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A LIFE NEREiDE test track with a poro-elastic pavement in Belgium

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ABSTRACT

The poro-elastic road surface (PERS) is an innovative pavement consisting of stone aggregates and rubber granulates, bound with an elastic resin, such as polyurethane. Dating from 1978 in Sweden, it can yield unequalled reductions of the tyre/road noise, ranging between 7 and 12 dB, whereas the best performing "conventional" noise reducing pavement, two layer porous asphalt, cannot do better than 7 dB. Since the invention of PERS, experiments have been carried out in several countries demonstrating the major drawback with this pavement type: its vulnerability and limited lifetime. In the FP7 PERSUADE project (2009-2015) a holistic approach was followed covering all relevant aspects. Several field tests on trafficked roads revealed that gluing prefabricated PERS slabs on a rigid under layer, is the most promising PERS technology. The LIFE project NEREiDE (2016-2020) focuses on the use of recycled materials in noise reducing pavements and comprises a work package about PERS. In the frame of this project, a 44 m long test track was constructed with prefabricated PERS slabs, on a local road in Gent, Belgium continuing on the technology developed in the PERSUADE project. This contribution outlines (briefly) the construction process and shows the promising results obtained so far during the subsequent monitoring. A noise reduction of up to 8-9 dB has been found, both with CPX and SPB methods.

Keywords: low noise pavement, rubber, poro-elastic road surface

1. INTRODUCTION

The main noise source of cars is the interaction between tyres and the pavement, at least if the car is driving at speeds above 30 km/h. Abating traffic noise is hence mainly reducing tyre/road noise. One should attempt to make tyres quieter, but the pavements as well. From the pavement perspective, the tyre/road noise can only be reduced by changing one or more of three pavement parameters. These parameters are: the pavement texture (rule of thumb: a minimum of megatexture combined with a maximum of macrotexture), the absorption by the pavement (high accessible void content and a proper shape and length of the “channels” formed by the voids) and the elasticity of the pavement. Low noise pavements based on an optimized texture or a high void content do exist and are even widespread in some countries, such as the Netherlands. However, the third possibility to reduce noise, reducing the dynamic stiffness, is barely exploited so far in the commercially available pavement types. A limited amount of extra noise reduction is claimed in some countries by adding rubber to bituminous pavements, typically 1 up to 2 dB(A), but these pavements are still quite “hard” compared to the tyre,. One can suppress tyre/road noise much more by making the pavement much more elastic, as demonstrated with PERS.

2. PERS: OPPORTUNITIES AND CHALLENGES

2.1 What is PERS?

PERS is a porous (at least 20 % of accessible voids) and elastic pavement containing rubber granulates (at least 20 % by weight, virgin material or recycled) and an elastic polymer as binder, such as polyurethane. It may contain other ingredients, such as natural or artificial stone aggregate, certain

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chemicals or certain types of fibres. Each of these ingredients has a specific function: enhancing skid resistance, durability, homogeneity of the wet mix, etc.

2.2 Why do we (still) want it?

PERS is in fact not a new idea: it has been invented at the end of the 1970ties by the Swedish consultant Nils-Åke Nilsson and some tests have been done in Sweden, Norway and from mid 1990ties also in Japan, demonstrating its huge and unequalled noise reduction potential: 7 up to 12 dB(A). The low noise pavements with the highest noise reduction which are in use today, two-layer porous asphalt, yield "only" 5 – 7 dB(A). Some further testing on PERS has been done in a national project in Sweden, in the national project "Noise Innovation Program" and in the subsequent project "Ultra Silent Pavement" in the Netherlands. A comprehensive overview of the history of PERS can be found in (1).

This huge noise reduction potential makes PERS very attractive. PERS reduces – at least for cars – as much noise as typical noise barriers, opening interesting perspectives for noise abatement. Noise screens indeed do have many disadvantages. They are expensive; their effectiveness depends on the local weather conditions; they are vulnerable to vandalism; intrusive and last but not least: there are many situations where they cannot be used, e.g. along most city streets.

2.3 Requirements and challenges

There are a few reasons why PERS is still a concept and not yet a widespread tool for noise abatement, in spite of the fact that the concept was invented 40 years ago. The history of PERS is up to now mainly a list of failures (1). The main reasons of the failures were: insufficient ravelling resistance, insufficient bonding to the sub layer and insufficient skid resistance. In some cases, the failures were due to reasons which were "external" to the PERS, such as disintegration or rutting of the sub layer(s) or accidental destruction of the PERS by a snow plough. The lifetime of the PERS varied from a few weeks up to a few years with some relatively successful Japanese experiments and a quite successful PERSUADE test track (see further). There were also questions about the fire safety and the safety of the workers, the economic feasibility and the sustainability of the product.

2.4 The PERSUADE project

Between 2009 and 2015 an FP7 project "PERSUADE" was conducted in order to develop PERS from a yet experimental concept to a usable noise abatement measure (2).

The problems to be solved and questions to be answered about PERS at the beginning of the project were numerous: how to produce a mix which would yield a durable, highly noise reducing pavement with a sufficient skid resistance? How to avoid the PERS to ravel or to loosen from the sub layer? What in the case of a fuel spill? Or in the case of an accidental vehicle fire on a PERS section? How to build PERS without increasing rolling resistance? Which precautions should be taken to protect road workers and residents living nearby from hazardous fumes during construction? What to do with PERS at the end of its lifetime? What about economic aspects?

The PERSUADE project turned out to be a partial success: achievements are the demonstration that PERS can be quite ravelling resistant (comparable to thin asphalt layers), that it is not toxic and there is no fire risk. On the contrary, PERS can be used for better fire protection in, for example, tunnels. Obtaining a good skid resistance is easily possible and its noise reduction is comparable to a 4 m to 6 m high noise screen on both sides of the road. Application techniques have been developed, tested and well documented. PERS can dramatically reduce the production of fine dust from studded tyres. Winter behaviour is an issue but, as for porous asphalt, this can be avoided by an adapted winter strategy. The product can be beneficial from an economic point of view in some cases. Moreover, when the noise reduction is taken into account it is a sustainable solution.

The project team was less successful in demonstrating the long term durability: the monitoring time of the full scale test sections became shorter than planned due to some delays with finding and testing durable mixes, but also the construction was delayed, and some of the test sections failed prematurely. The team learned that PERS on an asphalt sublayer combined with a significant volume of trucks is not a good combination as it leads to delamination within about one year. If water is not properly evacuated from the PERS after rainfall, this might speed-up the delamination. However, on a road without trucks, or a low proportion of trucks, PERS may work. Furthermore, at the end of the project (August 2015) the consortium had indications , based on the observations on the Swedish and Slovenian test sections and the test in the wheel tracking device, that a prefabricated PERS slabs glued on a semi-flexible or cement concrete sub-layer will be much more durable, even under the action of truck tyres.

2.5 The best performing solution so far: PERS slabs on a semi-flexible under layer (3,4)

PERSUADE partner VTI constructed three PERS test tracks on the road E 363 about 15 km west of the town Linköping in central Sweden. The Annual Average Daily Traffic (AADT) is there about 4700 vehicles with 6 % heavy vehicles. The speed on the location is about 70 km/h (also posted speed). One test track was constructed with on-site mixed PERS and two with prefabricated PERS slabs.

PERSUADE partner Heidelberger Elastomertechnik GmbH (HET) in Germany, produced the slabs for the Sjögestad test track in the size of 1.0 m by 0.5 m. The thickness was decided to be 30 mm, as a compromise between cost and expected acoustic performance.

The PERS material had the following composition by weight:

- 53 % hard aggregate, made of basalt (čedič from Libochovany in Czech Republic). The hard aggregate was a mix of 10 % of fraction 0/4 and 90 % of fraction 2/4.
- 38 % soft aggregate (rubber granules) with a size distribution of 1/3.
- 9 % PUR (MDI-type)
- 1 % polyol mixture (Z962.02)

Earlier work, notably the work on PERS by PWRI in Japan, see (1), had indicated that the success of PERS relies on having a base course which is at the same time very rigid and to which the PERS can have a very strong bond. For that reason, a so-called “semi-flexible base layer” was used for one of the two "prefab" test tracks . This was the PERS test track that performed best. In this paper, we will only consider this one further and it will be indicated with "the Sjögestad PERS test track".

The PERS on the Sjögestad PERS test track was only laid in two 1 m wide and 30 m long strips in the wheel tracks and were afterwards surrounded with porous asphalt for the sake of protecting the PERS against the influence of the numerous passages of snow ploughs.

The Sjögestad PERS test track remained in a good condition during two winter seasons (2014 - 2016), although during the first winter a snow plough with steel blades passed about 100 times over it and damaged the test track in spite of the precautions to protect it. In April 2016 it still looked quite nice. The Swedish National Road Administration however regrettably removed the Sjögestad PERS test track in the autumn of 2016 as the two other PERS test tracks on the location were failing and they wanted to repave the area in one time for budgetary reasons. During its lifetime, noise measurements were carried out showing a stunning noise reduction of 10 - 12 dB with respect to SMA 11.

3. PERS AND THE LIFE NEREiDE PROJECT

The LIFE NEREiDE project (2016-2020) (5) aims to demonstrate the use of new porous asphalt pavements and low noise surfaces composed of recycled asphalt pavements and crumb rubber from scrap tyres. Although the main body of the project deals with rubber asphalt, hence bituminous pavements, a work package of the project is dedicated to the demonstration of bitumen-free PERS. One of the main tasks in this PERS work package is the construction of a test track on a trafficked road in Belgium, for both research (durability test) and demonstration purposes.

3.1 Test location for the NEREiDE PERS test track in Belgium

A suitable location for a test track was selected with the collaboration of the City of Ghent: a local road, called Noorderlaan, along an artificial lake for water kayaking. Posted speed is 70 km/h and the AADT is about 5000. The road is straight and vehicles pass at a steady speed. The existing pavement is a dense asphalt concrete with a considerable age. It was decided to construct the test track on the lane on the side of the lake where the existing asphalt is in a better state than on the other lane, where the asphalt shows fatigue cracks and is locally repaired.

3.2 Construction of the NEREiDE PERS test track in Belgium

For the demonstration of PERS in Belgium, one used the same technology which had proven to be successful on the Sjögestad test section, except that in this case the PERS was applied over the full width of one lane and hence not only in the wheel tracks. The dimensions of the new PERS test track in Ghent are 44 m x 4 m. For the PERS layer the same type of prefabricated slabs were ordered from Heidelberger Elastomer Technik (HET), i.e. with same dimensions (1 m x 0,5 m x 3 cm) and the same composition, although some technical improvements were allowed.

One constructed the test track in the second half of September 2018 and the procedure is outlined in (6). In short, one can say that the whole road structure was rebuilt starting from the unbound crushed stone base. Two binder courses were applied and on top of that a semiflexible underlayer, consisting of

a porous asphalt whose voids were filled with a cement slurry, actually resulting in a very rigid layer. A very stiff under layer turned out to be necessary for the longevity of the PERS pavement. The semiflexible layer was cleaned with water under high pressure, brushed and dried before the actual construction of the PERS layer could start. The epoxy glue was spread with paint rollers, the slabs were placed and on the corners weights were applied in order to avoid curling up. After a proper drying of the glue, the weights were removed. The remaining gaps between the new PERS surface and the original pavement were repaved with dense asphalt concrete and the PERS test track was opened for traffic. Some pictures from the construction process are shown in Figure 1.

Figure 1 – The construction of the test track: spreading of the epoxy glue (upper left hand side), the placing of the slabs (upper right hand side), weights on the corners of the slabs during the drying of the glue (lower left hand side) and the finished test track (lower right hand side)

4. MONITORING OF THE TEST TRACK

An extensive monitoring program has started as soon as the test track opened for traffic.

4.1 Skid resistance

The skid resistance was measured on the slabs before they were applied and this by means of the Skid Resistance Tester (SRT), see (7). The value was 60, which appears to be satisfying. The skid resistance will be tested as well with a high speed device, the BRRC odoliographe (8).

4.2 Visual inspections

Visual inspections are carried out on a monthly basis. From the beginning, some damage at the right hand side and most vulnerable edge of the test track was noted, due to maneuvering of cars leaving the

parking strip along the test track. Some slight raveling of the surface was observed as well from the first months (Figure 2).

Figure 2 – The test track: on 8 October 2018, just after completion (left) and 4 months later, on 29 February 2019 (right). Some slight "general" ravelling is noticeable.

4.3 Assessment of the acoustic quality of the PERS

4.3.1 Close ProXimity (CPX) measurements

One week after the opening of the test track, noise measurements were carried out with the CPX trailer of BRRC (Figure 3, left hand side), with the SRTT tyre (representative for the noise emission of car tyres) and the AVON AV4 tyre (representative for the noise emission of lorry tyres) (9). One measured at 30, 50 and 70 km/h and compared the noise levels (CPXP/CPXH indices) measured on the PERS test track with the ones measured on the adjacent dense asphalt concrete. The noise reduction varies between 8 and 9 dB for the SRTT tyre and between 6.5 and 7 dB for the AVON tyre (Figure 3, right hand side).

For some cars, seemingly with wider tyres and at higher speeds, some influence from the joints is audible, as some kind of parasitic noise. It is not completely clear why, as one did not observe this phenomenon on the Sjögestad test section.

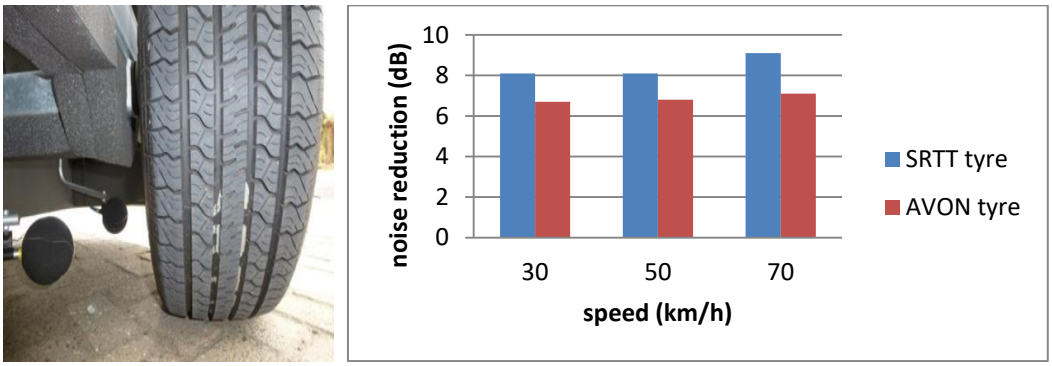

Figure 3 – CPX measurements on the test track on 8 October 2018 with CPX trailer: noise reductions of PERS with respect to the adjacent dense asphalt concrete as measured with the CPX trailer

4.3.2 Statistical Pass By (SPB) measurements

The noise reduction of the PERS slabs was determined six months after installation using the "Statistical Pass-By" (SPB) method (10) as well. In this study the reference speed v_0 is 50 km/h and no heavy vehicles are taken into account as not enough single heavy vehicles pass at the test location. All SPB-measurements were performed by two master students from UAntwerp with the equipment from the Belgian Road Research Centre (BRRC). Sound pressure levels were obtained using a B&K 2260 Investigator with a B&K 4189 Microphone, while the speed of the vehicle was determined using the Kustom Signals KR10SP. The complete setup, placed at a distance of 7.5 m from the center of test

track, is shown in Figure 4 (left). The results are summarized in Figure 4 (right) and compared to five different types of thin asphalt layers (TAL) and one reference (DAC 10) installed in Antwerp in October 2015 (11). The average speed of the passing vehicles was 51.2 ± 8.7 km/h, while the maximum SPL was 63.0 ± 2.9 dB. The noise reduction obtained with the PERS slabs is almost 8 dB while the TAL obtain on average 4.3 dB, with a maximum noise reduction of 5.2 dB.

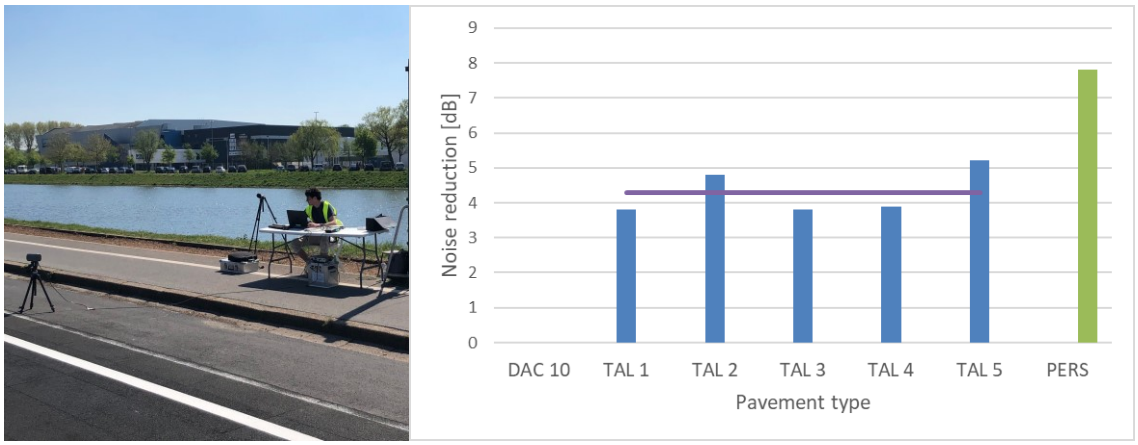

Figure 4 – (left) SPB measurement setup and (right) SPB results

4.4 Texture measurements

Macro- and megatexture measurements were carried out by means of the BRRC SELCOM laser profilometer (78 kHz band width, spot size 0,2 mm, vertical resolution 5 µm), see Figure 5(12). Mean Profile Depth values were calculated according to (13) and are shown in Figure 5. Generally, the MPD values have increased which reveals a light raveling. The average MPD value over the whole length was on 8 October 2018 0.72 mm ± 0.016 mm and on 29 January 0.80 mm ± 0.019 mm.

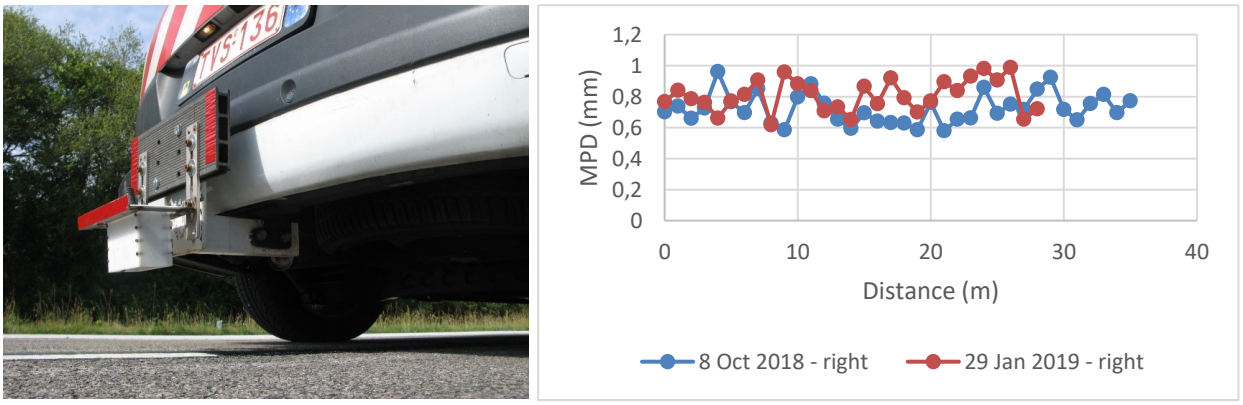

Figure 5 – (left) BRRC laser profilometer attached to the bumper of the test vehicle and (right) Mean Profile Depth values, averaged per m, measured in the right wheel track

4.5 Mechanical impedance measurements

The mechanical impedance of the prefabricated PERS slabs has been tested both in the laboratory as in situ. The measurement procedure and theoretical background are thoroughly described in (14) and shown in Figure 6 (left). A PCB Piezotronics high sensitivity, ceramic shear ICP accelerometer type 352C33 (upper frequency limit 10 kHz), a PCB Piezotronics Modally Tuned® Impulse Hammer type 086D05 and a PCB Piezotronics ICP Impedance Head type 288D01 are used for these measurements, as shown in Figure 6 (right). Measurement results will be available at the conference presentation.

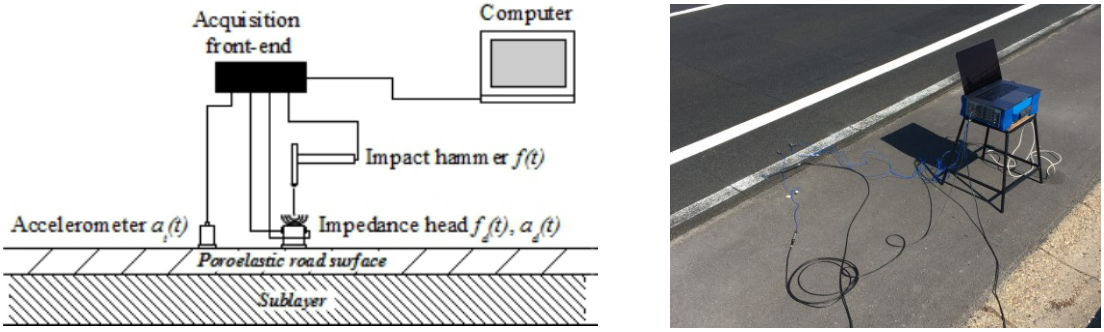

Figure 6 – (left) Procedure for the determination of the mechanical impedance (14) – (right) Actual setup

5. CONCLUSIONS

A new PERS test track with prefab slabs of 3 cm thick glued with epoxy on a semiflexible under layer has been built on Belgian soil according to the findings of the PERSUADE project. The test tracks looks well-constructed. Initial noise reduction is excellent, up to 8-9 dB as shown by both CPX and SPB results, but a parasitic noise allegedly caused by the joints is audible. During the first months a light raveling has been observed and measured. A follow-up monitoring plan comprising all relevant parameters is ongoing.

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