ANALYSIS OF A PARTICULAR OBSERVED ACCIDENTOLOGY ON DRY AND SALTED PAVEMENT

J. Livet
Ministère de l'écologie, de l'énergie, du développement durable et de la mer - CETE de l'Est
jean.livet@wanadoo.fr
&
S. Poissonnier
Ministère de l'écologie, de l'énergie, du développement durable et de la mer - CETE de l'Est
stephanie.poissonnier@developpement-durable.gouv.fr
&
A.Bazile
Ministère de l'écologie, de l'énergie, du développement durable et de la mer - CETE Méditerranée
alice.bazile@développement-durable.gouv.fr

ABSTRACT

During the past six winters, several services have been confronted with a particular accidentology winter on salted roads receiving repeated. Various investigations in situ and laboratory tests were carried out by the Scientific and Technical Department of the ministry (RST) with the support of operation services in order to identify the physico-chemical mechanisms leading to changes in adhesion observed and contextual factors favorable to their emergence. These changes in adhesion are observed on routes winding, located especially in mountainous areas with an alternation of wet and dry surfaces related to sun differential exposure. These phenomena occur when air temperatures and surface coating are well below 0℃ for long hours. They affect part icularly the treads and the top of the aggregates in the drylands of the pavements, generally succeeding in a wetland. They are accompanied by a crystal dome shape, and sometimes salt dust coating giving the impression of "talcage" surface. In some cases, it is reported in a filing rolling wetlands. Accidents are with come off the road in areas of cross solicitation. Various laboratory investigations have been undertaken to analyze:

- the impact on the adhesion of the coatings of the change in viscosity of the brine depending on its mass title.
- the gradient of temperature and humidity in the layer of air near the surface of the road
- the possible appearance of dihydrate sodium that would produce a deposit on the gel surface
- the transport phenomena of deicers by the traffic between wet and dry areas; transport becomes palpable and measurable when treatments are important in both assays that the frequency
- variation of adhesion induced by the appearance of dust in large quantities NaCl behaving like talc

These investigations have been completed on the ground by:

- raising the thermal footprint of the routes affected
- the implementation of various technologies to improve the operational supervision by the operators of the road

From these findings, and the various investigations reported, several operational measures are proposed. They focus on the specific methods of network monitoring winter, and on strategies and guidelines of treatment when weather road situations called “at risk” are identified.

MOTS CLÉS

ADHESION / DRY AND SALTED PAVEMENT / VISCOSITY / DIHYDRATE SODIUM / TRANSPORT OF DEICERS

1. THE STATEMENT

From the various meetings with operational services, memories, observations, actions and statements made in situ during the last four winters, the winter services of CETE has taken the very general following statements:
The changes in adhesion are generally observed in dry and salty pavements and on winding routes, located especially in mountainous areas (Alps, Massif Central, Vosges), with alternating dry and wet areas associated with a sun differential exposure.
These phenomena are observed when the air temperature (Ta) and the surface temperature (Ts) of the coating are well below 0℃ for long hours (even severals days).These adhesion variations appear in response to repeated application of deicers while it remains on the surface of the coating. They seem to particularly affect treads and the top of the aggregates in the drylands of the routes, generally succeeding in a wetland.
They seem to be accompanied by a formation of crystalline domes, dust and sometimes conferring salt then coating an impression of "talcage" of its surface. In some cases, there are reports of presence of a deposit gelled in wetlands.
Accidents, generally accompanied by an off route, is observed in areas of cross solicitation. These phenomena disappear by simply washing the surface or by treatment with NaCl brine. It is also noted that the speed's car is often excessive in light of the weather conditions encountered which makes the analysis of the phenomenon not easy. Various investigations in situ and laboratory tests were conducted with the support of operating services to identify precisely, on the one hand, the physico-chemical mechanisms leading to changes in adhesion observed, and secondly, the contextual elements favorable to their emergence.

Photo 1 Alternance of dry and wet zone

2. THE VARIOUS POSSIBILITIES EXPLORED

After a quick bibliography [1] [2] [3] and investigations nearby the international community (Quebec / Denmark), several investigations have been conducted to characterize and quantify the factors likely to support one or more scenarios of emergence of the phenomenon of change of adhesion.

The first investigation [4] in the framework of normative work for the project Prof. NF P 98-

181, focuses on the study of the variation of adhesion of coatings, induced by the presence of a deicer in liquid form applied to preventive. It shows that there is a close relationship between the viscosity of the deicer and road adhesion, even though the viscosity increases with the increase of mass as the aqueous solution and lowering its temperature.

The second investigation [5] was conducted in the framework of predictive modeling of surface. The study of the gradient of temperature and humidity to the vertical surface of a floor show that, during the night with clear sky or overcast, the air film in contact with the coating has a water vapor content higher to that observed in 1.50 m[1], providing a potential or frost formation or dilution of the brine on the surface.

The third investigation [6] tries to analyze the result in terms of adherence to a probable formation of dihydrate sodium ($NaCl\text{-}2H_20$), which, according to the only existing literature on the subject [2], lead to the emergence of a deposit gel surface coating. This study does not confirm the appearance of the freeze, however, to show the existence of a significant reduction in the coefficient of friction SRT[2] the one hand, in the presence of an important mix in melting recrystallized (peeling of the microtexture by NaCl) and on the other hand, when applying brine on a dry surface and highly saline (viscosification contact pad / floor).

The hypothesis advanced by [7] at the end of winter 2004/2005 led to refocus the investigation. It consists, in a simplified way to consider that there is a transport phenomenon of deicers by the traffic between wet and dry surfaces, transportation becomes palpable and measurable when the treatments are significant in both amounts and frequency .
The physical mechanism is that tires that are naturally contaminated with deicers in the form of fine crystals of NaCl on dry pavement with a salt (which gives a white at the periphery of the tire), are responsible for saturated brine to pass through areas remained wet. Arriving at the road remained dry brine supersaturated by fine crystals then gradually settles on top of aggregates where it is recrystallized without significant gravity flow forming crystalline domes (if the relative humidity is below 75%). The micro-mist of the supersaturated brine at the rear of the tire also leads to the formation of micro-particles of NaCl in the form of a white dust of NaCl (talcage phenomenon).

The fourth investigation [11] was to analyze with the SRT pendulum, the changes of adhesion of a surface road salted or not contaminated with NaCl powder or talc. It confirmed that these types of contaminants caused a significant reduction of adhesion surfaces tested, thus validating the statements gathered from the services.

The fifth investigation [12] was to let on the side the laboratory investigations to invest in real winter conditions, in a weather road situation "extreme" known as risk, and get a heat fingerprint using the vehicle (called Thermoroute) on a considered winding route to be exposed.
The detailed study of measurements has shown:

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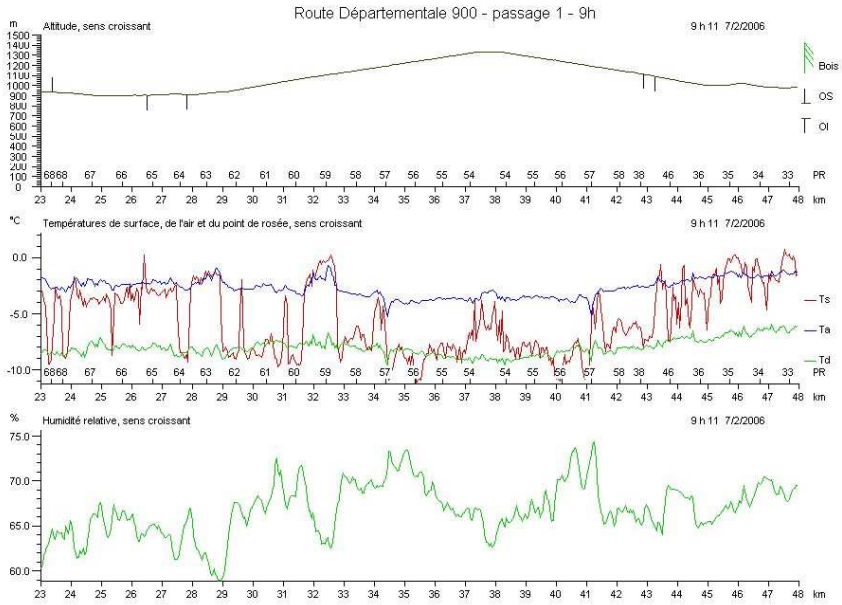
1 Measure under cover as standardized by Météo France

2 NF EN 14231, Methods of test for natural stones - Determination of resistance to skid through pendulum friction.

- the existence of a significant and permanent change of status dry / wet of the pavement surface due to the sinuosity of the route, which would facilitate the transport of deicers,
- variations in surface temperature over 10℃ in a few tens of meters corresponding largely to alternating dry / wet – exposed / not exposed to sun,
- the average surface temperatures close to -10℃ over the entire route examined, with extremes of up to -15℃ locally wetland. All was observed with ambient air temperatures neighboring -3℃ to -4℃. Today they are the biggest differences Ta - Ts identified by this technique,
- a significant proportion of the linear network with Ts<TD[3], which means a high probability of condensing solid (white frost in these areas), partially observed by the operator,
- low relative humidity between 60% and 75% (average 68%), ... favorable for drying natural brine NaCl,
- that during the day, less than 20% of length of the route has a surface temperature greater than Ta, the route is generally to a surface temperature of 5℃ less than Ta. This is attested by the orientation of the route to fully located at the north-facing side.



Graphique 1 Thermo-hygrometric footprint of the network (9:11 - on 7/02/2006)

These results should lead to question the merits of road salting to a surface temperature of -15℃ (under the theoretical title mass of the brine to maintain, in this case 18.7%) even though the maximum relative humidity is about 75% and we are obviously in a state of natural drying of the brine.

3. WHAT WINTER OPERATING MEASURES TO REDUCE THESE RISKS?

Of all statements richly informed by operational services, and various investigations reported briefly above, it is apparent that various operational measures can be taken now,

[3] Dew point temperature

while referring to the existing technical corpus and consisting of technical documents and methodological guides[4] dealing with both the operation and proper use of deicers. These documents make it possible to understand, first, the mechanisms of drying / dehydration of brine according to the humidity of ambient air and surface temperatures of the road, on the other hand, mechanisms of freezing brine according to the title of its mass and temperature.

3.1. Define the periods and places of exposure

- Identify routes winding, while the winter time, have no sunshine (Ubac the pavement) or have partial sunshine alternated.
- Identify these winter sequences where roads will, for several nights, put in to radiate and cool significantly (completely clear night sky, no fog or low stratus, low relative humidity) without its they do not have the energy daylight.

3.1. Define few simple operational rules where salting becomes unnecessary and even harmful

- Once the roads have been salted previously and regularely, and after ascertaining that there was no leaching located, do not the salt dry and humid during anticyclonic situations of longer than 3 days (clear sky with high impact night) where the nighttime temperature of the air is less than -8℃ and relative humidity below 75%.
- If we have instruments for measuring surface temperature, this decision may be based on this setting, more relevant than the air temperature, and is set at -10℃.
- If one has an instrument to measure the residual salinity (as Sobo 20), we consider that any salt, under the conditions mentioned above shall be deemed to be unnecessary as the residual amount is measured between 10 and 20g/m^2 (any observed value would correspond to a higher salting excessive harmful to the environment and road safety). Indeed this range, with a maximum amount of water between 25 and 100g/m^2, as observed on a traditional road circulated, naturally leads to a mass close to the maximum to protect the roadway -21 °C.

3.2. Complementary accompanying measures

Given the driving practices of some of the users who appear to have been observed locally, it should enhance the information to the user. This can be obtained as follows:

- Establishment of panels with AK4 pannel and m9 signed "frequently ice" in the most dangerous or deemed as such,
- Local improvement of the management of runoff from the road platform in order to avoid unintended movement (ditches, cross profile, management of cord snow, etc..).

[4] Pedagogical guides "saler moins – saler mieux" / "Verglas - mode d'emploi",
Briefing notes SETRA No. 53, 64, 66, 67, 72, 81, 122;
Dictionary of Road Maintenance, Volume 4 Winter

4. NEXT INVESTIGATIONS

During the winter of 2007/2008 it was decided to treat the pavement by the technique of replacing wetted salt brine of sodium chloride with calcium chloride brine on the assumption that this technique would:

- temporally homogenize wetting of the surface of the road given the hygroscopic nature of this deicer, thus limiting the transport phenomena of traffic
- To lower the freezing temperature of the brine present in the coating, thus protecting it from any decreasing of the extremes freezing temperature

The two winters 2007/2008 and 2008/2009 have not permit to validate this strategy in view of the sweet and snowy characters of those winters where there were no extreme temperatures and the frequent falls of snow have leached the pavements.
Whatever the measures taken by the authorities should remain vigilant in ensuring the traceability of actions undertaken by each in order to protect themselves from possible legal action.

5. THE NEED TO STRENGTHEN THE TECHNICAL COMPETENCE OF ALL ACTORS WINTER SERVICE

The phenomena described above show that the non-reflective use of sodium chloride as deicer may cause complex mechanisms, whose understanding and mastering increasingly require skills in the field of physical chemistry .
In the collective unconscious of users, and some managers, the sodium chloride is, or was seen as the panacea to the problems of adhesion winter. The nature and science come to remind us a little more humility.

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