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Winter maintenance on porous asphalt

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Wintermaintenance on porous asphalt

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About 20% of the Dutch highways is covered with porous asphalt. The expectation is that in the near future most highway constructions in the Netherlands will have this open structure. The main reasons for this choice are the noise reduction, the improvement of traffic safety and the higher transport capacity under wet circumstances.
Due to differences in surface temperature, road humidity and the ability to keep salt on the surface, porous asphalt behaves differently as compared to conventional dense road surfaces under winter conditions.

Environ 20% des autoroutes néerlandaises sont couvertes "d'asphalte poreux". Il est probable que la majeure partie des autoroutes néerlandais recevra une assise ouverte dans un proche avenir. Ce choix est surtout motivé par une réduction du volume sonore, une amélioration de la sécurité routière et une meilleure capacité de transport sous des conditions humides.
En hiver, le comportement de "l'asphalte poreux" est parfois différent de celui du béton asphaltique dense conventionnel à cause d'une différence de la température à la surface et de l'humidité de la chaussée, et de sa capacité de maintenir le sel à la surface de la route.

Ungefähr 20% der Holländischen Autobahnen sind bedeckt mit "porous asphalt". Die Erwartungen sind, daß in der nahe Zukunft die meisten Holländischen Autobahnen von dieser offenen Verschleißschicht versehen sind. Die wichtigsten Gründe für diese Wahl sind Lärmminderung, Verbesserung der Verkehrssicherheit und eine höhere Transportkapazität unter nassen Umständen.
"Porous asphalt" verhält sich im Winter, durch eine Differenz in Oberflächentemperatur, Feuchtigkeit der Straße und die Möglichkeit Salz am Oberfläche der Straße zu behalten, unter bestimmten Umständen anders als eine konventionelle undurchlässige Asphaltbetonschicht.

INTRODUCTION

The Netherlands, located in northwestern Europe, has a maritime climate with relatively mild humid winters. The high level of precipitation, which in the winter is mostly rain, means that on average road surfaces tend often to be wet or moist.
The improvement of traffic safety and the higher transport capacity under such conditions are, together with the noise reduction, the main reasons for using porous asphalt on Dutch highways.
Despite the mild winters, the average January air temperature is 1.7 °C, leading to rather changeable weather conditions with slippery roads. In the Netherlands slipperiness is caused mainly by the freezing of wet sections of the road and the formation of a layer of ice through condensation or frozen fog. Precipitation in the form of glaze ice or snow occurs only on a limited scale. The wintermaintenance in the Netherlands is mainly based on preventive treatment of highways by means of salt. Under certain winter conditions porous asphalt demands more attention from the highway authorities than comparible conventional dense road surfaces. This characteristic of porous asphalt is due to a different behaviour in surface temperature, road humidity and the ability to keep salt on the surface.

SURVEY

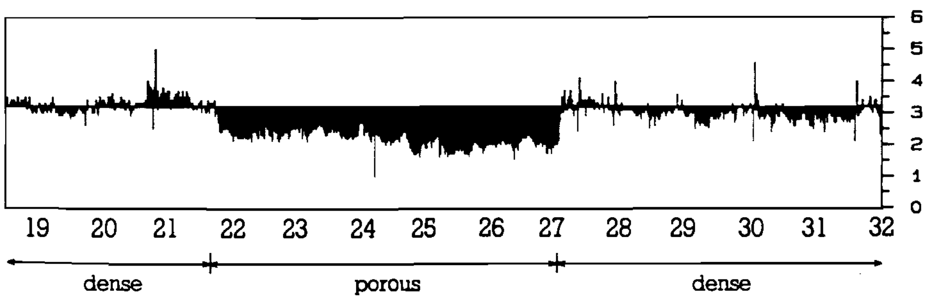
A survey shows that in the following situations porous asphalt requires closer monitoring in winter conditions:

- roads with low traffic intensity;
- roads on an incline;
- roads with a limited superelevation;
- on hard shoulders;
- in the event of changes from cold to warm temperatures;
- in the event of snow remaining on the road surface;
- in the event of slipperiness caused by condensation;
- in the event of slipperiness caused by freezing fog;
- at changeovers from porous asphalt to dense asphaltic concrete.

BEHAVIOUR OF POROUS ASPHALT

The main causes of the different behaviour of porous asphalt are:
- its different temperature behaviour compared to that of dense asphaltic concrete;
- its different humidity behaviour compared to that of dense asphaltic concrete;
- its different behaviour in keeping salt on the road surface compared to that of dense asphaltic concrete.

Temperature behaviour of porous asphalt



ROAD SURFACE
TEMPERATURE
IN DEGREES CELCIUS

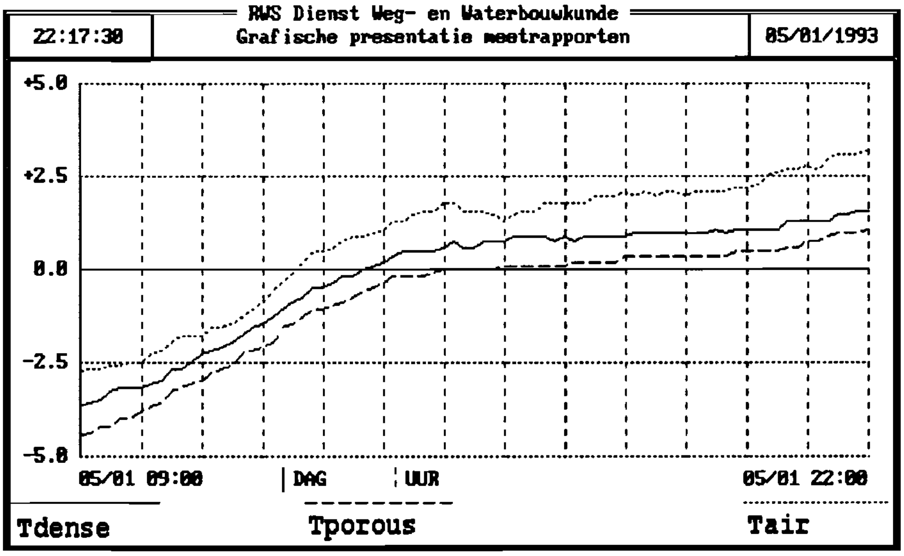
The figure presents the surface temperature, measured with an infrared camera, of a highway section in the Netherlands, which is partly made of porous asphalt. The colder porous asphalt can be clearly recognised. The measurement was carried out by cloudless weather and no wind.

Measurements in the winter season 86/87 revealed that road surfaces made of porous asphalt showed a different temperature behaviour from those made of dense asphaltic concrete.

The measurements show that:
- as temperatures fall, the temperature of road surfaces made of porous asphalt falls below freezing point an average of half an hour earlier than that of road surfaces made of dense asphaltic concrete;
- as temperatures rise, the temperature of road surfaces made of porous asphalt rises above freezing point an average of an hour later than that of road surfaces made of dense asphaltic concrete.

Besides these measurements show the temperature of road surfaces made of porous asphalt remains below freezing point about 5% longer than roads made of dense asphaltic concrete.
In addition to measurements made with temperature detectors located in the road, temperatures were also measured with an infrared measuring vehicle. These measurements show that in extreme weather conditions (little wind, clear sky), the surface temperature of roads made of porous asphalt is about 1°C lower than that of comparable roads made of dense asphaltic concrete.

The temperature behaviour of porous asphalt can be explained by the relatively high insulation value of the road surface due to voids. As a result, heat is less easily transported from the mostly warm subgrade to the surface in the event of frost from above. The voids also ensure greater contact surface with the cold air; this greater heat/cold interchange also contributes to the lower temperature of porous asphalt in comparison with a compact road surface.



The figure presents the air temperature and the surface temperature of porous and dense asphalt at the same spot after a cold period.

Humidity behaviour of porous asphalt

The voids in porous asphalt ensure that precipitation is slowly removed to the shoulder as a result of the superelevation of the road. Some of the precipitation remains behind in the pores. In summer the remnants quickly evaporates after a wet period, while in winter the road dries slowly. In the case of roads with a limited superelevation which are on an incline or which have a large number of traffic lanes, moisture remains on part of the porous asphalt for a long time. As a result of this residual moisture, road surfaces made of this type of concrete also remain damp.

If the road surface temperature falls below freezing point after a period of precipitation, roads made of porous asphalt will require extra attention on account of the moisture present.

Behaviour with regard to salt

Much of the thawing agent spread on roads made of porous asphalt disappears into the voids, and only a small amount remains on the surface. However, because of the "air pumping" effect of vehicle tyres, traffic will ensure that the thawing agent in the pores is brought back to the surface of the road. As a result of this vertical transport function performed by traffic, some of the salt which had disappeared into the voids will continue to contribute to the thawing process. This process will be disrupted if the traffic intensity is low (e.g. at night). Even if only a small quantity of moisture falls on the road at that time (condensation, freezing fog), this can result in non-compact road surfaces behaving differently from compact ones.

In order to bring down the freezing point of water salt is used. Under normal Dutch conditions 5.5 grammes of NaCl per square metre will sufficiently reduce the freezing point of the moisture that has collected. As a result of the extra moisture in the pores of porous asphalt, a larger quantity of salt is required on these roads.

In addition to the drop in freezing point, there is another important factor. On roads made of dense asphaltic concrete traffic readily leads to horizontal transport of the thawing agent (i.e. in the direction of the traffic). With porous asphalt this horizontal movement of the thawing agent is considerably less. As already mentioned, traffic also performs a vertical transport function on such roads. This means that the salt spread on porous asphalt roads is mixed with the moisture from the pores. In time a balance arises in which the salt is distributed as a solution over the pores and the surface as a whole. This solution is transported vertically and to some extent horizontally by the traffic.

Because the moisture in porous asphalt drains away to the shoulder only very slowly, the salt solution remains available for quite some time. If the vertical balance is disturbed, however, less moisture from outside will be required to reduce the drop in the freezing point on the surface sufficiently enough to allow the formation of ice than in the case of on comparable roads made of dense asphaltic concrete.

In places where a stretch of road made of porous asphalt is followed by one made of dense asphaltic concrete, the highway authority should devote extra attention to the initial section of the dense asphaltic concrete road. Since the horizontal transport of salt on non-compact road surfaces is limited compared to that on compact road surfaces, the limited supply of thawing agent from porous asphalt means that at changeovers from a road made of porous asphalt to one made of dense asphaltic concrete, there is a significant reduction in the amount of thawing agent in the initial section.

Traffic and dry conditions ensure that the quantity of thawing agent on a road made of dense asphaltic concrete will gradually disappear even without precipitation. On a road made of porous asphalt some of the salt crystallises in the pores under dry conditions. This slow crystallisation ensures good adhesion to the asphalt, and as a result the salt remains available. If gritting takes place several times in a dry period without the thawing agent being removed to the shoulder - e.g., if slipperiness occurs as a result of freezing fog or condensation - a salt buffer will be formed in the pores of porous asphalt. If following a dry period, precipitation falls at a road surface temperature below freezingpoint, the salt buffer which has collected in porous asphalt becomes available again under the influence of the traffic.

RECOMMENDATIONS FOR COMBATING SLIPPERINESS ON POROUS ASPHALT

The difference between the behaviour of a road made of porous asphalt and one made of dense asphaltic concrete under different winter conditions is explained below. A distinction is drawn between three different types of slipperiness:

- slipperiness caused by the freezing of wet sections of road,
- slipperiness caused by a small amount of moisture (condensation, freezing fog),
- slipperiness caused by precipitation.

Freezing of wet sections of road

The freezing of wet road sections of road is a common cause of slipperiness in the Netherlands. If following a period of precipitation temperature falls, the parts still wet may freeze. The information of an early ice warning system is used by the highway authority in order to provide the treatment necessary. Together with the "wetted salt" technique it is possible to give a preventive treatment. On roads made of dense asphaltic concrete preventive gritting can be carried out using 5.5 g/m^2 of thawing agent (7 g/m^2 wetted). Double the quantity is spread at the time if the road is very wet.
Owing to the quantity of residual moisture in the voids, it is advisable to spread double the quantity of thawing agent (11 g/m^2) on roads made of porous asphalt during the first gritting operation following a "wet period". If possible, the thawing agent is applied in two goes.
In the event of any follow-up actions, roads made of porous asphalt are treated in the same way as roads made of dense asphaltic concrete (5.5 g/m^2), with the exception of places where moisture can collect, which are given extra treatment if necessary.
If, following a period of precipitation, wet sections of the road freeze again, a double quantity of thawing agent will first be applied on roads made of porous asphalt, since the thawing agent has been removed to the shoulder.

On porous asphalt, wet sections of the road will freeze more often in comparison with a dense asphalt construction. This is caused by the lower surface temperature and the longer period that the moisture remains in the voids. This means that gritting will need to be carried out sooner and more often on road surfaces made of porous asphalt than on road surfaces made of dense asphaltic concrete.

Slipperiness caused by a small amount of moisture

Under certain temperature and humidity conditions ice may form on the road surface as a result of condensation and freezing. Following a cold period in particular, condensation forms rapidly owing to the "cold buffer" that has been built up in the subgrade. If air saturated with moisture comes into contact with road surface temperatures below freezing point while the ambient temperature is just above freezing point, a considerable quantity of moisture may condense on the road surface. At lower ambient temperatures, the amount of condensation will decline rapidly owing to the fall in the amount of moisture in the air.
As already stated, the temperature behaviour of porous asphalt differs from that of other types of concrete. This means that ice forms more readily on roads made of porous asphalt and that critical conditions last longer than with compact road surfaces. Critical places such as steel bridges and viaducts are particularly susceptible to slipperiness caused by condensation. For this reason automatic spraying installations, with NaCl solution as solvent, are constructed on several steel bridges with dense or porous asphalt.

This type of condensation slipperiness is particularly dangerous as it occurs at unexpected moments for road-users (e.g. there may have been no precipitation), and is also difficult to see. It must be tackled by preventive measures as much as possible.

Preventive measures are effective on roads made of dense asphaltic concrete. On roads made of porous asphalt, more moisture condenses owing to the lower temperature of the road surface. If this happens at a reasonable traffic intensity, the "air pumping" effect of vehicle tyres will fetch the thawing agent out of the pores and prevent condensation resulting in slippery roads. In these circumstances no problems will occur on roads made of either type of concrete.

If, however, the traffic intensity is minimal (e.g. at night), the condensed moisture may dilute the already small quantity of thawing agent on the surface of roads made of porous asphalt to such an extent that slipperiness occurs. This means that it is generally necessary to carry out gritting operations more often on roads made of porous asphalt and that the time at which gritting should take place also differs.
In the event of freezing fog or small quantities of precipitation, the same phenomena occur as with slipperiness caused by condensation. In a DRIVE*ROSES project more information on these phenomena is sampled

Slipperiness caused by precipitation

The effect of snow or glaze ice on porous asphalt varies widely. Sometimes it becomes slippery, while adjacent compact road surfaces retain sufficient skid resistance, but sometimes the situation is exactly the reverse.
Glaze ice simulation tests conducted by the Road Construction Research Centre in Belgium have confirmed this. If moisture already present on the road freezes and if supercooled rain falls on the frozen but ungritted road at a temperature of about 0°C, the tests show that porous asphalt retains better skid resistance than dense asphaltic concrete. This is due to the breaking of the ice layer on roads made of porous asphalt.
In the event of snow and glaze ice, preventive gritting using the "wetted salt" technique is carried out with 20 g/m^2 of thawing agent (15 g/m^2 NaCl) on roads made of both types of concrete. Efforts to clear the snow are started as early as the period of precipitation, with another 15 to 20 g/m^2 of salt being spread using the dry technique. Radar pictures are used by the highway authority for the right treatment.

Conditions such as traffic intensity, the salt buffer and the quantity of precipitation determine the behaviour of roads made of a porous asphalt in the presence of snow. Although it is difficult to establish the exact behaviour of roads made of this type of concrete in the event of snowfall, the following general rules may be used:

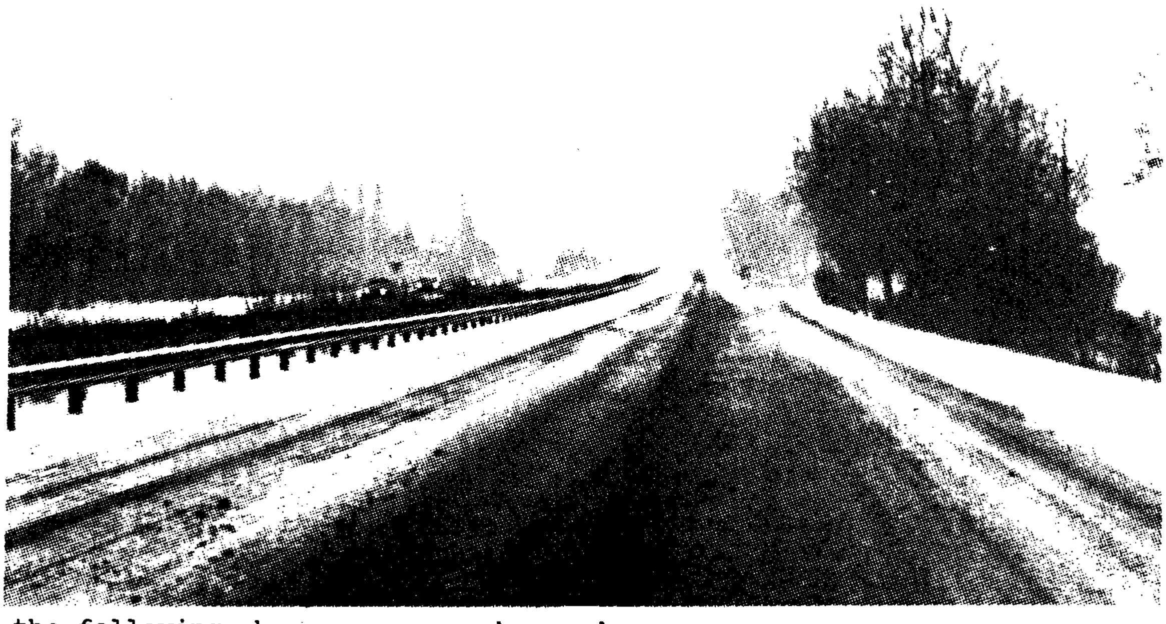
- low traffic intensity, small quantity of precipitation: in these circumstances a dense asphaltic concrete road is more passable than a road made of porous asphalt;
- low traffic intensity, large quantity of precipitation: roads made of both dense asphaltic concrete and porous asphalt can be kept passable only by being gritted and cleared by snow ploughs;
- high traffic intensity, small quantity of precipitation: roads made of both dense asphaltic concrete and porous asphalt remain passable;
- high traffic intensity, large quantity of precipitation: according to the quantity of salt which has collected in the preceding period, roads made of porous asphalt remain more passable than those made of dense asphaltic concrete under the same treatment. In the event of prolonged precipitation, both road surfaces can be kept passable only if they are gritted and snow ploughs are deployed.

If preventive gritting is carried out prior to a snowfall, dense asphaltic concrete roads are relatively simple to clear of the remaining snow after the precipitation. Roads made of porous asphalt need to be treated with extra salt.

Adjacent stretches of roads made of porous asphalt and dense asphaltic concrete were photographed at the beginning of a snowfall before being gritted or cleared by snow ploughs. The road made of porous asphalt is more passable owing to the salt buffer from previous gritting operations.

▲ porous asphalt ▲

▼ dense asphalt ▼



Also the following phenomena were observed:

- In the event of persistent snowfall icy patches are formed on dense asphaltic concrete roads, which reduce skid resistance. Icy patches were found less frequently on roads made of porous asphalt. If ploughs are used to prevent the quantity of snow on roads made of porous asphalt increasing too much, the amount of snow in the pores remains low owing to the "air pumping" effect of vehicle tyres. This prevents the formation of icy patches on roads made of porous asphalt. Roads made of this type of concrete were found to be far more skid resistant than dense asphaltic concrete roads when subjected to the same gritting treatment.

- If the removal of the thawing mixture via the voids in porous asphalt stagnates, e.g. because the hard shoulder is still frozen, problems arise if the temperature of the road falls again. To prevent problems if the temperature drops, the hard shoulder should be kept clear and gritted with sufficient thawing agent.

To keep a road made of porous asphalt completely free of snow, more salt is required than for a comparable road made of dense asphaltic concrete.

CONCLUSION

Dutch winters are characterised by unsettled weather. The temperature can pass the freezing point several times (often in one day). Long cold periods with a great deal of precipitation are rare. Although roads made of porous asphalt, owing to their non-compact structure and their temperature and humidity behaviour, require greater attention from the highway authority than comparable roads made of dense asphaltic concrete, the winter maintenance of porous asphalt roads will not cause the highway authority too many worries under "normal" Dutch winter conditions.

The main differences between the winter maintenance of porous asphalt roads and dense asphaltic concrete roads are:

- At high traffic intensities roads made of porous asphalt barely differ from roads made of dense asphaltic concrete. At low traffic intensities, on the other hand, the highway authority should carefully examine what extra attention the open surface requires.
- The amount of salt required to keep a road made of porous asphalt passable under Dutch conditions will be 25% higher than for a dense asphaltic concrete road, depending on conditions.
- The salt spread on the road ends up on the shoulder. On roads made of porous asphalt this is limited to the first few metres of the hard shoulder, in contrast to roads made of dense asphaltic concrete where it may take place over a larger area. Less environmental salt damage on trees and plants is the result
- After a gritting operation, the skid resistance of a porous asphalt road will decline at low traffic intensities in the event of a small amount of precipitation in the form of glaze ice, freezing fog or significant condensation. This can be avoided by prompt gritting (sometimes several times).
- Inadequate superelevation and inclines allow moisture to collect at certain places on roads made of porous asphalt. Wet parts of the road are more likely to freeze in these places partly as a result of their different temperature behaviour.
- At low traffic intensities with a great deal of precipitation, making roads made of porous asphalt completely free of snow (following snow plough operations) requires extra thawing agent.
- At high traffic intensities and following a heavy snowfall, roads made of porous asphalt are generally more passable (higher skid resistance) than comparable roads made of dense asphaltic concrete subjected to the same treatment.
- Following precipitation, the removal of the thawing mixture requires more attention on roads made of porous asphalt, and more thawing agent is required. It is also necessary to keep the hard shoulder clear in order to remove the "thawing mixture" from the traffic lanes as quickly as possible.
- The horizontal transport of thawing agent by the traffic is limited on roads made of porous asphalt, and far greater on roads made of dense asphaltic concrete. This means that the initial section of a road made of dense asphaltic concrete after a stretch of road made of porous asphalt will contain a lower quantity of thawing agent. For this reason changes from porous asphalt to dense asphaltic concrete should be avoided on roads as far as possible.