog, intense rainfall. However a challenge exists under night and low light conditions. Based on their network of 1875 cameras across 4250km of expressway they are seeing a reliability of detection of >90%. Targeting weather vulnerable corridors, particularly fog prone areas. The cost of the CCTV camera is only 5% of the cost of a new weather station. The longer term aim is to make CCTV more intelligent through AI and machine learning.

A new CCTV camera and AWS have been installed at Woljung-ri on Youngdong, Expressway, 202.05 km away from Incheon.

By David Batchelor

Carol Valentine: "The weather system is configured to utilise images from weather stations as well as CCTV featuring weather information processes that include precipitation, temperature, snow, rain and fog. All the data was fed into a weather information system. Advantages of CCTV was the multi-surveillance functionality, hazard identification, real time weather information, and warning to drivers.

CCTV is evolving and improving all the time: the aim is that CCTV evolution will equate to the human eye – viewing CCTV-thinking CCTV (Artificial Intelligence) - leading to seeing, thinking, judgement, forecasting etc.

More research is needed for making CCTV more intelligent; AI and Image processing needs to develop and improve"

Forecasting

Sweden The use of dynamic route optimisation to only treat those parts led to less use of salt, less driving hours and resulted in decreased fuel consumption. The system accounts for factors such as residual salt and the optimisation process takes about half an hour.

Forecast of road conditions 4 January 2017 04:00 in the Gothenburg area
Legend: Green: Dry, Light blue: Moist, Dark blue: Wet, Turquoise: Light Snow, Bluegreen: Snow, Pink: Slipperiness, Red: Hazardous

Alan Chambers: "GPS controlled spreading and ploughing automation is moving on at a pace – the Japanese are using it to ensure that snowploughs avoid obstructions and damage to buried infrastructure. Sweden is using route-based forecasting, route optimisation and GPS control to optimise the route for every winter action."

By Matt Evans

Equipment Management Support System

Lithuania raised the important change to higher winter precipitation levels due to climate change. From a winter service perspective the country was now seeing less snow events and more marginal nights. The winter was becoming less predictable and the requirement to ensure accurate decisions on winter treatments was becoming more of a challenge. To counter this Lithuania are to install a further 60 non-invasive weather stations to supplement their current network of 118. They also use 40 friction devices which provide in-fill coverage between weather stations. The friction sensors are mounted on public transport and postal services vehicles. As part of their integrated road weather system they have linked their weather stations to VMs network to adjust speed limits in poor weather accordingly. Lithuania has an open data policy for all elements of their management decision support system.

Mobil optical friction measurement device used by a technical road supervisor

Denmark raised the issue of salt loss and liquid dosing variations due to the turbulence effect around salt spinners and spray nozzles, wind tunnel testing had proved this. The research suggests that by reducing the turbulence and therefore salt and liquid wastage/loss the number of accidents can be significantly reduced as well as the hours of snow plough use. Careful setup of liquid jets for brine only spreading will ensure consistent application of brine liquid and reduction of losses. Important to take account of cross winds and spreader speed (up to 70 km/hr) to maximise consistency and amount of liquid application.

Denmark use the de-icer management system (DIMS). The development of this sprung from the modelling of residual salt project (MORS) which provides a recommendation on how much de-icer to use, how this should be distributed based on information within a "blackbox" which has traffic flow and road surface type data etc. Having designed and utilised a test facility at Bygholm in Denmark for residual salt the group has identified that one of the key parameters in determining the appropriate treatment is the pavement type (age, cross fall etc.) this determines how long brine will remain on the road. The DIMS system has a wide range of inputs and treatment options, which are optimised based on the forecast for the winter event. Interestingly there is a move to dynamic spreading using this model to create individual treatment routes which can be designed on an event by event basis. The future project will be co-ordinated through NordFou. Highways England is pursuing opportunities to become an associate member of this research group to share research data.

Matt Evans: "There was a common theme in a number of presentations – i.e. computer systems that can make use of the increasing amounts of data available, to speed up the decision making and to support less experienced decision makers through automated decisions. In Europe there appears to be a move away from the current approach of applying the same amount of salt over an entire routes, towards a more sophisticated approach of targeted spreading where required'

By David Batchelor

Materials – Brine v Pre-Wetted Salt Trials

United Kingdom - Brine v Pre-Wetted Salt Trials in Scotland

The brine only research and development commissioned through NWSRG stemmed from Transport Scotland's collaborative work with Highways England through the last cycle of the WRA winter group and from discussion at the Winter Congress in Andorra in 2014.

For winter salt treatments, roads authorities in Europe and North America are moving more and more to liquid only spreading to prevent ice forming on roads. Recent studies from Europe have demonstrated the durability of liquid brine only spreading in comparison with pre-wetted salt. They concluded that for precautionary salt treatments, especially on dry and moist surfaces that sodium chloride brine only spreading is recommended because it requires less salt and stays longer on the surface.

Therefore, Transport Scotland have promoted research into the durability of liquid brine through the National Winter Service Research Group (NWSRG). Trials of brine spreading have been carried out over the previous four winters on the Transport Scotland network. The main aims of the trials to date have been:

- comparing the rate of loss of salt from brine and pre-wetted spreading;
- monitoring routine brine treatments and comparing them with equivalent pre-wet treatments;
- assess the effectiveness and longevity of precautionary treatments using sodium chloride brine versus pre-wetted salt for UK climatic conditions and on road surfacing types representative of the wider UK network; and
- understanding of liquid performance in the range of conditions experienced on the Scotland network to support the development of operational guidance for liquid spreading.

Transport Scotland continue to be proactive and promote research into the durability of liquid brine and building on their research from previous years the trial this year on the A835 (our coldest route year-on-year) is to trial brine in all conditions including wet and snow to provide evidence on whether it can be considered a suitable substitute for pre-wetted salt or if it requires to be used in combination with a pre-wet mix in the worst conditions on our trunk road network.

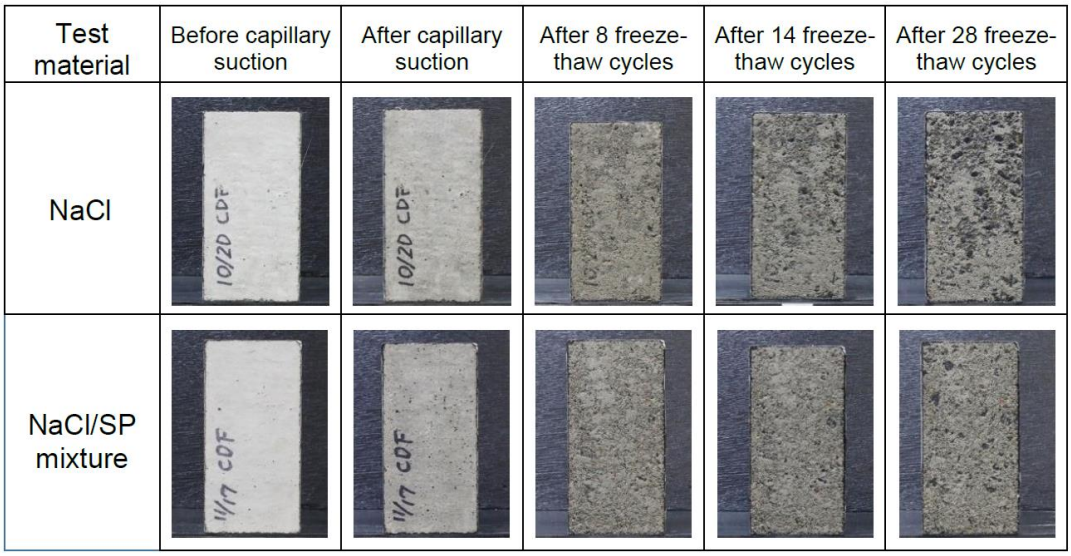
Figure 1 – Brine spreading on A1

Martin Thomson: "I am a member of the WRA Winter Technical Committee on behalf of Transport Scotland to share best practice in Scotland, the UK and internationally. Transport Scotland actively support the WRA and this has included presenting two papers and co-chairing in Gdansk as well as reviewing abstracts and full paper submissions beforehand"

By Martin Thomson

Sweden – presented on FS30 Brine spread rate and how it performed under skid resistance tests. The conclusions were: 1) Nacl should dissolve as quickly as possible to melt ice and snow and create an anti-icing film; 2) FS30 prevents some NACl to be transported away from the road by wind gusts from traffic, 3) Four combinations of Nacl, CaCl (20 weight % in total) were tested; 5) Dilution of CaCl2 solution is an exothermic process; 6) NaCl dissolved faster that brines of CaCl2; 7) Wet skid resistance (friction) was at a similar level for all solutions; and 8) Presence of brine on the road replicated during a simulated drop in air humidity were different., NaCl brine dried up faster which suggested that the dry content was dispersed to the road side.

Japan - Concerns had been raised around the use of Chlorides on the infrastructure and environment. Project was looking at alternative solutions. Sodium Propionate (SP) link was tested as less corrosive to metals and an organic material. Various tests were undertaken with the results presented. It was identified that SP was 10x more expensive than Sodium Chloride but used as a food additive In order to make it more cost effective a mixture of SP and NaCl was tried. Laboratory tests were conducted on metals, concrete, environment, and ice melting properties. The freezing point of SP was -17c, NaCl was -19.8c, and a mix of both was -18.9c. They went on to undertake field tests, and friction tests were undertaken during various stages of the test. The conclusion was an application of NaCl / SP mix was as effective as a conventional application, was highly soluble in water, and recommended for use as a pre wet material. SP was been purchased from China, its source was not disclosed.



Changes in the appearance of the concrete specimen

Matt Evans from TRL: A presentation from Sweden (VTI) demonstrated the advantages of using Calcium Chloride brine in pre-wetted salt. This may help salt dissolve more quickly and increase the amount of salt remaining on the road surface over time. A presentation from Japan demonstrated the effectiveness and reduced environmental and corrosive impacts of Sodium Propionate compared to normal salt. The use of alternative de-icers in the UK is still low and there may be benefits to be gained from further trials of different materials as demonstrated from these papers."

By Darren Clark

De-Icers

Germany - Global warming potential of de-icers. A research project to look at the potential environmental effect of three different types of de-icing salt rock, vacuum and sea. It provided some background on the specification of each material and environmental production impacts of each type. It also provided some comparison results on cradle to gate on global warming potential. This presentation had a very good map recording where the different type of salt was produced across Europe, and the different import routes. It provides some indication of the quantities imported into EU members, and how the materials were transported (and its global warming potential). Its conclusions Rock salt and Seas salt have a low GWP, aim to keep transport distances as low as possible, train or ship transportation is preferred over road, GWP should be considered when tendering as an evaluative criteria.

France - Pollution load of De-icers. This presentation looked at road run off and where this would end up. It suggested 50% of spread salt would be collected within the drainage network, with up to 5g /l finding its way into a retention pond. It looked at NaCl impacts on natural habitats. It had an objective of looking at how road salt behaved within a retention pond. It identified a specific site in France and undertook various samples and presented its results. It identified that 92% of salt was distributed into the environment. It also looked at de-icer impact on Zinc concentration. It concluded that high amounts of salt entered into the pond, and suspended solids effects of NaCl on these were observed.

Poland - Winter maintenance use of de-icers and impact on water. Presentation looked at salt pollutants – 1 teaspoon of salt permanently pollutes 19 litres of water. Suggesting less is more when it comes to salt usage. It looked at the environmental risks from the use of NaCl, MgCl2, CO(NH2)2, and CMA. The presentation went on to look at sources of contamination and environmental impacts in the US from uncovered salt stores. The project identified a lack of clear guidance to inform decisions on WM policies and treatment options to take into account the negative impacts on de-icing salts on the environment. It looked at proactive mitigations strategies by the use of salt management plans, clear policy and objectives. The presentation went on to explain the benefits of a decision support tool, and cost-benefit analysis. With the Decision support tool it looked at what the key functions are, how this fitted into wider system, its data requirements, and how salt loadings, application rates correlated with increased de-icer levels in the environment.

By Darren Clark

Carol Valentine: The paper 'Winter Maintenance: use of de-icing agents/chemicals and their impact on water bodies and the environment' by Ewa Zofka covered work that could be beneficial for NWSRG to engage with to share research outputs and topics. The winter maintenance assessment tool (WMAt) provides recommendations for road operators on the most effective, efficient and sustainable winter road maintenance solutions at environmentally vulnerable road network locations. Exploring proactive mitigation strategies covering key functions such as: identification of environmentally sensitive locations; selection of site specific considerations (climate, topography, infrastructure and quality of data); identifying and assessing impact of winter road maintenance measures with their respective scalable applications (e.g. salting amounts, ploughing intensities and salting techniques and technologies etc.).

Pavements – Belgium and France

Belgium - Winter behaviour of an experimental poro-elastic road pavement and recommendations for its winter management**.** This project was aim at developing the experimental concept of a poro-elastic road surfacing (PERS) into a feasible noise abatement measure.

The objective was to develop a pavement with a very high noise reduction at the same time as keeping other relevant performance criteria at a good level. The project included an extensive monitoring effort to understand how the PERS pavement behaves when faced with various typical winter weather conditions representative of different European climatic conditions.

Thermal behaviour monitoring has been carried out using embedded temperature sensors during consecutive winter periods on test sections in Belgium and Denmark. PERS tend to be colder than that of dense asphalt concrete.

Some snowfall event observations carried out in Belgium clearly showed that the snow sticks first and remains longer on the PERS than on the adjacent dense asphalt concrete. However, friction measurements carried out in Sweden, showed that the PERS mostly has better friction in light & slush snow conditions than the asphalt pavement.

Freezing rain events have been observed in Sweden. They showed that while the asphalt pavement was icy and very slippery the PERS surface was free of ice and amazingly seemed to have a friction similar to that of a wet PERS surface. This observation suggests that the ice had got cracked by the passing of tyres over the flexible surface.

In summary, an interesting presentation but not too relevant for our trunk roads as we have moved away from porous pavements.

France - Roads of 5th Generation: benefits and limits of phase change materials (PCM)**.** To prevent the formation or development of ice, and to break the bond of already-bonded snow and ice, anti-icing and de-icing operations have been commonly conducted as a primary snow and ice control strategy.

Two approaches were developed, one relying on the circulation of a fluid in a porous layer within the infrastructure, and a second one with phase change materials (PCM) inclusions below the circulated surface. It was highlighted PCM are now quite widespread in buildings.

In the study, several PCM were incorporated within pavement materials and tested. The pavement surface temperature was monitored with both thermocouples and an infrared camera. The analysis of observed thermal variations indicated the ability of PCM to provide some energy to locally generate a temperature increase and to delay a decrease. However; the effects depend on the PCM nature, its depth of incorporation into the pavement, and the intensity of the meteorological phenomenon.

By Martin Thomson

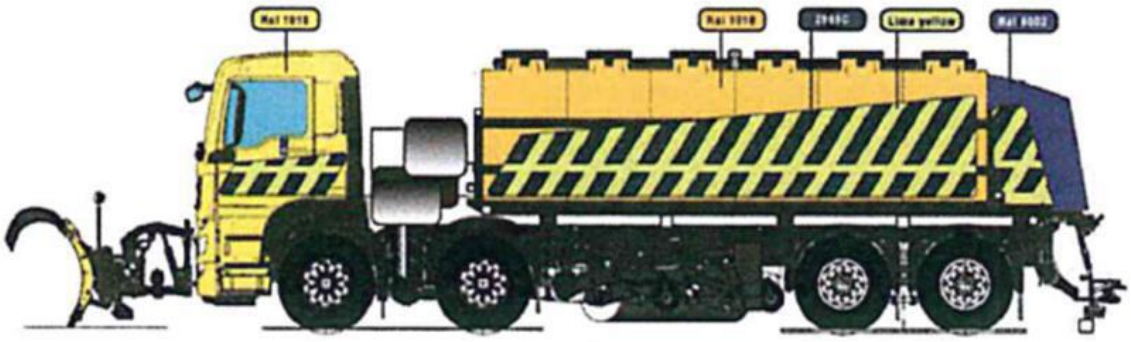
Pavements – Spain, the Netherlands and China (and France)

Spain presented research into the use of nanostructured bitumen for extreme climate locations. Evidence provided to demonstrate resistance to salt attack, ice and water (freeze thaw cycles) leading to a longer pavement life. Process creates a better bond between bitumen aggregate. Currently only available for use in Spain.

Netherlands (RWS) presented a useful overview of their special ice fighting equipment designed for porous asphalt and other ice prone road surfaces. RWS key data: 56 depots, 540so spreaders, 1100 snow ploughs, 290 RWIS, 1 bridge deck spray system, 4 special ice fighting machines, 220,000 tonnes salt storage, 89,000 tonnes average annual use.

Due to high traffic volumes hard packed ice sheets can form on porous asphalt. Previously used calcium chloride brine to treat this type of event with Firestorm specialist liquid spreader. Create calcium chloride brine by mixing prills with water – exothermic reaction allows liquid to reach 70 degC. Very positive de-icing effect, however spreader had short range and mixing water and CaCl2 prills was challenging.

RWS move to Lavastorm – this is used for conventional precautionary liquid spreading and reactive ice treatments. Matt Evans described this Lavastorm vehicle in his report. RWS aim to purchase more as they have been very successful. However challenges remain due to depot storage and production of sodium chloride brine and calcium chloride brine. Higher spreading speed than UK as RWS use 70 kph for liquid spreading and ploughing speed of 50kph.



Lavastorm

China - Long term performance of low freezing point pavement. Main beneficial outcomes:

- Provides pavement ant-ice ability
- High performance long-term release properties
- No effect on long-term performance of surfacing
- Effective temperature range can reach -25degC
- Low freezing point filler (LFPF) additive content is 3 to 6%.
- Shows good snow melting performance even after 8 years.
- Demonstrates a reduction in the bond between ice and pavement.

France – presented a new additive to salt or brine to produce a soft ice result after spreading.

Benefits:

- Biodegradable
- Easily added to salt or brine (CEREMA, Akzonobel Ecosel asphalt protection product)
- Trials on Massif Central region – 130km test route
- Positive impact in the lab – moving onto road trials (complete 2018-19)
- First road trial results due end of 2018
- 1% liquid additive to salt
- 5% additive to salt brine
- Reduces freeze / thaw cycles.

By David Batchelor

Pre-wetted spreading

Germany - Pre-wetted spreading has been in use in Germany since 1975, and has demonstrated since that time that there are many benefits such as a reduction in salt loss, better salt distribution, better adhesion to the road, faster to react, improved road safety at a reduced cost. The presentation went on to look at brine spreading it showed that FS100 provided better salt distribution at higher speeds than FS30 and had a faster thawing action and used less salt. It was used more often for temperatures down to -6c. The presentation showed an example of new German spreading guidance. They identified issues with equipment and that brine spreading was not applicable for all situations. They were aware that two solutions were needed: spinner discs and spray nozzles. And with 20% concentration capacity on vehicles was an issue; therefore they looked at developing several vehicle types. Further developments included FS50 or FS70 from a spinner disc, but these identified that it was only effective at low spread widths and road speeds (see similar in Austria below). FS100 has been trialled from a disc again limited to 8m width, up to 40km/h and dosages of 20g and above.

Better distribution of salt with pre-wetted spreading (right side) compared to dry-spreading (left side).

Austria - Winter maintenance was broken down into four different categories based on type of road and treatment times. With ranges from 3 hour, 5 hour, no level either 24hours a day or within a time frame depending on the traffic flows encountered. The presentation the amount of material used in 2016/17, how preventative treatments worked, limitations of de-icing capacity of Sodium Chloride. It presented results of thawing performance in a climatic chamber, and the thawing performance from sodium chloride and liquids. There were some on road tests conducted at FS30 but also looked at development of spreaders with higher brine dosages. They then looked at residual salt measure measurements ad FS30, FS50, FS70 and FS100.

Key observations and benefits as noted by **David Batchelor**:

- Spreading brine at 30gm2 corresponds to 6gm2 of solid NaCl
- Brine provides faster thawing
- Brine provides the same grip as pre-wet
- Brine uses half amount of salt
- Need to consider requirements for additional brine storage both on vehicle and in depot
- Salt loss figures 3.5 hrs after spreading:
    - FS30 = 67% salt loss
    - FS50 = 58% salt loss
    - FS70 = 36% salt loss

    - FS100 = 0% salt loss
    - Based on brine ratio to dry salt.
- With dry salt spreading the residual salt remaining after 10mins is only 25% of the total spread i.e. 5gm2 when a 20gm2 application is undertaken.
    - With 50% brine share this increases to 50%
    - With 70% brine share this increases to 55%

Typically user finer salt than UK – 3.5mm max particle size. Spread over two lanes. UK to review European salt standard – benefits of finer particle size.

- Lower Austria has typically seen 30% salt savings per m2 over the last 12 years.
- European questionnaire into winter service practices:
    - Only Transport Scotland has completed for UK.
    - Most use sodium chloride (19 authorities)
    - Some use magnesium chloride and calcium chloride (7 authorities)
    - Additives (ABP's) are used in only 3 countries
    - Germany has its own test research site (BAST)
    - Brine is an excellent preventative treatment
    - Guidelines and tables for treatment matrix need to be straightforward
    - Final PIARC report into liquid spreading due 2019
    - Brine is effective down to -6degC
    - German guidelines provide recommendations on spreading techniques and dosages – essentially preventative treatments all designed around brine spreading
    - Looking at innovative spreading techniques utilising trailer spreader where truck spreads pre-wet at FS30 and trailer can deliver FS100 (brine only treatment)

David Batchelor: "Brine spreading is strongly increasing in last few years across all WRA member countries."

Germany - Optimising Winter Maintenance during heavy snow - Presentation around the timing or precautionary treatments (3 hour circulation time).

This was not sufficient in times of heavy snow on critical sections. They undertook research on the influence of heavy snowfall on traffic, winter maintenance and salt spreading, circulations times, and different levels of service and measures.

It identified that traffic jams were generally caused by accidents, and during winter mostly caused by traffic volume and HGV's stopping on steep gradients. This often resulted from HGV's not been prepared for conditions, no special tyres, or driver experience. It only took a few HGV's to cause a big problems. Consequences were it took much time to recover the road, and caused economic issues.

The presentation looked at the effect of salt spreading during snow fall. It identified that the salt stopped the snow from sticking to the road surface. To thaw snow, a lot of salt was needed. At temperatures of 0c 40g/m2 was needed for only 1 cm of snow.

It looked at research of analysis snow with different salt content – a small amount of salt - 10% - was able to stop snow from sticking (queasy). It concluded that the aim was to stop the snow from sticking (queasy). Dosage had to be enough to aid snow removal and stop new snow from settling within the circulation time. There were a number of factors to be considered and for motorways high traffic volumes and steep grades were of specific focus.

They looked at various measures for WM such as more resources and shorter circulation times. Redeploying equipment in critical cases. It identified advantages of FS50, FS70 and FS100 stating that these had better distribution, faster thawing effect, better grip lower salt loss and reduced salt consumption over FS30.

It kept only the first lane snow free (where the HGV's were) It stated that HGV's were forbidden from over taking other HGV's to reduce the risk of blockages. They targeted high risk locations and would red X lanes where needed and implement block dispatch techniques - i.e. hold the trucks and dispatch in a specific way.

Example of not keeping all lanes open: in this case supported by variable traffic signs (left lane not cleared and blocked)

Austria - International Development of Application methods of de-icing **-** Presentation looking at the different approaches to winter maintenance by countries represented by PIARC. Level of service on motorways 2h or 3h were common, Most countries spread during snowfall, most common treatment was a mix of pre wet and dry treatments. Preventative spreading lead times vary greatly anything up to 8 hours. Spreading amounts vary from 5g/m2 to 40g/m2. All countries used pre wetting methods, and nearly in all cases FS30 is used. 19 countries use NaCl, 7 also use CaCl2, or MgCl2, 2 only use CaCl2, and one only MgCl2. It also provided an overview on brine spreading, other de-icing methods, and provided a short overview of some of the various countries different considerations.

Martin Thomson: "Spreading technique in Germany has improved over the years, especially the spreading patterns and the requirements and the quality control of spreading machines are now optimized.

The problem with pre-wetted salt is that the laying performance is limited, especially when preventive spreading on dry surface. So in the last few years brine spreading (full liquid) is becoming more and more established for preventive actions. However; only in addition to pre-wetting because both techniques have different advantages and disadvantages so that the best use depends on the circumstances. So in Germany guidelines and recommendations for the practical use of both techniques are developed, also with recommendations for spreading amounts.

Currently the further development takes place with practical tests and research of combined techniques (machines able to spread both) and pre-wetting with higher proportion of brine (50 up to 70 % instead of normal 30 %). This is particularly relevant based on the current brine research being undertaken in Scotland."

By Darren Clark

Maintenance Management - evidence based approach to investment

Germany - Test methods for sensors of road weather stations - Transport Scotland facilitated Horst's visit to Scotland back in 2015 and the presentation provided at the WRA was very similar to that given to Transport Scotland. For several years, the Federal Highway Research Institute has been operating a test field with various sensors for road weather stations. The test field is located on a motorway with a temporary high traffic load. Under the same real conditions, some of the sensors give very different results. Based on the inconsistent data, very different decisions on the winter service would be made despite equal conditions.

The presentation illustrated how the differences in measurement can affect the further processing of the data and thus the decisions for winter services. Following the meeting with Transport Scotland and BAST in 2015; this provided the concept for our research below:

> *Martin Thomson: "Transport Scotland and Highways England are collaborating in a cross-border project to develop a winter service on-road testing facility. Our collaborative plan is to develop an on-road winter test facility on the M8 motorway between Edinburgh and Glasgow in Scotland; and construction commenced on site in late August 2018. We have support from a range of leading weather station and sensor suppliers to provide their latest innovative sensors to fully instrument the test facility and the Congress enhanced our network of contacts."*

United Kingdom - Transport Scotland & Vaisala - Idaho Storm Performance Index Trials - At the 2014 Winter Roads Congress, a paper was presented from Transport Scotland (TS) outlining an approach to better understand the economic welfare impact that occurred in the country during the winter of 2010/11. The results stated clearly the benefit of well-targeted investment in winter maintenance activities; however, there were key data gaps with judgement employed. In 2013, Idaho Transportation Department (ITD) published a paper outlining their approach to performance measurement of their winter maintenance activities. Their original work was carried out manually each day to assess how well the roads were kept free from ice and snow. However as a close partner of ITD, Vaisala agreed to automate the report that is based on output from its weather stations. As a result the index report can be run for any customer using the Vaisala service.

Following discussion between TS and Vaisala it was believed that the outputs from the index could help in reducing the risk of the original assumptions in the TS study to bring quantifiable data for further analysis. Over the past three years Transport Scotland has worked collaboratively with Vaisala to better understand the economic and welfare impacts resulting from severe weather disruption alongside the cost benefit analysis of investing in the winter service. Information elicited from this analysis has given a clearer indication of the saving made through current levels of investment in winter maintenance activities and provided an understanding of individual event performance, as well as macro level network details. The presentation was a summary of the three years of our collaborative research and demonstrates the power of analysing weather station data after the fact to gain insight and knowledge about both climate and winter service performance. The longer this data is collected the more useful it will be in being able to engage an evidence based approach to investment and the return on investment that it brings. Also illustrates the demonstrable benefits of attending and participating in the Winter Road Congresses.

By Martin Thomson

Chemical Use

Combining the overall theme of the four presentations:

- Research projects that are driving the move away from manual salting decisions to a mix of automatic and enhanced manual salt top up applications.
- Use of on-board salinity measurement device is facilitating this approach. Limited by the fact that device will only measure salt concentration on damp or wet roads as it relies on salt spray.

Vehicle fitted with salinity sensor in Japan

- Germany had carried out research into the demand for salt during snowfall – lower rates than typically spread in the UK. Important to have lower route treatment cycle times - impact is greater number of vehicles and drivers (risk that snow events are decreasing but becoming more intense and disruptive when they do happen).
- Tyre based contact area information system (CAIS) can assess road surface state (96% accurate). Currently fitted to 9 patrol vehicles and 21 spreaders to allow for automatic control of the spreading rate. Noticeable reduction in salt application rates over the course of one season on one test section.

By David Batchelor

The Effect of Pavement Texture on need to for salt in winter maintenance of bicycle roads

Sweden – the winning paper across the whole of the Congress was awarded to Anna Niska and Goran Blomqvist from Sweden for the paper 'Sweep-salting – a method for winter maintenance of bicycle paths'. The paper was interesting identifying that skidding was a key reason for serious injuries to cyclists (based on data from hospitals). Sweden has started to use 'sweep salting'. They brush the surface to really ensure a clear surface and can therefore use a lower amount of salt. There were a number of questions and the timing of clearance was clarified: the paths should be ok at 6am and 4pm (and if there was snowfall there would be a second clearing). Asked about the type of vehicle used: was it a three-in-one machine? The preference was for single type vehicles to be used. Some other key points:

- The operating speed must be adjusted according to the prevailing conditions.
- In mild weather with moderate amounts of snow brine is sufficient, but with lower temperatures and/or heavy snow-fall larger amounts of salt is needed and pre-wetted or dry salt must be used.
- When spreading brine, a spreader using nozzles will give a more even distribution of the salt, but a spinner is needed when spreading pre-wetted or dry salt.
- For the method to work properly it is important that the bicycle path construction is of good condition without cracks and other damages in the surface.

A sweep-salting measure on a bicycle path in Stockholm when a large amount of salt is swept off the surface.

Alan Chambers: "Cycleways: there were many papers on treatment of these and this will become more and more important to the UK as we promote cycling."

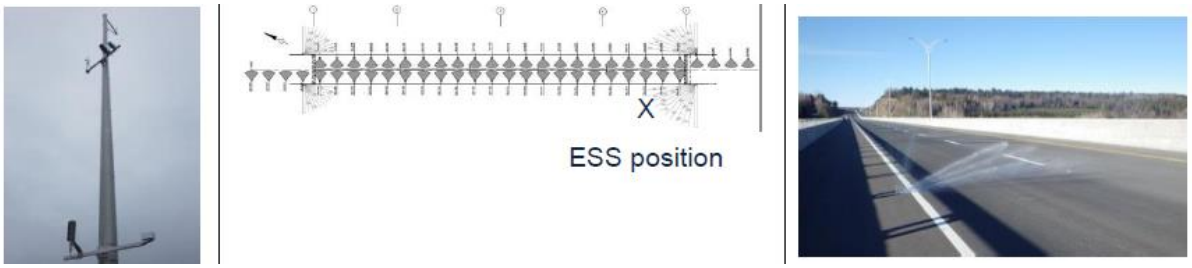
By Justin Ward

Management of Tunnels and Bridges

Canada - Assessment of real structures - This presentation looked at the effect of winter and salt on structures and how it can cause deterioration in concrete or metalwork – such as causing chipping or steelwork corrosion. It looked at the USA which has over 250,000 structures between the ages of 30-50 years old. Further slides detailed the effects of the climate, salt and exposure from salt spreading in the US. It made mention to a salt laden mist and how this also affects the structure there was a mention of corrosion after only 5 years.

David Batchelor noted: "20% of repair costs are linked to corrosion in Canada".

Canada - Bridge slippery Conditions - A presentation that started with the statement bridges and overpasses present higher deck surfaces icing risks than adjacent roads. It demonstrated a road surface condition sensor system and an environment sensor station (ESS) site that provided advisory advice on slippery roads, and associated warning signs. The other location was one with a fixed anti-icing spraying system. It explained how this worked and was looking at how the systems performed, and how they could be optimised. It detailed how the systems were tested through the use of sensors, dash cams and mechanical means. The results are not yet known as this winter is the last winter of three years' worth of evaluation. It did present an analysis so far of the data presented at each location. Initial findings suggest that surface condition sensors do no differentiate between loose snow or packed snow – it gives similar levels. Other road surface conditions are well detected. They have also changed some of the algorithm settings to lower liquid consumption in prolonged snowfall. They plan to doe further analysis and fine tuning after year three. They are looking to optimise the performance of both systems, and then evaluate the costs and benefits.



Gilbert River Bridge, Canada – ESS, spray nozzles with a view of the bridge

France - Impact on De-icing salt on bridges - This looked at the corrosion of different metals from de-icing materials. It looked at the legislation for the use of different de-icers and direct and indirect impact on the environment. It was using various environmental sources, and looking at impacts on water courses. Its aim was to identify the pollutant flux, and diminish the pollutants. In an operational context its aim was to test the de-icing material compatibility, to check it conforms to TS EN16 811-3 and to optimise spread coverage. As part of the research it looked at metal immersions tests and provides details on the materials tested and looked at how the material reacted. This concluded the first phase of the research programme. The research is still ongoing.

By Darren Clark

Contracts

Sweden - Bjorn Eklund explained the Swedish government policy for contracting out road maintenance services, including winter services. There are contracts for 110 areas of Sweden, each contract is performance-based so the government sets the desired outcomes and the contractors devise the appropriate services. There are tight performance criteria that are monitored by 3rd party contractors, and there is an innovative system called 'GDP Analys' so that multiple data platforms can communicate with each to monitor performance and activate remedial works.

Overview of the system in Sweden

Japan – Roberto Tokunaga described a careful experiment undertaken in Japan to assess how human operators take on-the-spot decisions to commence and cease salt spreading. The country needs to develop new solutions as the ageing workforce for winter maintenance reaches retirement and the pipeline of new employees is insufficient. The experiment, which involved live running on a test track as well as questionnaire answers, provided two big insights. First, it turned out that unskilled human operators performed better in the test conditions than the (older) skilled employees. Second, the more information that operators were given, the better their performance at the tasks. The next step is to see whether these insights can lead to greater automation in decisions about salt spreading.

Graham Pendlebury: "This was where the two presentations had synergies. The application of automated winter maintenance systems, incubated in Japan, to the rigorous Swedish contract management approach, should lead to ever-better outcomes for road administrations and their customers."

By Graham Pendlebury

Winter Service Organisation

Netherlands - gave an interesting presentation on winter service delivery in Holland. They have a central national winter team (RWS) of six advisers and nine regional staff. Much like Highways England national winter team they are responsible for salt stocks, research and guidance etc. Netherlands is fairly unique in that 95% of the strategic network is porous asphalt construction (3300km). Traffic levels: 11 million cars and 23 million bicycles are high for a small country. High level of service to maintain roads black at all times based on impact and risk management– have some 1000 snow ploughs to achieve this.

Due to winter requirements of porous asphalt they have developed some special snow and ice clearance equipment. Precautionary treatment routes have a two hour treatment cycle. Snow clearance / reactive treatments have a 1.5 hour treatment cycle. Much like Transport Scotland they actively communicate with the public via their interactive website able to display all spreaders on a map over the last six hours. Public can see road temperatures and cold spots and the roads that are treated.

Website that shows where spreaders are

In terms of maintaining quality and staff knowledge all winter decision makers have to have a mandatory diploma (five day course provided in-house). Spreader drivers are mandated to attend and pass a one day course. All the following is delivered in-house in order to minimise risk -: depots, salt; spreading equipment; decision making, and policy, research, guidance. RWS use calcium chloride brine to combat polished/compacted ice which can form on porous asphalt surfaces. Now starting to use heated salt brine to cut through ice with Lavastorm vehicles (specialist kit).

By David Batchelor

Traffic characteristics in winter time

Mrs **Aleksandra Romanowska** of Gdansk University talked about the impact of adverse winter weather conditions on traffic flow. Her data basically showed what one would intuitively guess – that traffic speed and traffic flow are affected adversely by bad weather, especially during peak hours.

Dr **Jacek Oskarbski**, also of Gdansk University, talked about the impact of adverse weather in urban areas. His data showed that traffic was slower during snow episodes, but traffic speeds were not impacted by rainfall.

By Graham Pendlebury

Extreme Weather Conditions

Germany - Standards for de-icing salt storage capacities. This is as a follow on from previous papers submitted in Andorra in 2014 and a 2nd paper in 2016. It created an excel based model for salt requirements per region. It was based on a standard requirement and used data from anything up to 100 years.

Japan - Study on an index for assessing the severity of snowstorm and heavy snowfall. Looking at serious disasters caused by snowstorms. The aim was to look at the relationship between closure of the national highways and meteorological values with the aim of formulating a set of indexes for the severity of snow and associated road closures. The project collected a number of datasets from over 20 -35 winter periods from 183 spots in their automated metrological data system. They then looked at an snow event with snow fall foe 3 hours which exceeded 200kg/m or a heavy snow event where snow depth over 3 hours exceeded 10cm. It identified 164,811 snow events and 45071 heavy snow events. It then ascertained how many road closures occurred (1825). It presented some results from this data and noted closures increased as snow fall increased, specifically at 250kg/m/h and over. It identified that there was a direct relationship between reduction in visibility, and the formation of snowdrifts. Road closures were more noticeable at snow depths of 75cm or over. It suggested that the increase in snow depth affected the snow clearance activities as there was insufficient space to put removed snow directly impacting on the road surface availability. It also looked at the minimum air temperatures which influenced road closures and lower temperatures tended to cause more closures Wind after 9m.s the proportion of events with road closures increased significantly with nearly 50% resulted in closures of 19ms/ or higher. It finally went on to detail the impacts from heavy snow fall events.

Japan - Effects on countermeasures against heavy snowfall disaster on road traffic. Provides a brief overview of Japan and the region. It was looking to validate the measures on the roads in winter in Japan. This included a review of the measures and evaluation of the methods, and then confirming the efficiency of the measures in snow.

It looked at the measures for roads such as snow removal, minimising snowslide, chain attachment areas, disaster countermeasures, such as stranded vehicle removal, snow removal using a stop and go plan, working with stakeholders, and creating a greater awareness. It looked in a fair amount of detail at the economic effect from snow removal and how it calculated economic losses.

It then looked at a case study (Fukushima snowfall disaster 2014) to confirm the efficiency of the measures. Such as confirming the economic losses, looking at the responses – based on early road closures, and efficiency of concentrated snow removal - it found that by early intervention they could shorten the subsequent traffic delays and therefore reduce economic losses. That it was important to verify the economic effects from actual events.

By Darren Clark

Equipment Management support systems – snow removal

France - Control of spreading machines - This presentation was around de and anti-icing, and various dynamic tests. It was looking at the accuracy of the spread rate of 10g, with the aim of been able to go down to 5g with the increase in the use of liquid treatments. In 1999 the French created a set of standards for the control of vehicles CEN-TC337. The presentation then gave some background to the standard and EN15597-1 & 2 and detailed the various dynamic testing approaches that used to look at the spread rates

Finland - Mobile snow melting machine. This presentation was around an innovative solution around snow removal. Due to the high density within the city (Helsinki) places to store snow was diminishing, so they were looking at using a melting device. Looking to answer questions such as: was it suitable for an urban environment? What the total cost was? What were the environmental impacts? Could it be used to replace transport in some situations?

It also detailed how the equipment worked and provided and impact assessment, and cost analysis of melting the snow compared to transporting it. The project identified problems with locations for the equipment, and logistics to get the snow to it. This also raised issues such as emission levels from using different fuels, the capacity of the machine in certain weather conditions, and how to buy or lease the machine. It has identified that it still needs to further develop its snow management plan.

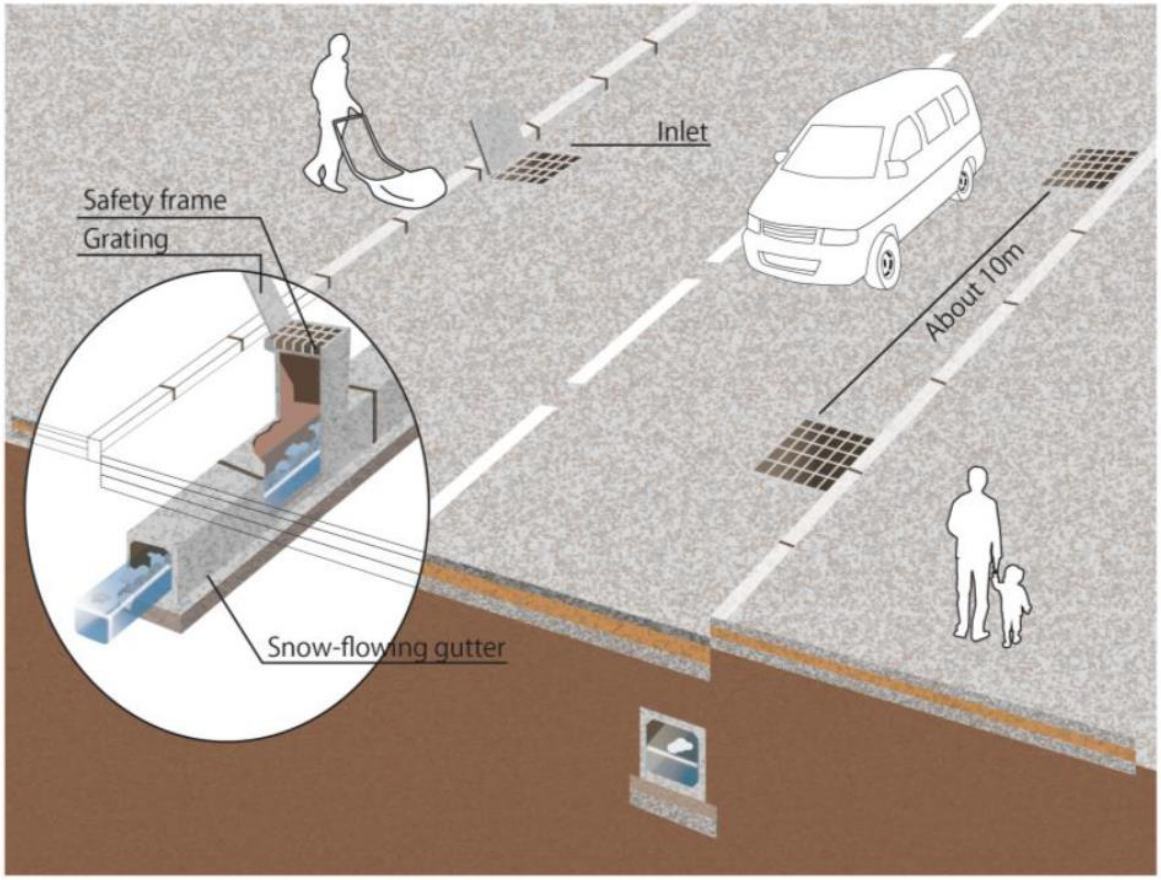
Melting water is conveyed to a sewer.

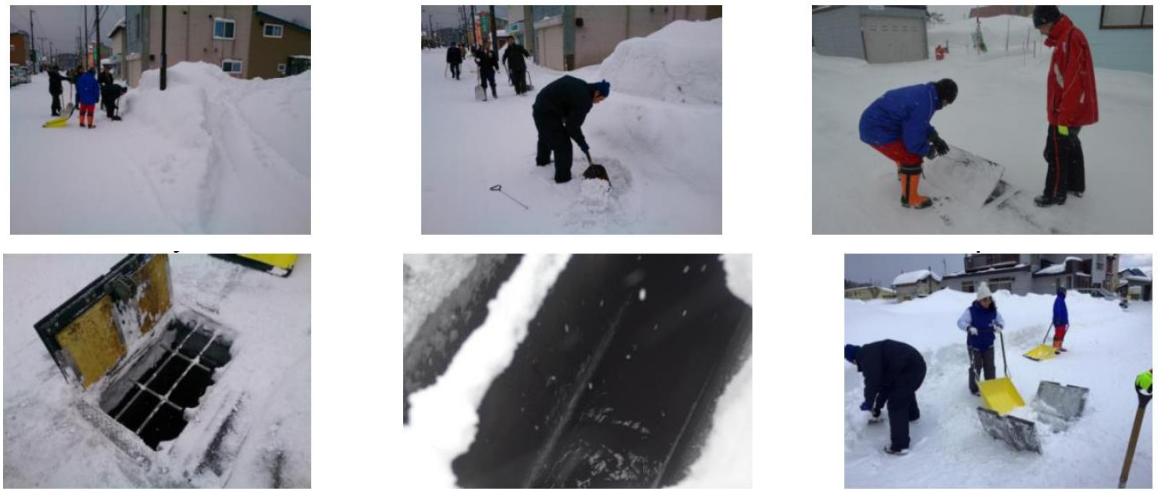
Japan - Failure of snow removal machines - This presentation was around the reliability of their snow clearance machines and degradation of the condition and their reliability. This involved the collection of data and looked at how a reduction in budgets over recent years contributed to the breakdown and failure. The task consisted of the collection of various data on types of defects. It identified the key component failures relating to the different types of equipment. The task identified the breakdown rate was around 180-190k km, and that overhaul should be around 90k km – 140k km. it found also that using a calculation of age, operational hours, or travel distance as a useful tool.

By Darren Clark

Winter resilience and sustainability

Japan - Mr Konishii Nobuyoshi of Japan talked about “snow flowing gutters in an ageing community”. This seemed fascinating, and appeared to be about the disposal of snow into gutters which have warm water pipes causing the snow to melt rapidly and flow away safely.





Structure of snow-flowing gutters – a sidewalk is blocked with snow, the inlet is located, the inlet cover is opened, the snow is deposited within it: the footpath was cleared.

Japan - Mr Takeshi Ikeda, Director of Road Planning for the Hokkaido Regional Development Bureau (Japan) talked about new ways of communicating with residents for safe traffic. The example he gave was a key strategic route in northern Hokkaido which connects an economically important town (Soya, I

think) to the rest of the island. The road is single carriageway and carries a wide variety of traffic, from agricultural vehicles to heavy lorries, and is prone to delays caused by adverse weather, slow moving vehicles etc. Major infrastructure upgrades are not feasible due to cost, so the local highway authority developed "collaborative infrastructure management", whereby a committee was formed involving local stakeholders such as local residents, businesses, emergency services providers, technical experts and so forth. The committee was tasked with deciding the requirements for improving the road (including target-setting), and identifying possible innovative solutions. They were given information about costs, budgets, technical possibilities etc. The committee identified specific problems with the road, then came up with ideas. Three examples given were:

- Problem – being stuck behind slow moving vehicles. Solution – overtaking lay-bys every 3 minutes on the road
- Problem – sudden snowfall trapping vehicles. Solution – covered "parking shelters" at points along the road, where vehicles could be safeguarded until the road is cleared. The shelters even have emergency supplies for vehicle occupants.
- Problem – high winds causing drifting snow. Solution – create snow breaks by planting certain types of trees along the road that prevent snow drifting onto the road and are also environmentally harmonious.

The approach of collaborative infrastructure management was very successful. It resulted in "user-focused improvements" with a high level of stakeholder satisfaction and a sense that "the road, including its administration, has become closer to the community". It also gave people a better awareness of what is possible and affordable, therefore more willing to consider innovative and relatively low cost solutions. The technique seems particularly applicable to strategically significant roads in deep rural areas.

France - Finally, Mr Charles-Edouard Tolmer talked about using information and modelling to improve winter service reliability. The starting point is BIM methodology, which needs to be built into the design and construction of new road infrastructure. The key is to identify possible risks, and plan ahead. This can involve 3D modelling, including visualisation of possible snow and rain conditions i.e. what would the planned road look like in those conditions. These techniques are also relevant when planning for future autonomous vehicle infrastructure, which needs to be "active" so that it captures, processes and transmits data about road conditions to the AVs, for example where "black ice" may be forming that the AV's sensors won't detect.

By Graham Pendlebury

Avalanches

Summary:

- To protect roads from avalanches is important for keeping roads open safely.
- We had three presentations in this session; two from Japan and one from France.
- Whilst avalanches are not applicable to our roads in the UK; the similar principles with landslides made the topic relevant.

Japan - Study on cost-benefit analysis for road avalanche defense structures. First there was a presentation on a cost-benefit analysis on avalanche defence facilities in Japan. They are engaged in research on avalanche and blowing-snow control measures and trends of winter climate conditions. However; for avalanche defence facilities, only few studies had been conducted. The study presented here appeared to be complicated but the concept may be useful for future studies.

Japan - A perspective on evaluating avalanches caused by a non-persistent weak layer during snowfall. This presentation illustrated how snow properties change after snow falls on the surface. The research involves prevention technology related to natural disasters such as snow avalanches and atmospheric icing. This study isn't for practical use but such studies may be important to predict avalanche risks.

France Avalanche risk management on the road. This was an interesting presentation and we learned a lot of countermeasures and activities that are conducted on the border tunnel between Spain and France.

Whilst avalanches are not common occurrences in the UK there are best practices that can be shared such as disruption risk management and communication. There is a four hour diversion route if the tunnel is closed and they have experienced 6 days of closures from avalanches. March is the highest month of occurrence when the snow melting risk increases. Some key points:

- Good mapping of the mountain is critical to understand the geographical challenges and to record data for historical use and monitoring purposes.
- Communication is paramount to inform road users of any disruption/closure. This is achieved via web-sites, social media and the radio.
- Monitor conditions they have two weather stations and take weekly samples from the hillside.
- Controlled avalanches are triggered as a proactive mitigation measure.

By Martin Thomson

Snow Fences and Mobile Barriers

UK – John Bullas presented his ideas around measuring residual salt at traffic speed. His proposal centred on using a salt marker or tag that could be measured via a fluorescence measuring technique. With over £7.5 million of salt being spread on Highways England's roads during an average winter there is significant scope to reduce salt usage and to better target top-up treatments. Residual salt is an area that is of significant importance to UK winter service managers and forms a key research area for NWSRG that will be taken forward in the next research phase.

By David Batchelor

Exhibition Stand Presentation: Japan Roads Association

Presented the satellite controlled snow blower – highly accurate and able to work to close tolerances to avoid street furniture and roadside technology.

Intelligent Salting Control Optimisation System (ISCOS) – delivered a 10% reduction in salt use. Also presented the automatic salting control systems this integrated artificial intelligence utilising data and inputs from weather observations / forecasts, traffic flow, road surface construction and surface state, operational data. This system can support winter decision making / semi-automated process and the handing down of skills, knowledge and expertise – a challenge for a large number of countries at the Congress.

By David Batchelor

The Japanese Pavilion in the Exhibition Area of the Congress

Other key observations from Martin Thomson:

- Nippo Corporation in Japan produce rubber rolled asphalt which has a frozen controlling effect with durability.

- Plough spreader with brush is of interest to Transport Scotland; particular for the Forth Road Bridge due to high expansion joints not allowing back to black ploughing. Following on from Gdansk, a meeting was held with Schmidt at Stansted Airport to view similar fleet and to discuss custom made fleet.

- Schmidt Lavastorm used in Holland and displayed outside the Amber arena is also of interest to Transport Scotland; particularly on inclines during high ice risk / snow events.

- Hilltip spreaders mounted on 4x4 pick-ups to mitigate accessibility issues we have experienced in recent years. Following on from Gdansk, Transport Scotland are trialling on the M80 for the 2018/19 winter season.

- Cold Comfort Scotland was held on 26 April this year and prior to the event a meeting was set-up with Sommer to discuss the inclusion of their IDS-20 ice detection system within our winter service on-road testing facility.
- Bucher's electric powered spreader is an interesting innovation; particularly with government environmental and sustainability targets. However; it is only the de-mount that is electric powered and not the actual truck. Transport Scotland are trialling the spreader as a patrol vehicle on the M8 through Glasgow for the 2018/19 winter season.

References and contacts

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