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Ice Control with Brine on Highways
Implementation of Brine Spreading Technologies in former County of Funen, Denmark

Lars Bolet, Aalborg University
July 11th 2008
<table>
<thead>
<tr>
<th>Feature</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>County of Funen</td>
<td></td>
</tr>
<tr>
<td>Inhabitants (2006)</td>
<td>478,347</td>
</tr>
<tr>
<td>Area</td>
<td>3,486 km²</td>
</tr>
<tr>
<td>National highways</td>
<td>135 km</td>
</tr>
<tr>
<td>County highways</td>
<td>1,011 km</td>
</tr>
<tr>
<td>Local roads</td>
<td>5,684 km</td>
</tr>
<tr>
<td>Municipalities</td>
<td>32</td>
</tr>
</tbody>
</table>

- Closed down January 1st 2007
- 273 km
- 6,563 km
Studies 1998-99 – South-Eastern Funen

- A significant higher percentage of the salt spread as brine are still present 2-10 hours after spreading compared to pre-wetted salt.
- After 2 hours 85-90 % of the brine and 60-65 % of the pre-wetted salt remains.
- Brine seems to be spread more uniformly.
- 1,800 measurements.

Residual salt 2 hours after spreading:
- 7.6 g NaCl per m² as pre-wetted salt
- 4.6 g NaCl per m² as brine

Average of 43 measurements of sections.
Studies 2000-02 – Motorway E20

- In hoar frost situations no difference found in the winter road maintenance between lanes with traffic towards East and West.
- Overdosing by the pre-wetting spreader in the fast lane is more expedient in snow situations than the uniform distribution by the brine spreader ... overdosing was a fault, but a good fault.

7.7 g NaCl per m² as pre-wetted salt ➔ 5.2 g NaCl per m² as brine
SOBO20-measurements in 5 cross sections, 2 m apart, every 0.5 m.

- 7.7 g NaCl per m²
- Nido: Plate rotating clockwise
- Epoke: Plate rotating counter clockwise
- 5.6 g NaCl per m²
- Falkøbing: Plate rotating clockwise
Measurements 2004 – II

- Average of salt measured on left and right lane, and outside lanes.
- Assuming the lane with the less salt (here right lane) have had just enough …
- … 30 % of the salt measured are of use on the road
- … 61 % of the salt are over-dosed (wasted) in left lane due to imbalance
- … 9 % of the salt are wasted outside the target

Epoke SW3501 (measurement # 8)
- pre-wetted salt
- NaCl: 7.7 g per m²
- Width: 6 m
- Velocity: 60 km/h
Measurements 2004 – III

- Waste of salt due to imbalance and due to spreading outside target
  - … for all measurements with the gritter considered
  - Imbalance:
    - Average: 48 %
    - Standard deviation: 26 %
  - Outside target:
    - Average: 10 %
    - Standard deviation: 4 %

Epoke SW3501 (all measurements)
- pre-wetted salt
- NaCl: 3.8 – 11.7 g per m²
- Width: 3 - 7 m
- Velocity: 60 km/h

Graph showing the distribution of imbalance and outside target values.
Measurements 2004 – IV

- Standard deviation of wasted salt due to imbalance and due to spreading outside target
- Comparing all gritters shows a wide range of variation
- Assuming calibration can be improved, the “best” type of gritters is the one having the smallest standard deviations
- New gritters bought, proves to fulfil this challenge
Brine mixing plants

> Attractive to concentrate production of brine on two plants instead of seven surveillance centres due to
  > High average age of employees
  > Low unemployment rate
  > Legislations of resting time (health and safety acts)

> The two plants had adequate mixing and storage capacity to meet the demands of the entire county highways

Each plant:
  > Mixing tank: 280 m³
  > Storage tank: 700 m³
  > Strong propeller to prevent stratification
  > 2 pumps, each: 55 m³/h
  > Price: 0,35 M€
New brine spreaders, 2005

> Tank volume 14 m³ - control proved 13.98 m³ could be used
> Excellent spreading across the road
> Data collection excellent (± 3%)
> Nozzles is optimized to spread a continuous thick jet
  – the jet must be faster than the speed of the wind along the vehicle
  – calibration can simply be verified
> With GPS the dosage can be raised:
  – on the high level on the middle
  – in curves on the high level
  – on lanes and other places with less traffic.
## Costs – example

<table>
<thead>
<tr>
<th></th>
<th>Brine</th>
<th>Pre-wetted salt</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Length: 1011 km. Width: 7,20 meter</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technology</td>
<td>Nozzles</td>
<td>Rotating plate</td>
</tr>
<tr>
<td>Cost price per spreader (11 spreaders)</td>
<td>39,000 €</td>
<td>27,000 €</td>
</tr>
<tr>
<td>Salt-/brine-volume</td>
<td>14 m³</td>
<td>5 + 2 m³</td>
</tr>
<tr>
<td>Effectively volume</td>
<td>97 %</td>
<td>90 %</td>
</tr>
<tr>
<td>Residual salt on road after 2 hours</td>
<td><strong>90 %</strong></td>
<td><strong>65 %</strong></td>
</tr>
<tr>
<td>Waste due to unbalance in spreading</td>
<td>5 %</td>
<td>25 %</td>
</tr>
<tr>
<td>Dry salt in a “normal” year</td>
<td>-</td>
<td>4,500 tonnes</td>
</tr>
<tr>
<td>Brine (24%) in a “normal” year</td>
<td>12,500 m³</td>
<td>1,900 m³</td>
</tr>
<tr>
<td>Price (salt + brine) in a “normal” year</td>
<td>173,000 €</td>
<td>266,000 €</td>
</tr>
<tr>
<td>Interest (5%); writing off (10 years); repair</td>
<td>75,000 €</td>
<td>59,000 €</td>
</tr>
<tr>
<td>Annual expenses</td>
<td>248,000 €</td>
<td>325,000 €</td>
</tr>
<tr>
<td>Annual expenses per kilometre</td>
<td>246 €</td>
<td>322 €</td>
</tr>
<tr>
<td>Waste of NaCl per km in a “normal” year</td>
<td><strong>1,6 tonnes (13%)</strong></td>
<td><strong>3,4 tonnes (54%)</strong></td>
</tr>
</tbody>
</table>
Implementation

- Two brine mixing plants replacing seven salt barns means new logistics – routes have to be redesigned and optimized ✔
- Introducing GPS-technology requires data on all roads in order to set-up the spreading programmes ✔
- The GPS-technology makes it possible for the drivers (contractors) to concentrate on driving – but they have to be very thoroughly instructed to follow the routes planned 🌌
- Own staff were involved in the development-process and in establishing the quality-management system applied – and were thus committed to the new procedures ✔
- New technology means new challenges to the mechanics and they have to be trained ✔
- Presence of several technologies makes it necessary for the mechanics to specialise – making the garage vulnerable 🌌
Consumption

Brine spread with nozzles made it possible for the County of Funen to use less than half the amount of salt per square-metre compared to the neighbour counties, none of whom used this brine spreading technologies.

Source: www.vintertrafik.dk
### Traffic Safety

<table>
<thead>
<tr>
<th></th>
<th>Pre-wetted salt</th>
<th>Brine</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Length</strong></td>
<td>438,819 m</td>
<td>604,053 m</td>
</tr>
<tr>
<td><strong>Average width</strong></td>
<td>7.24 m</td>
<td>7.22 m</td>
</tr>
<tr>
<td><strong>Accidents, slippery</strong></td>
<td>40</td>
<td>48</td>
</tr>
<tr>
<td><strong>Accident-rate per year</strong></td>
<td>0.09 per km</td>
<td>0.08 per km</td>
</tr>
</tbody>
</table>

Accidents reported during winter-seasons by the police, where road condition were reported to be slippery.

Questions not yet addressed:
- Are the two road-networks truly comparable:
  - rural vs. urban roads?
  - intensity of traffic?
- What is the accident-frequencies?
- What is the level on injuries?
Experiences

> Political interest and good-will towards the project was easily gained, but you have to put efforts in keeping politicians as well as the public well-informed.

> The project proved to be good to involve all the staff in taking responsibility in and pride of the overall goal and the activities, and thus to provide acceptance to organizational adjustments.

> Measurements collected mainly for practical engineering decisions do not have to be easily compiled in a scientific way ; - )
Conclusions

> Brine can substitute pre-wetted salt in all situations, is not so likely to blow of the road surface, and can be spread more precisely … the amount of salt can be reduced by more than 1/3
> Accident-rate with slippery roads seems not to be higher when using brine
> Good design of spreaders and the use of GPS-controlled brine spreading makes it possible to optimize route-planning, at thus improve day-to-day economy
> Investments in mixing plants should be made in order to guarantee the quality of the brine and to improve day-to-day economy; out-phasing of salt-barns and surveillance centres may be possible
Thank you for your attention.

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