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A New Test Track With The Ultra Noise Reducing Poro-elastic Road Surface (PERS) In Gent, Belgium

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ABSTRACT

PERS is an innovative yet experimental pavement consisting of stone aggregates and rubber granulates, bound together with an elastic resin, such as polyurethane. It was invented at the end of the 1970ies in Sweden and it became quickly clear that it can yield unequalled reductions of the tyre/road noise: between 7 and 12 dB, whereas the best performing "conventional" noise reducing pavement, two layer porous asphalt, cannot do better than about 7 dB. Since the invention of PERS, in several countries experiments have been carried out quickly making clear the major drawback with this pavement type: its vulnerability and hence limited lifetime. In the frame of the EU PERSUADE project (2009-2015) a holistic approach was followed covering all relevant aspects. Several field tests on trafficked roads revealed that the prefab PERS slabs, glued 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 for further study and demonstration. In the frame of the LIFE NEREiDE project, a 44 m long test track was constructed on a road in Gent, Belgium with prefab poro-elastic slabs, building on the technology developed in the PERSUADE project. This contribution outlines the construction process and the first test results obtained in the subsequent monitoring program.

Keywords: Noise, Environment, Tyre/road noise, Low noise pavements, Noise reduction, Poro-elastic road surface, Rubber
I-INCE Classification of Subject Number: 30

1. INTRODUCTION

Tyre/road noise is for cars already at low speeds (typically as low as 30 – 40 km/h) the dominant noise source. Abating traffic noise is hence mainly reducing tyre/road noise. One can (and should) work on the tyre properties to reduce noise but also on the pavement. To reduce the tyre/road noise, one can only “turn on three buttons”: the pavement texture (rule of thumb: a minimum of megatexture combined with a maximum

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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, making the pavement elastic, is hardly exploited so far in the commercially available pavements. Some extra noise reduction is gained in some countries by adding rubber to bituminous pavements, but these pavements are still quite "hard" and the gain is limited, typically 1 up to 2 dB(A). One can suppress tyre/road noise much more by making the pavement much more elastic, and this idea is exploited with PERS.

2. PERS: OPPORTUNITIES AND CHALLENGES

2.1 What is PERS?

PERS is a porous (at least 20 % of 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 chemicals or certain types of fibres. Each of these ingredients may have 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, as noise screens do have a lot of 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 a lot of situations where they cannot be used, e.g. in 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 where 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 snowplough. 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 [2]

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.

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 people living around from hazardous fumes? 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), 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 friction is not a major problem 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 overcome with 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. The consortium had at the end of the project (August 2015) indications however, based on the observations on the Swedish and Slovenian test sections and the test in the wheel tracking device, that a PERS 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. 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 one used for one of the two "prefab" test tracks also a so-called “semi-flexible base layer”. 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 snowploughs (Figure 1).

Figure 1 The PERS track in Sjögestad (two strips in wheel tracks) under construction (photo: courtesy of Ulf Sandberg, VTI)

The Sjögestad PERS test track remained in good condition during two winter seasons (2014 - 2016), although during the first winter a snowplough with steel blades passed about 100 times over it and damaged the test track in spite of the precautions to protect it by surrounding it with porous asphalt. In April 2016 it still looked quite nice (see *Figure **2***). 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 budget reasons. During its lifetime, noise measurements were carried out showing a stunning noise reduction of 10 - 12 dB with respect to SMA 11.

Figure 2 The PERS track in Sjögestad in April 2016 (photo: courtesy of Ulf Sandberg, VTI)

3. PERS AND THE LIFE NEREiDE PROJECT

The LIFE NEREiDE project (2016-2020) aims to demonstrate the use of new porous asphalt pavements and low noise surfaces composed by 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: one has chosen a location on a road, called Noorderlaan, along an artificial lake for water kayaking (Figure 3). 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 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 also locally repaired.

Figure 3 The location of the NEREiDE PERS test track on the Noorderlaan in Ghent, Belgium

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 de 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 prefab 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 we allowed HET to include any technical improvements in their product which has been introduced since the production of the slabs for the Swedish test track, i.e. 4 years ago. When we received the 180 slabs, it was striking that the quality looked better than the ones delivered for the Swedisch test track: there were no slabs with a poor homogeneity. The skid resistance was tested in the laboratory with the Skid Resistance Tester and turned out to be very good: 60.

The construction by contractor Stadbader started on 17 September 2018 with the milling off of the pavement to a depth of -18 cm, down to (and into) the unbound crushed stone base. Subsequently, two binder courses are applied, the first is laid to the crossfall required to provide a good substrate for runoff. On top of the second binder course, a "combideck" under layer is constructed, which is similar to the semiflexible under layer used on the Sjögestad PERS test track. In fact a semiflexible or combideck under layer is very stiff. This turned out to be necessary for the longevity of the PERS pavement. The slightest plastic deformation of the underlayer can cause loosening of the PERS top layer and a premature failure of the test track. The combideck under layer is constructed by laying a porous asphalt 0/14 of 4 cm thick (Figure 6). The voids of the porous asphalt are a few hours later filled with cement slurry (Figure 7).

Figure 4 Porous asphalt layer

Figure 5 Filling of the voids of the porous asphalt layer with cement slurry

After 48 h, the hardened combideck was treated with water under high pressure in order to remove the cement film and to ensure a good adhesion of the PERS layer to it.

Another 48h later, one started with the cleaning and drying of the surface with compressed air and heat in order to prepare it for the gluing of the PERS slabs.

First a primer is applied which cured for about two hours and then one started to lay the PERS slabs. The glue was mixed – it was a two component epoxy glue – and spread with paint rollers in a tick coat (Figure 6, left hand side). The slabs are applied manually (Figure 6, right hand side) and a mass was applied on the corners in order to prevent them to curl upwards (Figure 7, left hand side). The laying process took about 1,5 day. Finishing areas have been left around the test section, to allow good connection with the existing pavement and this has been done the day after. The parking area along the test track had been milled of and repaved in such a way that its top level corresponds to the underside of the PERS slabs in order to allow rainwater to flow out of the porous PERS unhindered. As aforesaid, it is presumed that water being trapped in the porous structure of PERS is adverse for its durability, especially to the bonding to the sub layer.

On 3 October 2018, the test track is opened for traffic, i.e. 8 days after the laying of the PERS slabs. The test track looks quite smooth and level (Figure 8). There is some variation of the width of the joints, from say 0 up to 5 mm, and they are on some places wedge formed, but everything within acceptable limits.

Figure 6 Application of the glue (left hand side) and manually laying of the slabs

Figure 7 Curing PERS test track with bricks on the corners to avoid curling up of the slabs

Figure 8 View on the PERS test track one day after opening for the traffic

3.3 Measurements on the test track

One week after the opening of the test track, noise measurements were carried out with the CPX trailer of BRRC (Figure 9), 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) [5]. One measured at 30, 50 and 70 km/h and compared the noise levels (CPXP index) 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 10).

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

A planning for the further monitoring has been made and one will measure periodically the acoustic quality, the texture, the skid resistance, the evenness, the mechanical impedance and the sound absorption. The test track will as well be inspected visually on a monthly base to record any damage. BRRC will keep monitoring the test track extensively after the end of the project in March 2020, as long as the test track remains in an acceptable condition.

Figure 9 CPX measurements on the PERS test track one day after opening for the traffic

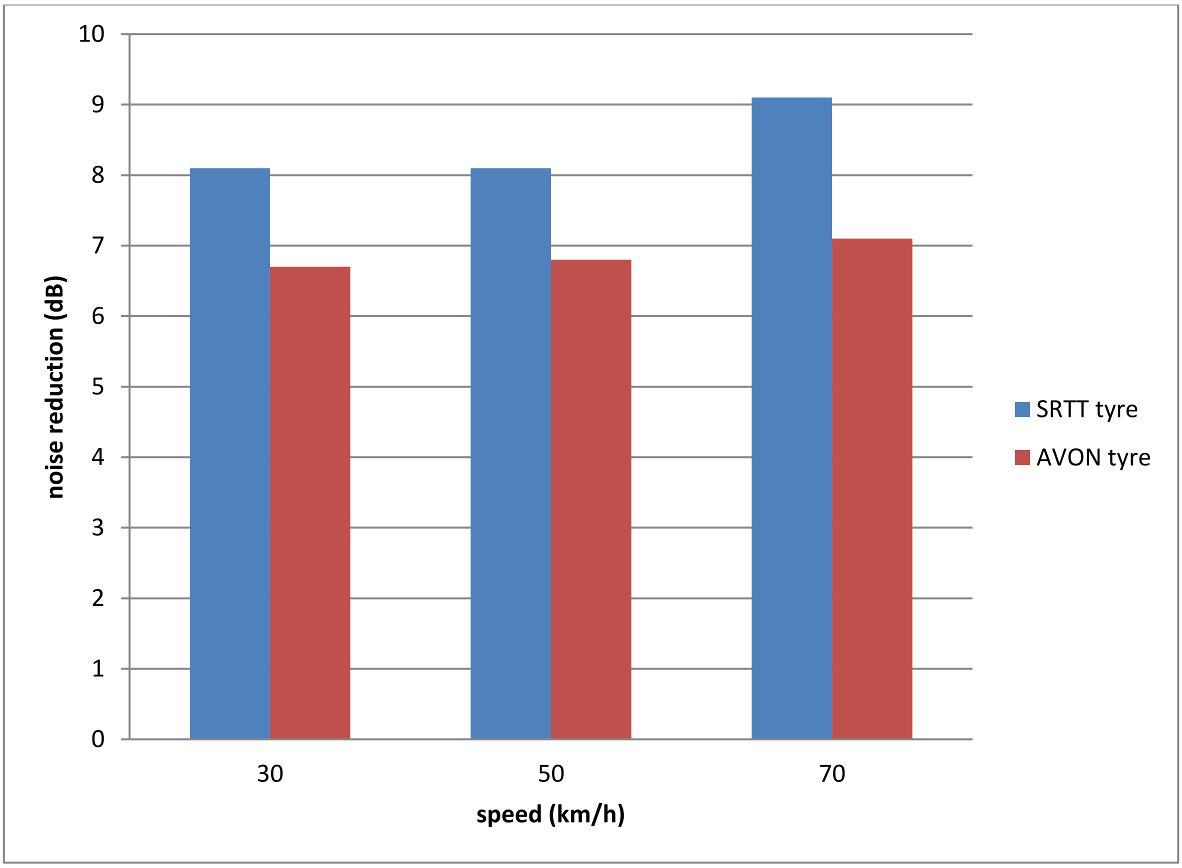

Figure 10 Noise reductions of PERS with respect to the adjacent dense asphalt concrete as measured with the CPX trailer one day after opening for the traffic

4. CONCLUSION

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. Initial noise reduction is excellent and the test track looks well-constructed. A follow up monitoring plan comprising all relevant parameters has been initiated.

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