Development and testing of low noise pavements in Norway

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ABSTRACT: A research and development project named ‘Environmentally friendly pavements’ is being conducted under the auspices of the Norwegian Public Roads Administration and in close cooperation with research institutions and the road industry. The project focuses on the noise and dust properties of road surfaces. The project was started in 2004 and will be completed in 2008. The project aims to optimize the environmental properties of road surfaces and thereby contribute to achieving the national targets set for levels of noise and suspended matter (road dust). A central part of the project is the development of low noise asphalt surfacings adopted to Norwegian conditions. Under the project, a wide range of test pavements have been constructed and are being monitored. The effect of reduced maximum aggregate size in ordinary pavements is investigated. Further two sections with one layer porous pavements and three sections with twin layer porous pavements have been constructed. Different types of thin layer pavements are also being tested. Description of selected test pavements and results from field measurements is presented in this paper.

1 INTRODUCTION

The Norwegian Public Roads Administration started a research and development project on environmentally friendly pavements in 2004. The objectives of the project were to reduce noise and dust originating from road-tire interaction by optimizing the acoustic properties of surfacing materials as well as improving their resistance to wear.

Pavement wear caused by the use of studded tires in winter times is a major cause of rutting in asphalt pavements in Norway and other Nordic countries. The problem of pavement wear due to studded tires has been extensively studied in the 1970s and 80s. As a result of this work several measures were introduced to reduce the wear including the use of large and hard stone materials in the asphalt, development of so-called environmental studs, development of stud-free winter tires and introduction of fee for using studded tires in some urban centres. The use of asphalt mixtures with relatively large maximum aggregate size as surfacing materials has however resulted in another environmental problem; namely noise. Owing to the rough surface texture resulting from the use of large aggregate sizes, these pavements generate significantly more noise compared to asphalt pavements with lower maximum aggregate sizes.

Road traffic noise has become one of the major environmental problems. In Norway, about 1.4 million people are exposed to road traffic noise levels exceeding the acceptable limit of 55dB(A). This accounts for 79% of the noise annoyance expressed in terms of noise annoyance index.

In the last few decades attempts have been made, in several countries, to mitigate the problem of road traffic noise through the use of low noise pavement surfaces and noise barriers. However, noise barriers have not been effective particularly in urban setting where high rise buildings lie close to the streets.
Therefore, emphasis has been placed on the development and use of low noise pavements. Several types of pavement surfaces with varying levels of desirable acoustic properties have been developed. These pavement surfaces include porous asphalt pavements, thin pavements, surface treatments, poroelastic surfaces, etc. Porous asphalt was considered to be the most effective in terms of noise reduction and was tried in many countries. While some countries report to have successfully used porous asphalt pavements, many others have reported loss of noise reducing property of the porous asphalt due to clogging of the pores with dust and detritus.

In Norway, a major research project was initiated 1990 by Norwegian Public Roads Administration on low noise road surfacings, particularly porous asphalt pavements. The objective was to establish mix design for low noise road surfacings under urban conditions. Field test sections were constructed in several places and their performance in terms of noise reduction and other pavement performance indicators was studied. The study concluded that it is possible to obtain noise reduction of up to 5 dB (A) by using porous asphalt compared to the conventional dense asphalt wearing course (Arnevik and Storeheier 1994). It also noted that friction levels on porous pavements are approximately the same as those on dense wearing course. The main problem identified in the study was the clogging and that the available technology did not allow effective cleaning of the pores to maintain the noise reducing properties of the porous pavement. As a result of the use of studded tires, the problem of clogging can be severe. Because of the clogging problem, the Norwegian experiment on the use of porous asphalt was considered unsuccessful and the traffic noise problem remained largely untouched.

Since the end of the project however several developments took place in other countries; including the development of low noise thin pavements and double layer porous asphalt. These pavements have been used successfully in a number of countries (Bendtsen 2002). The current project therefore aims to evaluate these low noise pavements for use under Norwegian conditions and to come up with needed improvements to make them more suitable to prevailing road, traffic and climatic conditions in Norway. This paper gives the description of the test sections and the results of noise measurements.

2 THE TEST SECTIONS

Test sections were built at several locations and on various kinds of roads in Norway. Summary information for the test sections is provided in table 1. Results from these locations are reported in this paper.

Table 1. Test sections

<table>
<thead>
<tr>
<th>Road No./Location</th>
<th>Mixture type</th>
<th>Dmax (mm)</th>
<th>% ≤ 2 mm</th>
<th>Binder type</th>
<th>Binder cont.</th>
<th>Void content</th>
<th>Thickness (mm)</th>
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<td>14</td>
<td></td>
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<td>10.8</td>
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<td>T8g</td>
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<td>11.0</td>
<td></td>
<td>6.2</td>
<td>23.3</td>
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<tr>
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<tr>
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<td>6.2</td>
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<td>6.25.0</td>
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<td>40/45</td>
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</table>

3 MEASUREMENT OF NOISE

All measurements have been made with a CPX trailer, owned by the Norwegian Public Administration. Figure 1 shows the picture of the trailer. The trailer was built by M+P Noise & Vibration engineering, a Dutch company in 2005. The trailer is fixed with an absorptive enclosure,
with two microphones on the inside of the enclosure, close to each of the two tires fitted to the trailer.

The measurements were made according to ISO/CD 11819-2, a proposed ISO standard procedure for close proximity method of measurement, (ISO) using the reference tire A (Avon ZV1). Tire A is chosen to be representative of the passenger car traffic on the road. The method is currently under revision, including a selection of new reference tires.

At three of the locations reported here, measurements have been made every year from 2005 to 2008. This means that the test surfaces on these locations have been exposed to three winter seasons. At location 4, the surfaces were laid in 2006, so they were exposed to the influence of two winter season only.

Measurements were conducted at both 50 and 80 km/h. Since the majority of the houses exposed to traffic noise in Norway are close to roads with a speed limit less than 80 km/h, it was necessary to investigate the noise reduction potential of the road surfaces also at 50 km/h. At location 3, the speed limit is 60/70 km/h, so measurements at this location were only made at 50 km/h. The measurements at location 1 were conducted only at 80 km/h in 2005 and 2006, so only those results are reported here.

Figure 1. The CPX-trailer

4 RESULTS OF NOISE MEASUREMENT

This section presents the results from the noise measurement. The reported noise level is, according to the ISO-standard, the average level over the measured distance, LA + 1.0 dB(A). All levels are the average of left and right wheel track, as well as the average of both lanes (except for location 3, where measurements were made in one lane only).

All levels have been temperature corrected to + 20 °C, using the correction formula of -0.06 dB/°C. The air temperature during the measurements was in the range of +17 to +25 °C. Figures 2 to 6 show the measurements results at the 4 locations reported here. At location 2, measurements have only been made at 80 km/h and at location 3, only at 50 km/h.

As a reference value, an average level of a range of measurements on dense surfaces with maximum aggregate size of 16 mm has been chosen. Based on the reference tire A, this reference value is 94.1 dB(A) at 50 km/h and 101.6 dB(A) at 80 km/h.
Figure 2. Noise measurement results at location 1 at 80 km/hr

Figure 3. Noise measurement results at location 2, at 80 km/hr
Figure 4. Noise measurement results at location 3 at 50 km/hr

Figure 5. Noise measurement results at location 4 at 50 km/hr
5 DISCUSSION OF NOISE MEASUREMENT RESULTS

With a few exceptions, there is a considerable change in the noise levels after 1-3 winter seasons. On average, the noise levels increased by approx. 2-4 dB(A). The smaller the maximum aggregate size, the higher the increase. This increase in noise levels is probably due to use of studded tires during the winter times in Norway. At the locations presented in this paper, the percentage of cars using studded tires was approx. 50%.

After one winter season, the noise levels on the dense surfaces seem to stabilize somewhat. At location 4, it is interesting to observe that one of the double layer porous asphalt surfaces, the ViaQ11/16 has retained its initial noise level at 50 km/h and almost also at 80 km/h after the first winter season. This double layer porous asphalt surface with 11 mm maximum aggregate size in the top layer seem to perform acoustically very well, also after being exposed to one winter season. However, after the second winter, the clogging effect seems to have reduced most of the sound absorbing effects of all the porous surfaces. One of the other double layer surfaces (DaFib8/16), has changed considerably with an increase in noise of more than 6 dB(A) and this is probably due to some construction problem.

The thin layers tested seem to give noise reduction of approx. 1-2 dB(A) in the speed range of 50 to 80 km/h, compared to the reference surface. Thin layers with a maximum chipping size of 6-8 mm have the highest noise reduction, compared to layers with 11 mm.

The best double layer porous asphalt layer seems to give a reduction of approx. 2.5-3 dB(A) compared to the chosen reference. Note that this reduction estimate is related to passenger cars only, due to the measuring method described above. It is likely that the overall traffic noise reduction will be somewhat lower, because truck tires/truck noise is less influenced by a porous surface than light vehicles. Measurements according to the statistical pass-by method (ISO 1997) have been performed at location 4 and will be used for further analysis of the acoustical performances of the test surfaces.

6 CONCLUSIONS AND RECOMMENDATION

Noise measurement results presented in this paper show that thin pavements can reduce noise by about 1-2 dB (A) compared to the reference surface. The best performing double layer porous asphalt gave a reduction in noise of about 4 dB (A) after the first winter season, but reduced to approx 2.5-3 dB(A) after the second. A noise reduction of about 3 dB (A) is obtained from a
single layer porous asphalt after one winter, but reduced to approx. 1 dB/(A after the second, compared to the reference. The performance of the tested pavements in terms of noise reduction appears to diminish fast after exposure to winter. The challenge, therefore, is to find ways of making the low noise pavement durable in terms of their acoustic performance. Currently further monitoring of the test pavements is underway to draw firm conclusions with regard to their acoustic performance.

REFERENCES


