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Deicing Salt — Its Use and Effect on Road Safety and the Living Conditions of Roadside Trees and Shrubs

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ABSTRACT

Deicing salt is used to avoid ice or snow on road surfaces and to facilitate snow clearing. For ecological and economical reasons wet salt should always be used; dry salt represents an adequate alternative only in very few circumstances and even then wet salt can be used without any disadvantages. As short a time as possible should elapse between ice formation and salt spreading. This can be accomplished by improving the regional meteorological service and by routing optimization. In the interests of safety, common economic and traffic regions, e.g. the EC-member countries, demand identical levels of service as far as winter service is concerned.

Investigations conducted by Darmstadt Technical University have shown that the accident rate after spreading deicing salt falls to approximately one-third of the values recorded before road clearance commenced. In the Federal Republic of Germany (without the five new states) during one winter period some 1,000 deaths or serious injuries, approximately 1,500 slight injuries and some 6,000 accidents with material damage could be avoided within one hour after deicing salt being used outside built-up areas (excluding motorways). The theoretical assumption that motorists drive considerably slower on slippery roads, thus obviating the need for deicing salt, is not verified; evidence shows that speeds are reduced, but not to the extent required to compensate the lower friction coefficient. The accident figures increase substantially in cases where deicing salt is not being used. The number of injuries suffered by pedestrians has increased considerably in areas where deicing salt is not permitted on footpaths.

Long-term ecological investigations at Giessen University, have revealed that no systematic damage to roadside shrubs outside built-up areas can be determined. Only on motorways the larger amounts of salt spread give rise to individual cases of salt induced damage to plants at a distance of up to approximately 10 m from the edges. These almost exclusively involve contact damage which does not lead to an accumulation of chloride in the plant. The occurrence of such cases can be reduced to an acceptable level by an appropriate choice of plants and locations, suitable plant care, structural measures and optimization of winter service.

The importance of protecting life and health of persons by deicing salt in conjunction with economic benefits outweighs the negative effects on roadside shrubs that suffer avoidable or reparable damage locally in very few cases.

THE USE OF DEICING SALT

Due to the use of deicing agents in winter services, traffic safety and economy of the traffic flow have been improved considerably. Comparing studies on the effects of dry salt and of wet salt show that considerable savings of salt can be achieved with the use of wet salt, without affecting efficiency. Both wet salt technologies "Wet Salt 5 (FS5)" and "Wet Salt 30 (FS30)" are based on the principle of moisturing, while the latter number indicates how much percentage by weight of liquid are admixed to the salt.

In the case of Wet Salt 5, the salt is sprayed with approximately 5% of water at the time of loading. When it is falling from the conveyor belt to the spreader it can also be sprayed with NaCl or $CaCl_2$ solution. This quantity of liquid is sufficient to create the required adhesive effect which is retained when the salt is spread to the road, later.

In the case of Wet Salt 30, the liquid, exclusively saline solution, is admixed in such a form that the solution is carried along on the spreader vehicle to a tank and is sprayed on the salt at the moment of spreading. For this procedure, approximately 30% by weight of liquid is required in order to immediately achieve a consistency that permits adhesiveness on road surfaces.

The studies executed by the Technical University Darmstadt on behalf of the Federal Ministry for Transport (Durth et al., 1990) show that FS30 is clearly advantageous to FS5. With the use of FS30, salt savings between 24 and 44% are possible; with

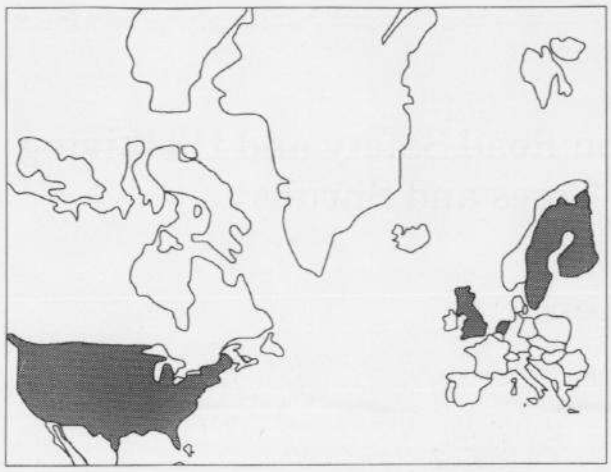

Fig. 1. Countries with links to weather offices (Thornes, 1990).

the use of FS5 savings of 5–20% are possible. Thus, it is recommended that wet salt should become the standard in winter services while the use of dry salt should be an exceptional case. Due to its cost advantage and quick realisation, FS5 can be accepted as an intermediate solution; however, a general adaptation to FS30 should be the long-term target.

To achieve the optimum when using wet salt, the capacity of the alkaline tanks and the length of the routes must be maintained and the location of the filling stations where salt and alkaline can be loaded must correspond to each other.

The effects of deicing salt are more favourable when the time between the formation of ice on the road and spreading of salt is short. This can be achieved by obtaining reliable information about the road condition and by intensive training of personnel. The customary reliance on radio and television weather forecasts are no longer sufficient for optimum control of the activities of winter maintenance services. Increased cooperation with meteorological stations concerning relative air humidity, temperature, direction and speed of weather front must be a part of winter maintenance service planning. Various European countries have achieved considerable progress in this context over recent years. Figure 1 shows countries with links to weather offices (Thornes, 1990).

Moreover, ice prediction equipment, which is installed in the pavement can be used in conjunction with their warning effects to furnish information to the meteorological stations.

EFFECTS ON TRAFFIC SAFETY

Historically there has been no reliable, generally acceptable information concerning the effectiveness of the use of deicing salt improving traffic safety. Another study, also performed by the Technical University of Darmstadt on behalf of the Federal Ministry for Transport provided quantifiable results (Durth et al., 1988).

Four thousand seven hundred accidents from four winter seasons with 80 fatalities, 573 severely injured persons, 1,321 persons with minor injuries and material damage of approximately 55 million Deutsche Mark have been analysed and evaluated. Moreover, in connection with these examinations 60,000 rates of speed have been measured, 13,000 on winter-icy roads. The study proves that during winter conditions the rates of accidents — that is the number of accidents related to kilometers driven (accidents/1 million Veh · km) — is approximately six times higher then during non-winter conditions. On grades the accident rate during glazed frost conditions rises to 10 times this value compared with normal road conditions. Upon removal by spreading salt, the accident rate decreases to approximately one third to one fourth of the value before deicing salt has been spread to the road.

Another perception is that accidents with severe personal injuries are approximately five times higher on roads with winter glaze than under normal conditions. Thus, the erroneous assumption has been refuted that only the number of minor accidents with property damages increases during ice and snow due to rate of speed. Figure 2 shows the speed distribution on slippery, wet and dry pavement. Since spreading of deicing salt causes a wet pavement, driving speed increases compared with slippery pavement. However, this is, as a result of the higher friction coefficient in the last section of the braking distance, less dangerous (Fig. 3). However, in that last section the danger of collisions caused by insufficient braking distances is in-

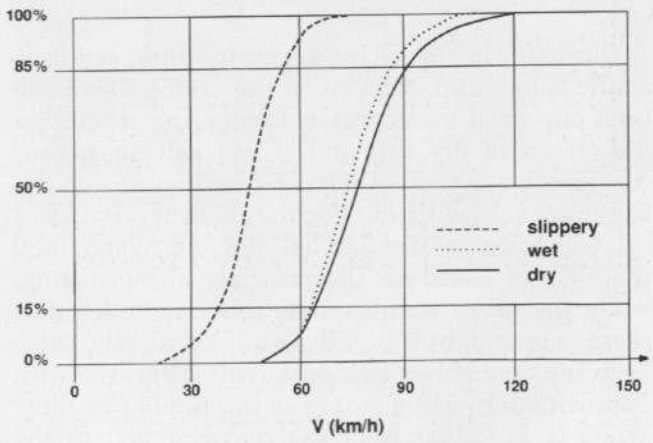

Fig. 2. Speed distribution of slippery, wet and dry pavements.

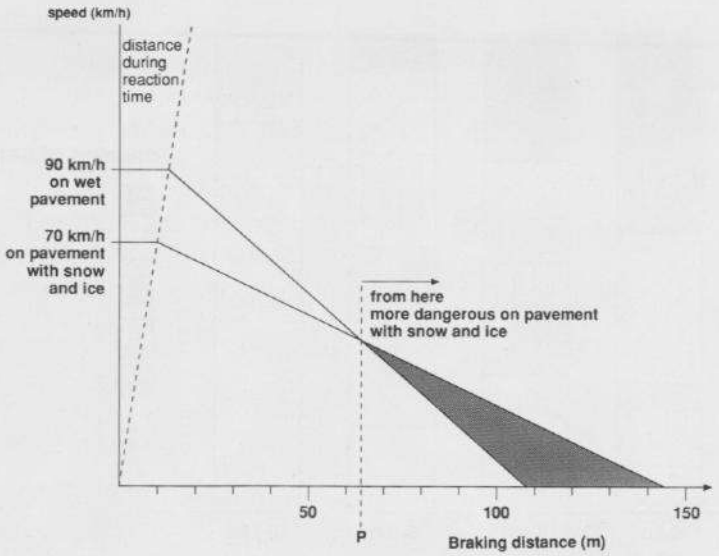

Fig. 3. Slowing-down process on wet pavement and pavement with snow and ice.

creased. The real accident figures are proof of this theoretical assumption.

The rate of accident costs — that is, the costs of accidents related to the kilometers driven (accident cost DM/1 million Veh. km) — on roads with glazed frost is approximately six times higher than during periods without icy conditions.

The projected figures found in the investigated area on all roads outside built-up areas in the former West Germany — Autobahnen excluded — shows that already within the first hour after deicing salt has been sprayed approximately 1000 fatalities or severe injuries, 1500 minor injuries and 6000 accidents with property damage can be avoided.

Furthermore, considerable quantities of gasoline are saved if the roads are cleared and deiced: an important factor for environmental protection.

Safety is the main objective for the use of deicing salt in winter maintenance services. Additional benefits of economic progress and better traffic flow are of secondary importance.

There are indications that at locations where the use of deicing salt has been avoided on walkways, accidents involving pedestrians have increased considerably during glazed frost during recent years. However, there are no statistically based figures, because pedestrian accidents are not registered by the police.

In view of the requirement to create single-market conditions throughout the European Community, interests of safety dictate that border-crossing motor vehicle traffic be provided with road conditions that remain as uniform as practicable even during the winter months. In order to achieve this state of affairs, it would be desirable for all EC member states to participate in the same types of winter maintenance services. A model set of requirement levels for winter services should be prepared. It seems feasible that, for example, 24-hour winter services be recommended for all "European" roads during winter.

INFLUENCE OF DEICING SALT ON LIVING CONDITIONS OF ROAD-SIDE TREES AND SHRUBS

In discussions concerning environmental protection, the use of deicing salt in winter maintenance services has been critically evaluated. The importance of and sensitivity to environmental protection in our society requires serious discussion.

Unfortunately, the discussions about deicing-salt damage to vegetation lack well-founded perceptions. Very often only general arguments concerning the influence of deicing salt on the ecological system have been raised, which might be conclusive only in certain individual cases. The most important findings of the famous doctor and philosopher Paracelsus, "Sola dosis facit venemum", however, has not been taken into consideration. The quantity of the deicing salt has not been discussed, only the fact that snow and ice are fought with salt.

In order to obtain representative results, the Highway Administration of Hessen placed an order in 1985 to the University of Gießen concerning a long-term study of the connections between the use of deicing salt and its influence on the living conditions of road-side trees and shrubs (Steubing et al.,

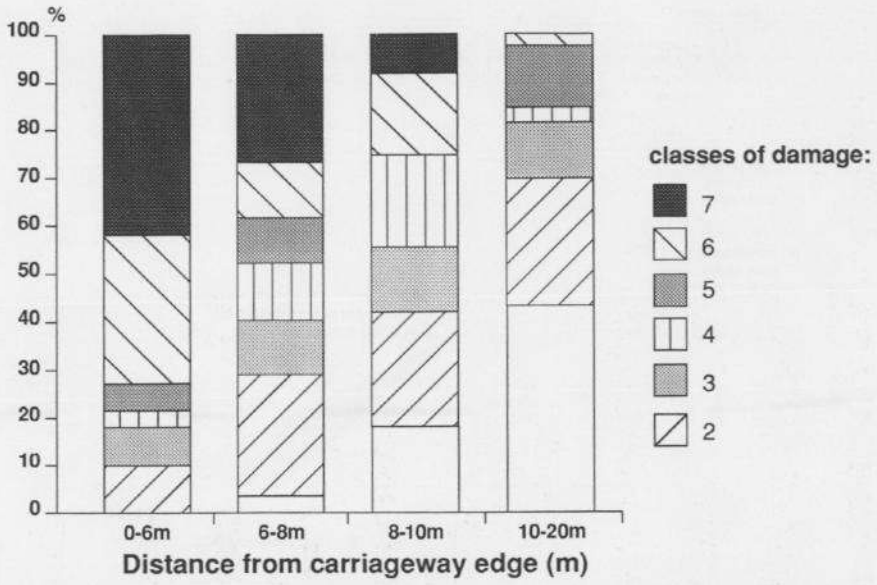

Fig. 4. Percentage portion of stages of damage at different distances from the carriageway edgs, after a winter with a high use of salt.

1988: Giesa and Gumprecht, 1990). The study covered all trees and shrubs outside cities and villages, which are place along federal and state roads up to 10 m distance and along Autobahnen up to 20 m distance from the road edge. It showed that the influence of the salt on plants along federal and state roads was of such minor importance that further studies along these roads could be stopped after 2 years (1985 and 1986) upon request of the Plant Ecological Institute of the University of Gießen. After more than 30 years of winter maintenance service, no systematic damage to the road-side plants could be determined. It goes without saying that even on these roads winter maintenance service authorities respect ecological points of view and make every effort to use as little salt as possible.

Vegetation along autobahnen (federal motorways) shows more damage near the pavement. The results of the long-term study prove that the greatest influence is of the salt-containing mist, which is whirled up by passing vehicles. Clearly, most of the damage is based on such contact with the salt spray. Shrubs up to 6 m from the pavement edge are especially damaged. Approximately 80% of the moderately and severely damaged shrubs can be found at these locations. Figure 4 shows the percentage of individual stages of damage of the examined shrubs at different distances from the pavement edge. It can ben seen that damage decreases with increasing distance from the pavement edge and there is no damage caused by the use of salt in surrounding areas. The chloride concentration shown in Fig. 5 using a pine-grove as an example clearly shows that a Cl-concentration decrease can be registered in the course of the vegetation period over the whole year. It can be asserted that chloride ions are disposed of in the autumnal fall of leaves.

Shrub damage due to salt contamination of the soil was only found in a small scope and was locally limited. This damage is only clearly recognizable during the vegetation period when they are, contrary to contact damage due to the chloride stored in the plant fibres, more durable.

Lasting recovery of damaged shrubs is recognizable after various successive winter seasons with the use of small quantities of deicing salt. However, in no case could it be determined that soil contamination due to salt caused an accumulation of chloride in the vegetable fibres.

The soil examinations show that salt contamination of the soil is low and that it can no longer be found at 2 m distances from the pavement edge. Only in some cases, such as sloping embankments or on separation strips of parking lots on Autobahnen, could contamination due to the deposit of salt-containing snow or the penetration of surface water run-off be proved.

Damage to shrubs can be minimized by choosing plants that are resistant to salt contact. Moreover, new plantings should consider a closed, graduated vegetation pattern, in order to avoid large distribution of the salt spray. Thus, new narrow plantings of shrubs could protect the trees behind. In addition, plant distances from the pavement should be large, wherever possible: the greater the distance from the edge of the road, the less danger to plants.

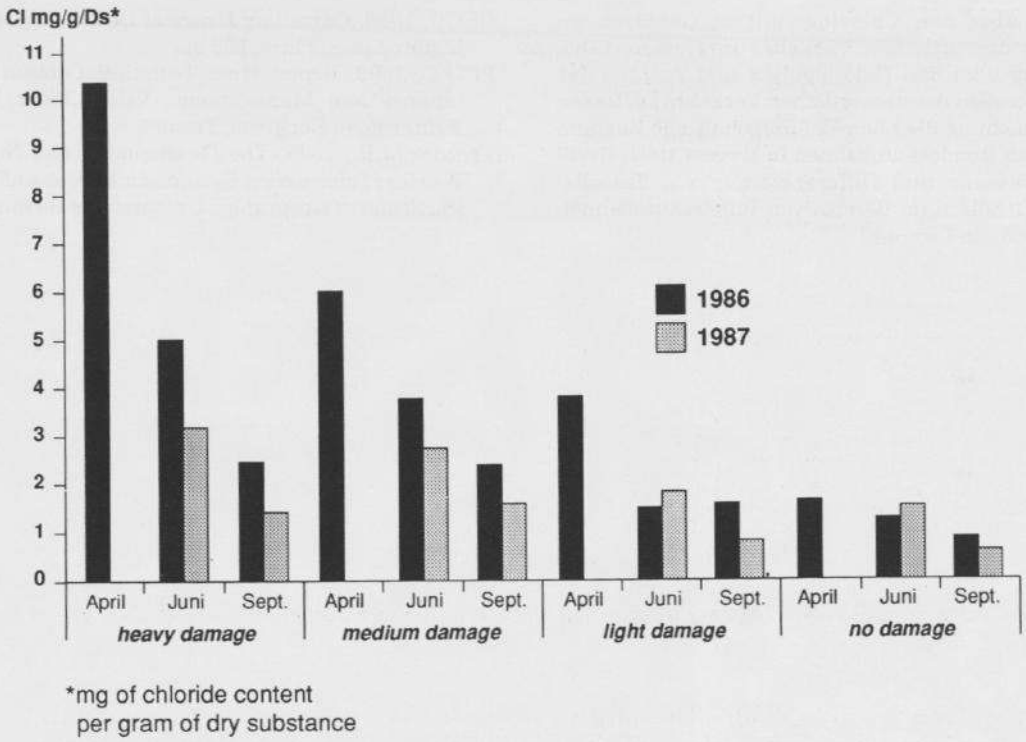

Fig. 5. Cl-concentration in the course of the vegetation period (example: pine-grove for different classes of damage).

By taking care of shrubs, early cutting, well planned irrigation and proper fertilization, damage due to the use of deicing salt can be minimized and the salt resistance of the plants can be increased.

In locations where soil salination occurs, it should be ascertained to what extent this is due to uncontrolled run-off of surface water. Appropriate precautions during construction work should be undertaken to provide that water run-off from roadways will be channelled into catch basins. For example, landscaped dividers separating parking areas from roads or steep slopes should be protected by lip kerbs.

CONCLUSIONS

These are concrete and quantifiable research results addressing both sides of the issue. They can now make a worthwhile contribution to introducing greater objectivity into the frequently emotional discussion regarding traffic safety, environmental protection and the role of deicing salt in winter maintenance services. Results of long-term plant ecological studies yield no evidence of any wide-scale incidence of harm to trees and shrubs growing alongside rural roads due to the use of deicing salt.

If one considers the advantages and damage of modern winter service with the deicing salt based on scientific studies concerning traffic safety and the effect on road-side plants, several facts become clear. One can show that the proven increases in traffic safety for the life and health of the road users as well as the economic advantages are disproportionally higher than the locally limited and partially or completely avoidable damage to roadside plants.

Other examinations recently executed by the OECD in Sweden and Finland concerning the effects of deicing salt to roadside vegetation and traffic safety resulted in similar perceptions (OECD, 1989; PIARC. 1990).

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