The progress of weather forecasts on Winter Road Maintenance in the Netherlands

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Introduction

Traffic and transport are of vital importance to the Netherlands. The country has an average winter temperature of just above 0°C, and winter maintenance is important to keep roads open and safe. The organization, the strategy and the progress in weather forecast are discussed. Special attention is given to the National Ice Warning System, which has been installed on highways and secondary roads in the Netherlands. This system, along with regional weather reports, weather radar, satellite images and road-service forecasts provided by experienced meteorologists, gives authorities up-to-date road and weather conditions.

Because of its favorable location, the large ports of Rotterdam and Amsterdam and Schiphol International Airport, the Netherlands is a main gateway to Europe. Roads and waterways are essential elements of the transport system and account for a significant part of the Netherlands national income. For the Netherlands to continue to be Europe's distribution hub, the infrastructure must be efficient to use.

Transport is and will continue to be a growth sector. The continued unification of Europe moves markets. The extension of the European Union and the fading of the borders with Eastern Europe will accelerate this process. Consequently investment in infrastructure, safety, and environmental protection has become a priority of the present government. A population of 16,1 million in only 41.600 km^2, over 6 million cars, 500,000 vans and 90,000 trucks all seriously test the capacity of the Dutch road system. The activities necessary to keep roads clear and safe for driving during the winter months are explained, as is the interaction of the government authorities that co-ordinate winter maintenance in the Netherlands.

Climate

The Netherlands, located in northwestern Europe, has a maritime climate with relatively mild, humid winters. The warming effects of the Gulf Stream generate a predominately westerly wind, which in turn has a marked influence on temperature.

Because of the high level of precipitation, which in the winter is mostly rain, road surfaces tend to be wet. Despite the relatively mild winters, the average January air temperature is 1.9°C. The changeable weather leads to hazardous road conditions, which mainly are caused by the freezing of wet sections as well as the formation of a layer of ice through condensation or freezing fog. Snow and freezing rain are infrequent. Winter maintenance mainly is based on the preventive treatment of highways and secondary roads by salting.

In the colder Northeast of the country, severe weather occurs considerably more often than in the warmer Southwest.

High humidity combined with temperatures below freezing result in conditions that require the Dutch government to maintain a well-structured winter maintenance program.

Winter Maintenance Organization

The Netherlands has three government authority levels; each authority maintains its own road system. The public authorities maintain more than 2500 km of main roads, and the county authorities are responsible for about 50.000 km of secondary and tertiary roads. The municipalities maintain about 50.000 km of municipal roads.

The supervision of main roads is the responsibility of about 25 geographical based divisions. County authorities divide the maintenance and control of their roads into several areas. The municipalities are responsible for their own road system and, together with the counties, also are responsible for bicycle paths (nearly 20.000 km), which are maintained as well.

During winter maintenance, all authorities are autonomous. However, public authorities and county authorities consult each other regularly on an executive level; thus, the two levels of authority have established similar procedures for winter maintenance. The main goal is to prevent hazardous road conditions, and this is done through salt spreading.

All organizations use the prewetted technique for spreading operations. The public and county authorities both purchase or refurbish equipment and material (e.g., spreaders, snowplows and salt) before

the winter season begins and store these items in several locations for easy access during the winter months.

The trucks needed during spreading operations are rented from the transportation industry, and the drivers are hired from the same industry.

Municipalities, on the other hand, use their own trucks. In the municipalities, the changeover from the dry salt technique to the prewetted technique has not been completed. About 70 percent of the larger municipalities use the prewetted technique. In smaller municipalities, the changeover has not made much progress.

With the help of a computer program, all spreading routes have been optimized during the last few years. The duration of a spreading operation on highways is about 45 minutes. The time it takes to alert the drivers to put the spreader on the truck, load the salt, and perform the spreading operation is a maximum of two hours. A fixed snow plow route takes about one hour to complete.

Spreading is done mainly in the evening or just before the a.m. peak, to disturb traffic as little as possible. The county authorities have a similar organization but take longer to spread, typically 1,5 to 2 hours for secondary roads.

As mentioned, the prewetted technique is frequently used. In general, calcium chloride ($CaCl_2$) is the wet component used in prewetted spreading operations. Quantities of salt used depend on conditions.

Freezing of wet road sections caused by dropping temperatures is the most common form of road ice in the Netherlands. In general, this can be prevented by the application of 5.5 grams of sodium chloride (NaCl) per square m. Porous asphalt (drain asphalt), which is often used for main roads, needs a higher dosage (11 gram/m^2 = 140 lb/mi).

Road ice, caused by condensation, also may be prevented by the application 5.5 grams sodium chloride per square meter. The Netherlands road authorities use preventive measures as much as possible, especially for approaching snow or freezing rain. 15 gram of sodium chloride per square m prevents the snow from attaching to the asphalt. During snowfall, 15 to 20 grams/m^2 sodium chloride is applied to the road surface right after plowing. Normally, a dry salt is used in this case. In the Netherlands both evaporated (vacuum) salt and rocksalt are used. The heavy metals in the salt are limited to 10 ppm.

In addition, the division of grains has its limit. The maximum permitted size is 3.15 mm (= 0.124 in). Larger grains are permitted when a price reduction is stipulated, as are fine materials. Snow is removed from bicycle paths with revolving broom instead of a snowplow.

Porous Asphalt (Drain Asphalt)

In 1986, porous asphalt (drain asphalt or open-graded asphalt) was introduced in the Netherlands. By 2000, approximately 50 percent of all highways in the Netherlands had been paved with this open asphalt. The main reason for the use of porous asphalt is its ability to reduce traffic noise and improve traffic safety. The increase in the use of open porous asphalt in the last couple of years has shown that its winter behavior deviates from that of normal dense asphalt. The main causes of the different behavior of porous asphalt compared with dense asphalt, are its responses to temperature, humidity, and salt on the road surface. Under "normal" Dutch winter conditions (in which slipperiness is caused mainly by the freezing of the wet road surface), winter maintenance of porous asphalt roads will not cause significant problems for the highway authority, requiring only a high consumption of salt to keep the road sate.

However, in the case of freezing rain, the difference in friction between porous asphalt and dense asphalt is considerable. In highly intense freezing rain, a layer of ice will swiftly form on porous asphalt and cause a subsequent loss of friction.

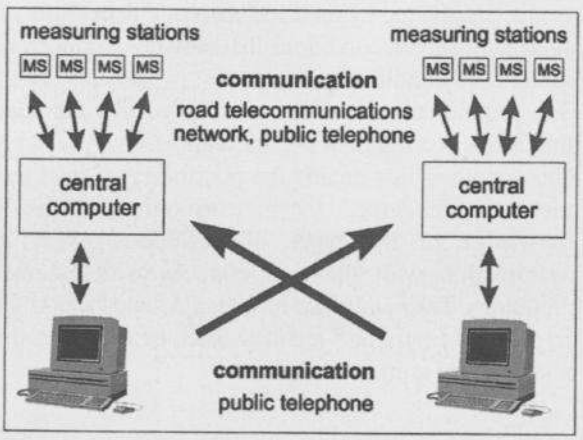
Hard shoulder of porous asphalt next to dense asphalt concrete road surface. Shoulder is fully covered with snow because without traffic action, salt remains in voids rather than transferring to surface.

National Ice Warning System

Prevention is the best policy for main and secondary roads. Without the required data regarding ice conditions, road authorities may order needless spreading operations, resulting in wasted money and resources. Adequate planning also reduces environmental pollution caused by the thawing agents. Porous asphalt requires special attention. Measuring points installed along sections of porous asphalt have improved the winter maintenance capability of the road authorities.

In 1989, the first phase of the National Ice Warning System was installed. The experience gained led to a series of improvements, mainly in the reliability of the system. The ice warning system is now installed on all highways and on most of the county roads. The measuring points on the county roads often run in conjunction with the highway system. In addition, measuring stations have been installed on the municipal roads.

The Ice Warning System consists of several elements. First, the measuring stations along the road collect relevant data measured on or near the road. The collected data are then retrieved by a central computer, either through the emergency telephone network or, if such a system is not available, through the public telephone network. The computer collects the data from measuring stations in its district every 5 minutes. If the data are transmitted through the public telephone network, they are collected once or twice every twenty-four hours.



National Ice Warning System, communication

However, in situations in which road ice is likely to occur, the data are collected on a much more frequent basis. Of course, current data from measuring stations can be retrieved whenever the road authority in charge considers the data to be essential.

By using the public telephone network, all road authorities can establish a connection with the central computer with a modem-equipped personal computer. Through the telephone network, a connection to the central computer system can be obtained from anywhere. If hazardous conditions are expected in one or more places, the central computer, on the basis of programmed parameters, sends a semaphone or telephone alarm signal to the road authority in charge of the road sections involved. Because the parameters of the ice warning system produce alarm signals before the road actually becomes icy, authorities can carry out preventive spreading actions. Communication between the personal computer and the central computer is standardized, which means that all the ice detection systems in the Netherlands use the same ommunication algorithms. As a result, road uthorities can collect data for areas outside their own district, and use the data as a solid basis for their spreading decisions.

Measuring station

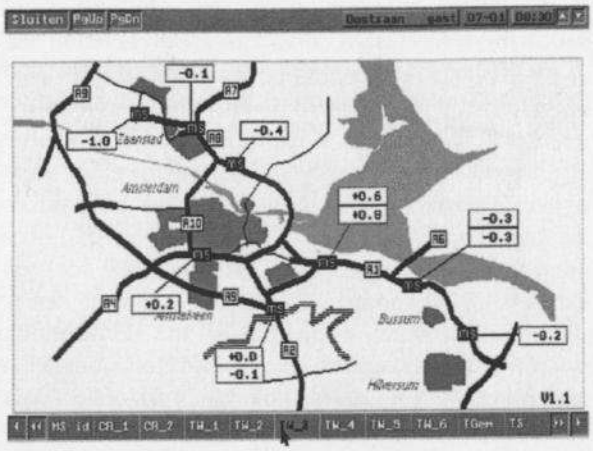
The roadside measuring station is one of the most important elements of the National Ice Warning System. To determine the position of a measuring station, thermal mapping is carried out under certain prescribed conditions. These conditions include light winds, cloudless skies and temperatures around freezing. Thermal mapping indicates the coldest spots of a specific section of the road system.

The pertinent road authorities apply these data to their experience to establish the first areas of road ice formation.

The Netherlands' infrastructure contains many bridges and flyovers. Since bridges and flyovers receive no heat from the subsoil, they often are the first places to become icy. Yet, under certain circumstances, road ice easily develops in many other places, including elevated roads and roads near forests and large water surfaces. In addition, the low position of the sun in winter allows entrances and exits to highways, specially those on the north side, to become hazardous. Through review of these critical spots, a safe distribution of the measuring stations can be established within each district.

Currently, over 300 measuring stations are situated on primary and secondary roads throughout the

Netherlands. These computers are linked to 20 central computers. Decisions about spreading operations are made not by the ice warning system but by the road authority in charge. Because of the present parameters the road authority is warned more than 2 hours before hazardous conditions occur.



Road temperatures around Amsterdam. Highest temperature is for a steel bridge. Measuring stations around the country provide such relevant data to road managers.

On the basis of an evaluation made from the data provided by its own system and, if necessary, by adjacent ice warning systems, the road authority then makes a decision. In addition, meteorological forecasts play an essential part in the decision.

Sprinkler equipment

The Netherlands abounds in waterways. Many bridges cross the country's rivers and canals, and a number of these bridges have steel frames. Especially during clear and windless nights the temperature of the road surface of these steel bridges often drops to values below freezing, whereas the temperature of adjacent road sections may stay well above freezing. The humid maritime climate often causes condensation on these bridges. To the surprise of drivers, steel bridges often become slippery during spring and autumn. To prevent this, a few steel bridges equipped with an ice warning system, which alerts the road authority to potential hazardous road conditions. Instead of sending a warning signal to a road authority, however, some ice warning systems independently activate a sprinkler system permanently located on the bridge.

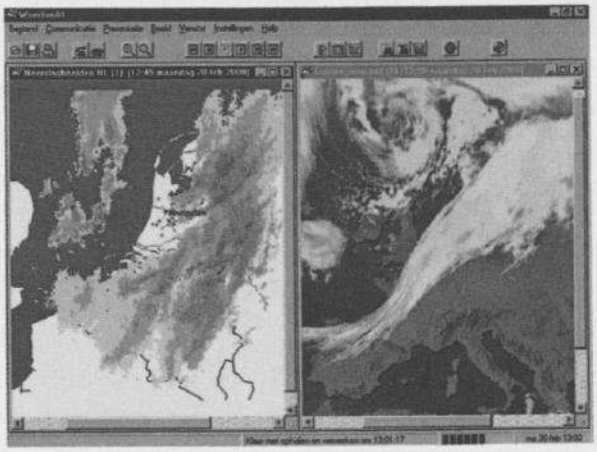
Sprinkler head spraying NaCl over a bridge road surface.

The sprinkler system sprays a 20% sodium chloride solution on the road surface. Five bridges have been equipped with the automatic sprinkler system, which has produced satisfactory results.

Meteorological services

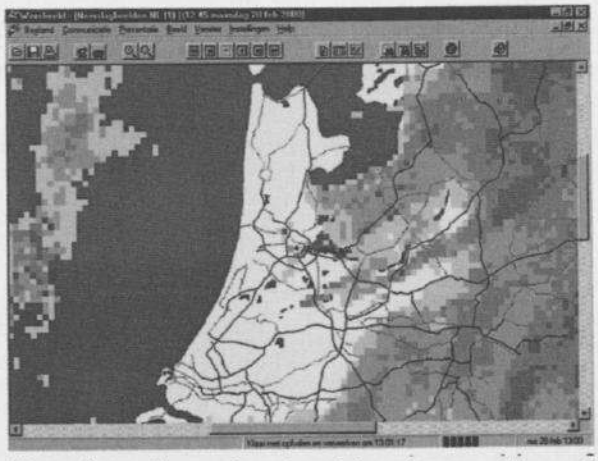
Several years ago there was little cooperation between road authorities and meteorologists. The most important source of information was weather reports broadcast on the news. Since then cooperation has accelerated and enormous progress has been made by combining the knowledge of road authorities with the knowledge of the meteorologist. All road authorities autonomously decide which meteorological products they need and who will supply these products.
Road authorities often use several meteorological products provided by their meteorology firm to obtain information about conditions that may favor dangerous winter road conditions.
One product developed by meteorologists for road authorities is a regional weather report.
This report, which details the possibility of road ice, has been developed by meteorologists by using knowledge of the types of hazardous roads in coordination with their experiences with weather conditions. The authorities receive a detailed report for the first 24 hours and a 5-day forecast detailing the possibility of winter conditions.

In addition to providing regional weather reports, meteorologists also warn the road authorities of snow or freezing rain several hours before it reaches their areas. From that moment the road authority watches the situation with the help of weather radar.



On the left, weather radar indicating rain over eastern Netherlands. On the right, satellite image.

Radar pictures and satellite images are available to all road authorities in the Netherlands. Through contact with the host computer, an updated picture is available 4 times an hour for weather radar and once an hour for satellite images. For weather radar also a forecasted radar product is available.
Detailed information about a specific area can be obtained by using the magnifying feature included in the program's package. By using the network of main roads, the road authority can relatively easily see the velocity and the direction of the precipitation.



Use of road overlay to determine position of precipitation.

Many models for road surface forecasts have been developed. These models, which are based mainly on physical/statistical processes (i.e. balance of heat), considerably, improved the "nowcast" (short-term forecast) conditions for the road authorities. In these models, data from the ice warning system is incorporated into the meteorological formula. From these models, nowcast and long-term forecasts are generated for the road authority.

Designated Meteorologists

Increased knowledge of ice warning systems and meteorology encouraged some divisions of the main road network to employ Meteo Consult for assistance in winter maintenance. The meteorologists therefore broadened their knowledge of the requirements and ice warning systems. During the winter period, the meteorologists operate 24 hours a day to ensure optimal efficiency of the ice warning system.
The road authorities receive the collected data directly from Meteo Consult and decisions for spreading operations can be based on the data. During unclear situations, an inspection of the roadway is carried out following close consultation between the meteorologist and the road manager. Cooperation between road authorities and meteorologists has improved through this type of regular contact.
More and more services are introduced in the Netherlands where meteorologists analyze all of the available information. The high knowledge and experience with the ice warning system and the direct linking with the weather forecast makes it favorable for the authorities to allow meteorologists to analyze the data and let them report the integrated information to the coordinator of the authority. The decision and responsibility for spreading action still is taken by the Road Authority.

Conclusion

The combination of winter maintenance, knowledge of road management and meteorology appears to be a success in the Netherlands. In a few years, Meteo Consult, as a private weather service, has been able to enlarge its share in the market to about 80 percent. However, in most European countries only one provider (the national weather service) is available to supply road authorities with meteorological services. Experience in the Netherlands has proven that free competition can improve quality in this part of road management, without reducing safety or increasing cost.