The effective planning of measures for noise abatement in relation to maintenance of roads

Drs. Petra Paffen
Ministry of Infrastructure and the Environment, Directorate General Rijkswaterstaat, Department for Major Projects and Maintenance, PO Box 2232, 3500 GE Utrecht, the Netherlands

Ir. Leon Schouten
Infram BV, PO Box 150, 3950 AD Maarn, the Netherlands

Ing. Frank Bouman
Ministry of Infrastructure and the Environment, Directorate General Rijkswaterstaat, Department for Major Projects and Maintenance, PO Box 2232, 3500 GE Utrecht, the Netherlands

Ir. Jeroen Kamer
Royal HaskoningDHV, PO Box 1132, 3800 BC Amersfoort, the Netherlands

Summary
Noise abatement measures need to be planned ahead in order to apply them effectively. They should be integrated in the programming of all measures. The paper explains how Rijkswaterstaat ensures that there is always a multiannual programming that looks years ahead and thereby not only effectively plans noise control measures, but also measures for effective road maintenance. We show that maintenance can be confronted with conflicting objectives, and how general rules help them to reach a weighted decision in a responsible and uniform way. An insightful programming that looks ahead at least 6 years, is the basis of this consideration.

PACS no. xx.xx.Nn, xx.xx.Nn

1. Introduction - Rijkswaterstaat's area of management

Rijkswaterstaat manages and develops three main infrastructure networks in the Netherlands: the main waterway network, the main water system and the main motorway network. The latter is the subject of this paper. It consist of just over 3100 km of motorways and more than 1250 km of access and exit roads and connecting roads. It also includes close to 3250 bridges and bridge-like structures and 16 tunnels [1]. All these assets have to be maintained, preserved and operated in such a way that smooth and safe transport is ensured. This guarantee not only applies for transport that takes place today, but also for transport that ensues in 10 or 50 years from now.

2. Processing information on maintenance of motorways

To uphold this guarantee Rijkswaterstaat needs information on the current state of the various assets and on the intensity with which they are used. Therefore Rijkswaterstaat monitors the condition of the road surfaces, the bridges and the other structures that are part of the highway network. It also registers the number of vehicles that pass at representative locations and at specified times.
In order to fulfil its social tasks and in compliance with national policies, Rijkswaterstaat has since long applied road surface types that are safe and minimize noise pollution. These types are porous. Additional advantage of porous asphalt is the reduction of splash and spray which adds to the comfort and safety of motorists [2].

The condition of the road surface is determined by devices that measure various parameters like ravelling (stone loss), cracking, rutting, unevenness and skid resistance. Data from these measurements are used as input for a model that yields a date for maintenance. Our maintenance strategy distinguishes addressing the right lane, or tackling all strips. When part of the road has to be resurfaced, it has to be closed off and hence it is temporarily not available to traffic. The programming of road work therefore aims to combine different tasks. For example roadwork on pavements, bridges, tunnels, traffic guidance systems and lighting. The combination should lie in the middle between the constraints imposed by agreements on finance, works on parallel roads and policy on mobility, safety and environmental issues such as the reduction of noise emission.

3. Typical features for maintenance and combination with noise abatement measures

On the motorways maximum traffic speed limit is 130 km/h, freight traffic is limited to 80 km/h. The major component of traffic noise comes from the tyre/road interaction. Only on roads where the traffic speed is below 50 km/h the noise is predominantly attributed to engine, transmission and exhaust emission, especially from trucks. The noise that is produced by the tyre/road interaction has various sources, like the vibration of the tyre wall and the compression of air within the contact area of the tyre [3]. These are sources that cannot be affected by Rijkswaterstaat. A more pertinent source is the noise generated by air forced out between the rubber blocks of the tyre and the road surface (the air pumping effect). This noise can be reduced by the application of porous asphalt. The pores of this type of asphalt absorb sound waves from the engine and transmission system of the vehicle and therefore reduce the propagation of noise. In the late 80s of the last century, these properties have prompted the Dutch government to make the application of porous asphalt types mandatory on all parts of the motorways with the exception of places where technical conditions require different surface types. The transfer to porous asphalt has been applied gradually, on moments that the existing top-layer of the non-porous pavement needed to be exchanged by a new layer. After 25 years of transfer, 86% of Dutch motorways have porous asphalt. Of the other 14% none-porous asphalt, 11% is applied on slip roads, exits and connecting roads where traffic speed is low and technical conditions are not optimal. The other 3% will be transferred to porous asphalt as soon as possible (1% before 2017).

Legislation forces Rijkswaterstaat to monitor the noise levels emanating from motorways closely. Since 2012 the law prescribes that noise levels have to remain below a threshold value. In the Netherlands we call it the 'Geluidproductieplafond' or GPP. The GPP-value is calculated by a sophisticated noise model that uses a wide range of input parameters. The model computes GPP-values for every 100 meter section of the motorways. Rijkswaterstaat has to prevent the modelled noise level to exceed the GPP. The noise model Rijkswaterstaat uses can simulate the increase of noise emission and henceforth can predict the moment the GPP-value will be reached. On locations where an imminent overrun of GPPs has been identified, noise research is necessary to identify effective noise measures like noise barriers and/or noise reducing pavements.

One way of ensuring that the noise level remains below the threshold value, is to apply a speed reduction. There is a clear relation between the noise level and the average speed of the traffic on the highway. However, (with the exception of the concerned residents) a speed reduction is not welcomed by the general public and it is not in compliance with current policies. Another way to mitigate noise levels is to replace the surface layer of the pavement with a type that has better properties for noise reduction than the one applied (which is mostly single-layer porous asphalt). This type is available and is called double-layer porous asphalt [4]. Double-layer porous asphalt is generally 30 mm thicker and it is applied only when the entire road is resurfaced (otherwise extra costly measures will have to be taken to prevent that the height of the new lane will stick out). The transfer from single to double-layer porous asphalt does not take place when measures are taken to prolong life of the right hand lane.

Research is done in order to stimulate the development, possibilities for practical use and putting into service of other noise reducing surface layers.

4. Guidelines for the planning and programming of maintenance

This implies there are two main criteria for resurfacing a road: the technical state of the road surface and the noise level. Application of these two criteria will almost always yield in two different resurfacing moments. Choosing between them comes down to finding the best way between the unnecessary destruction of capital on the one hand and meeting the legal demands for noise reduction on the other hand. This choice emphasis the necessity to plan and programme the transfer from single to double-layer porous asphalt meticulously. And the need to do that according to understandable and practical guidelines. In this paragraph we will outline them by using an example.

Let us assume a section of highway X has obtained a new surface of single-layer porous asphalt in 2004. On average, the pavement on the right hand lane will last 11 years and would need to be replaced in 2015. It then should receive a treatment that prolongs its function for 6 years, after which the left hand lane(s) will also need to be replaced. On average, life expectancy of the left hand lane(s) is 17 years. In this example, the left hand lane(s) should be replaced in 2021. That is also the moment when the service lane should be serviced. The next moment for the complete resurfacing of all lanes would be 2038.

Let us also assume that the noise model predicts that there would be an overrun of the GPP in 2027 and that transferring to double-layer porous asphalt would be effective to stay below it.

Then the question would be, when and how to replace the single-layer porous asphalt by double-layer porous asphalt. Should that be in 2021, when the entire surface layer would normally be replaced by single-layer porous asphalt? So, with 6 years to go before crossing GPP? Or should the single-layer porous asphalt be replaced by double-layer porous asphalt in 2027, when half of the capital in the right hand lane and two thirds of the capital in the left hand lane would be destroyed by prematurely upgrading the surface layer? Or could we prolong the moment of intervention by another means than maintenance techniques?

We have agreed upon the following guidelines.

- Primarily, it is the technical state of the road surface that prescribes the moment of maintenance. Upgrading the surface layer from single to double-layer porous asphalt can only take place when left hand lanes are worn out and the entire road is serviced.

A. If the GPP year is no later than 5 yrs after the programming year, then transfer will happen immediately (on the programmering year) and thus maximally 5 yrs in advance of the GPP year. In our example, transfer takes place in 2021.

B. If the GPP year is later than 5 years after the programming year, then method 1 or 2 is used to decide upon the year for transfer.

B1. Method 1: If the maximum speed is 130 km/h, the scheduled timing for transfer will be the first possible technical moment before the year GPP is reached. In our example, this is 2021, 6 years ahead of reaching GPP. In other examples this time lapse can only be longer, but necessary to meet the legal demand. Rijkswaterstaat will not get allowance to delay noise reduction at these locations.

B2. Method 2: If the maximum speed is less than 130 km/h, then the scheduled timing for the transfer can be 5 years later than the GPP year, if the Minister allows it. An allowance to cross GPP can legally be given only once, for maximally 5 years. In our example, with allowance, transfer can take place in 2032. If the allowance is not given, the transfer should take place prematurely (in 2021) in order to prevent capital destruction.

In our example, that means that the programmer has to advise to follow method A or B1 or B2 in 2020 or earlier. So, the important realisation is, that in order to follow the guidelines, programmers need to have all necessary information well ahead of reaching the first possible year for transfer. As many transfers should take place maximally 5 years ahead of reaching GPP, information should be available *at least* 6 years ahead of reaching it.

5. Risk analysis in the process for maintenance by Rijkswaterstaat

And it is, but only for part of the necessary information. Input on the technical year for maintenance and on the whether allowance will be given is available long enough in advance. But information on the exact year of crossing GPP is not. In 2014 we reported the growth in noise emission level up to 2018 [5], no more than 4 years ahead in time. For 2019 and beyond, no distinction is made on when the GPP limit will be reached at a certain location. For those years, we lack information to follow the above guidelines.

One of the reasons for this omission appears to be the amount and the detail of information the noise model uses. It seems to be too much and thereby overly sophisticated for long term estimations. Possibly a simpler version of the model, or an extra tool, should be developed to establish insight in reaching GPP levels for more than 6 years ahead.

As long as we are without sufficiently long term information on when GPP is reached, we cannot follow the guidelines. In the near future (2019 and further), this can result in either exceeding GPP-limits without the proper legal exemptions (by which Rijkswaterstaat may find itself violating the law) or in larger than agreed upon capital destruction of relatively young single-layer porous asphalt (by which Rijkswaterstaat may find itself exceeding budget agreements).

6. Conclusion

In order to be able to conduct the agreed upon guideline for the transfer of single to double-layer porous asphalt, it is necessary for Rijkswaterstaat to estimate noise emission levels at least 6 years ahead. That is further ahead in time than momentarily practiced. In order to do this, it may be useful to develop a much simpler tool for noise modelling than the one in practice and to put it to use in the process to maintain GPP-limits.

Acknowledgement

This paper is the result of the chairman of this section of the congress, drs. Wiebe Alberts (Rijkswaterstaat, Department for Water, Traffic and Environment), pushing the authors to submit a paper, rather than just presenting a power point. As we always think we have no time, we indeed never find it. Thank you for pushing.

References

[1] Rijkswaterstaat, Annual report 2013, The Hague, 2014.

[2] S.T. Muench, C. Weiland, J. Hatfield, L.K. Wallace, Open-graded wearing courses in the Pacific Northwest, Final Report, SPR 680, Department of Civil and Environmental Engineering, University of Washington, Seattle, 2011.

[3] A. Kuijpers, G. van Blokland, SILENCE Simulation tool for road/tyre modelling – The influence of road parameters on tyre/road noise, 6th Framework Programme, 2006.

[4] P.A. Morgan, IPG Research Report – Innovative mitigation measures for road traffic noise, DVS-2008-18, Delft, 2008.

[5] Rijkswaterstaat, Nalevingsverslag geluidproductie-plafonds rijkswegen 2013, Delft, 2014.