Tyre/road noise reduction of poroelastic road surface tested in a laboratory

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ABSTRACT

A so-called poroelastic road surface (PERS) is being developed in Europe. This contains a large percentage of rubber particles mixed with hard aggregate (stone and sand) and bound with polyurethane. This gives high air void content (around 30 %), high elasticity and smooth texture, all of which should give low noise properties. In this experiment a nominally 30 mm thick sample of PERS was mounted on a steel drum. Various car tyres were then run on the PERS surface at a range of speeds, while measuring noise levels and frequency spectra. Similar measurements were made when the drum was equipped with a replica of a dense asphalt surface as well as a rough-textured surface dressing. These measurements indicated a 9-10 dB reduction in A-weighted noise level compared to the replica of the dense asphalt surface, and even higher when compared to the surface dressing. In addition, rolling resistance measurements were made with similar equipment and facility. The results showed that the rolling resistance was almost as low as that on a smooth sandpaper surface (a standard surface allowed in ISO tests), which is likely to give lower rolling resistance than most conventional road surfaces.

INTRODUCTION

The road surface material and construction have a substantial influence on the tyre/road noise emitted by traffic [Sandberg & Ejsmont, 2002]. Especially, double-layer porous asphalt pavements have been found to provide noise reductions of 5-7 dB(A) compared to conventional pavements, such as dense asphalt concrete (DAC) and stone mastic asphalt (SMA) with nominal maximum aggregate size of 11 mm which are, arguably, the most common pavement types worldwide. However, the porous pavements, and most others offering high noise reduction, generally deteriorate much faster than the normal pavements. Therefore, attempts are made to produce low noise pavements with better acoustical and technical longevity and/or with higher noise reduction. An innovation which has a potential to meet such demands is the so-called poroelastic road surface (PERS). This contains a large percentage of rubber particles mixed with a hard aggregate (stone and sand) and bound with polyurethane.

Within the ongoing large European project PERSUADE (www.persuadeproject.eu), this special type of low-noise road pavement is being developed. As part of the project, several PERS mixtures with various proportions of the major materials have been produced, of which the one selected for the experiment reported here is one of the two most promising mixtures. Preliminary laboratory tests of durability and skid resistance have shown this material to have acceptable friction properties and provide a reasonable durability.

PURPOSE

Before laying this material in full scale on a road subject to regular traffic it was tested in a laboratory to check that it met the desired acoustical properties while at the same time not resulting in too high tyre/road rolling resistance.

Therefore, the purpose of the experiment reported here was to study the acoustical properties and the rolling resistance of the most promising PERS material so far, to see if it met the targets of the project and would be worth testing in full scale.

REQUIREMENTS THAT POROELASTIC ROAD SURFACES SHOULD MEET

The most important requirements of a PERS are as follows (based on the aim to give substantially better acoustical performance than double-layer porous asphalt):

- Noise reduction compared to the most common road pavements should initially be 10 dB(A) or greater, and it should not deteriorate with time faster than about 0.5 dB(A) per year
- Noise reduction should occur not only at the prominent peak in the frequency spectrum around 800-1000 Hz, which is the case for most porous asphalt pavements, but over the entire range 400-4000 Hz
- Lifetime should be at least 8 years, which means that adhesion to the road's base-course, ravelling, rutting and clogging should be acceptable over such a time period
- Skid resistance should meet the same minimum standards as those of asphalt pavements
- Rolling resistance should not be substantially higher than that of a double-layer porous pavement (to avoid causing excessive energy consumption and CO_2 emission)
- Emission of harmful chemical substances and the spreading of fires from crashing vehicles must be acceptable
- The excess cost relative to a conventional pavement should be comparable to or lower than that of noise barriers on both sides of the road

The cost requirement is based on the aim that a PERS will never be economical for general use, but that it should be used to replace noise barriers or provide the same noise reduction at the same cost but without the problems associated with noise barriers.

It is recognized that meeting all the listed requirements simultaneously is very difficult and requires extensive testing.

PREVIOUS EXPERIENCE OF POROELASTIC ROAD SURFACES

The poroelastic road surface is originally a Swedish invention [Nilsson, 1979], but development in the 20th century failed to produce a durable surface. Instead, Japanese researchers worked further on the concept and made considerable progress. New research by VTI in Sweden in the middle of the previous decade made progress too, but failed due to damages appearing in the underlying asphalt pavement. An illustration is shown in Figure 1 where rubber panels are mounted on a street in Stockholm.

Figure 1. Mounting of rubber panels in 2004 on a street in Stockholm.

In the latest years there have also been some trials with PERS in the Netherlands, but also these have failed to be durable.

These efforts are described extensively in a state-of-the-art report possible to download from the PERSUADE website [Sandberg et al, 2010].

The Japanese trials were the most successful [Fujita et al, 2011], but finally also those were discontinued. The PERS pavements produced for three full-scale road sections by the Nippon Road Co. Ltd in cooperation with Yokohama Rubber Co. Ltd lasted up to three years with only limited damages, but still the trials finished in 2011/12 [Fujita, 2012]. Figure 2 shows a close-up view of PERS material used in Japan.

The PERS materials tested before 2008 typically contained 75-85 % by weight of rubber (most of the rest was polyurethane as binder), whereas after 2008 sand and stone aggregates have been added at the expense of rubber. Thus, the latest materials have had 15-30 % of rubber by weight. This has been considered as the best way to obtain sufficient wet friction.

It means that at the beginning of the PERSUADE project, after so many previous failures, the chances for success were not looking good.

Figure 2. Close-up photo of PERS material used in test in Zama City, Japan in 2010.

ENVIRONMENTAL ISSUES

In addition to the exceptional acoustical features, PERS has a number of other environmental issues.

First, the rubber material in PERS is from recycled tyre rubber. Since the rubber content is relatively high, around 40 % by volume, it means that this product when applied on roads will consume substantial amounts of recycled tyres. This may help solving another environmental problem: how to take care of worn-out tyres.

Second, PERS is a relatively soft and elastic material. There is a significant depression of the material as a result of the tyre load. Laymen sometimes consider that the tyre is always "rolling uphill" on surfaces which are not totally rigid, since it is located in a depression. However, what may create increased rolling resistance is not the depression itself; it is the energy loss during the depression and following expansion of the PERS which counts. These can be illustrated by the hysteresis curve. The energy losses create rolling resistance which creates a need for fuel or other energy for vehicle propulsion, which in turn is proportional to the emission of CO_2.

Third, the fine rubber particles which are worn off the PERS by the tyres may be harmful to the lungs, both as particles contaminating the lungs and by containing harmful chemical substances.

Fourth, in case of accidents on the road covered with PERS, a fire fuelled by petrol or oil, or by the rubber, may create harmful fumes, may propagate rather fast and be difficult to distinguish.

All these issues are covered in a special work package of the PERSUADE project. Some of them are discussed later in this paper.

TEST METHOD AND EQUIPMENT

Both tyre/road noise emission and rolling resistance were tested on the drum facility at the Technical University of Gdansk (TUG) shown in Figure 3. This is a drum having an outer diameter of 1.7 m whose two regular surfaces are a sand-paper-like surface with product name Safety Walk as well as an imitation of a rough-textured surface dressing, having a product name APS4; see Annex 1 of [Sandberg & Ejsmont, 2002]. The Safety Walk surface was replaced temporarily by a sample of the PERS material. The Safety Walk surface is a standard surface for rolling resistance measurements, but it is irrelevant for noise measurements since it gives totally non-representative results (for noise). Instead for testing noise on a representative smooth-textured surface, noise measurements were made also on a somewhat smaller drum (1.5 m diameter) on which a replica of a dense asphalt concrete with maximum aggregate size 12 mm was mounted.

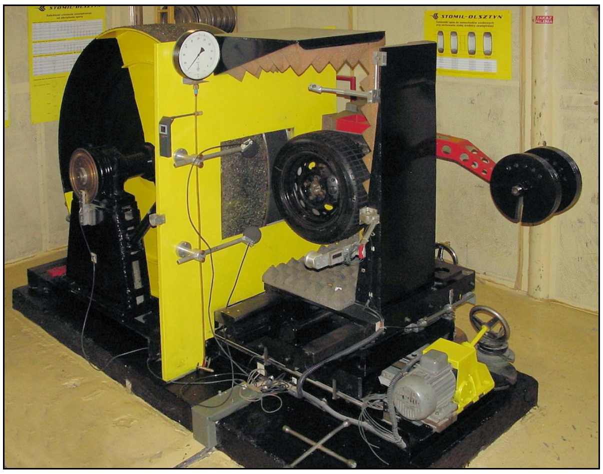

Figure 3. The drum facility at TUG used for testing noise emission and rolling resistance the PERS material. The drum diameter is 1.7 m.

The macrotexture values of the test surfaces, expressed as Mean Profile Depth according to ISO 13473-1 are listed in Table 1. MPD has been estimated based on earlier measurement before standardization of the MPD [Sandberg et al, 2008] and transformed to MPD from an experimental relation between these parameters and MPD determined on the basis of newer measurements on roads. Note that MPD for the PERS has not been measured, and it is arguable whether it is relevant, since it is a highly porous surface. However, if one would disregard its pores, the authors estimate that MPD would be around 0.3-0.5 mm.

Table 1. Drum surfaces used in the measurements. RR = rolling resistance

Surface type	Surface description	Measurements	Drum used	MPD [mm]
PERS	Poroelastic road surface from HET	Noise + RR	1.7 m	Not meas.
APS4	Imitation of surface dressing	Noise + RR	1.7 m	2.0
Safety Walk	Sand-paper-like anti-slip surface	RR	1.7 m	0.2
DAC12	Replica of actual road surface	Noise	1.5 m	0.4

MEASUREMENT PROCEDURES AND TEST TYRES

The noise measurements were made with two microphones located near the test tyre in a position similar to that used in the CPX method as of ISO/DIS 11819-2 (they can be seen in Figure 3). The test tyres were loaded onto the drum also in accordance with the CPX method (load 3200 N, inflation 200 kPa) and run at speeds 30, 50, 80 and 100 km/h. Measurements of A-weighted sound level and third-octave-band spectra were averaged over 60 seconds. Experience has shown that such measurements have a repeatability of around 0.2 dB(A).

As test tyres, the following tyres were used:

SRTT Uniroyal Tiger Paw, 225/60R16 97S M+S
AAV4 Avon Supervan, 195R14C 106/104N
MCPR Michelin Primacy HP, 225/60R16 98V
WINT Vredestein Wintrac Nextreme, 205/55R16 94V M+S
SLICK Vredestein slick (no tread pattern) 235/45R17 94W

The SRTT (standardized in ASTM F2393) and AAV4 are tyres proposed as reference tyres for the CPX method (ISO/DIS 11819-2). The slick tyre might be considered as a proxy for a worn-out tyre. The AAV4 is a light truck tyre (but run at the same load and inflation as the passenger car tyres).

For rolling resistance, only the MCPR tyre was used; the reason being that this tyre had been used extensively in earlier rolling resistance testing.

MEASUREMENT OBJECT

The PERS material was manufactured by HET Elastomertechnik GmbH in Heidelberg, Germany, which is one of the partners in the PERSUADE project. It was glued around the 5.4 m long circumference of the 1.7 m drum, covering a width of 0.22 m. The thickness of the PERS sample was 28-30 mm. Figure 4 shows the material during mounting on the drum. Joints were cut diagonally.

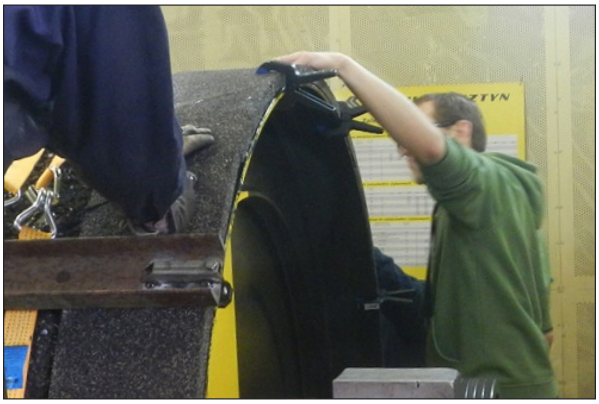

Figure 4. Mounting of the PERS material around the drum.

For reasons of protection of intellectual property, the exact composition of the material cannot be given, but the following rough values may give an idea of it:

- Major content: polyurethane binder, soft aggregate by rubber granules, hard aggregate by sand and small stones. The proportion between the soft and hard aggregates (rubber versus sand+stones) is in the range of 15-30 % versus 70-85 % by weight. This is a rubber content which is 10-20 times higher than that of the pavement family called 'asphalt rubber' or 'rubberized asphalt'.
- Grading of the aggregate is such that an air voids content of 25-35 % is reached. Max aggregate size is appr. 4 mm

A picture of the material appears in Figure 5.

MEASUREMENT RESULTS: NOISE

The results of the noise measurements are summarized in Figure 6, where the A-weighted sound pressure levels (SPL) are shown for all tyres, all speeds and the three surfaces used. Note that APS4 is an imitation of a rough-textured surface dressing and DAC12 is a replica of dense asphalt concrete with max 12 mm aggregate. The DAC12 is smooth-textured. Also the APS4 has a max aggregate size of 12 mm.

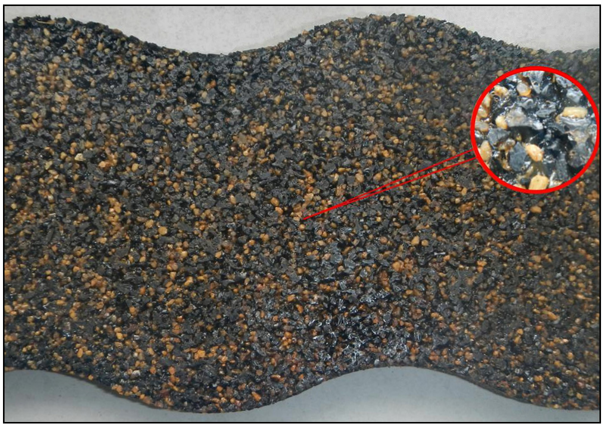

Figure 5. Close-up picture showing the texture of the PERS material, with a circular patch expanded. The sample is 100 mm from top to bottom. The waveform is adapted to be glued on corresponding interlocking paving blocks.

It appears that the PERS gives 6-15 dB lower noise level than the DAC12, depending on speed and tyre. A maybe better overview is shown in Figure 7, where the levels for all five tyres have been averaged. The diagram shows that the noise reduction of PERS increases somewhat with the speed and is 10 dB(A) or better at speeds 80-100 km/h.

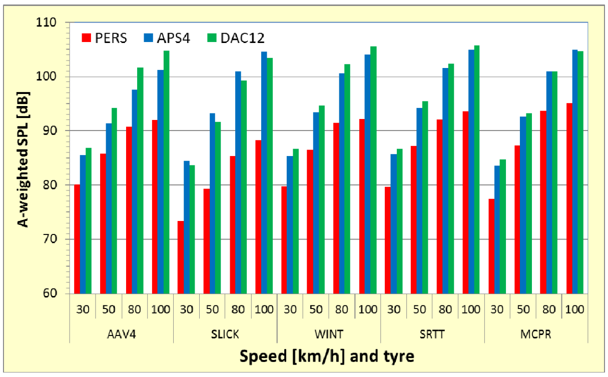

Figure 6. A-weighted noise levels for all tested combinations of tyre, surface and speed.

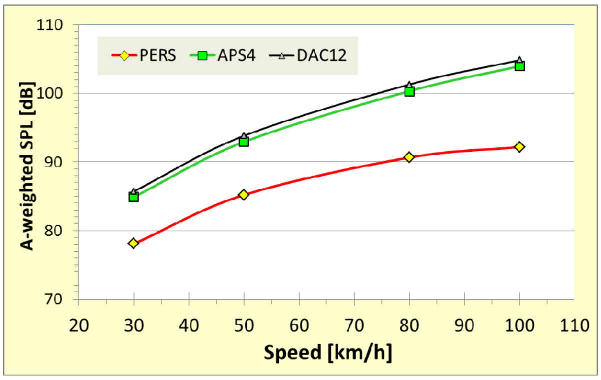

Figure 7. Same data as in Figure 5 but averaged values for all tyres have been plotted against speed.

Frequency spectra are shown in Figure 8, again for an average of all tyres, but only for 80 km/h. First, the "normal" difference in spectra between a rough-textured and a smooth-textured pavement is shown [Sandberg & Ejsmont, 2002]. Despite this quite dramatic difference, the overall A-weighted noise levels are rather similar (Figure 7). Second, the PERS appears to provide lower or equal sound levels over the entire frequency spectra than any of the other surfaces, and at many frequencies noise is 15-20 dB below one of the other surfaces. The most effective frequency range seems to be 1000-2000 Hz, with 1250 as the very best one.

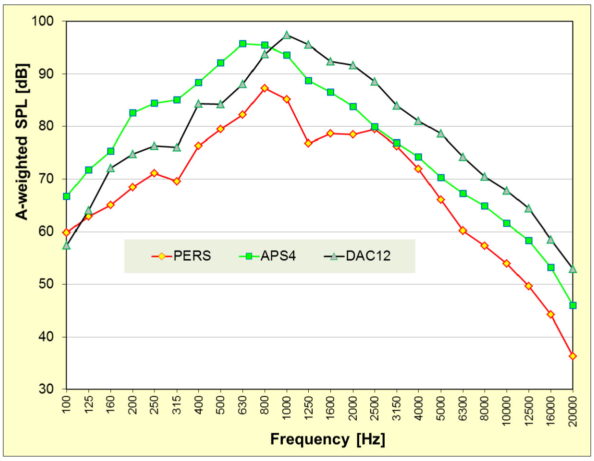

Figure 8. Third-octave band frequency spectra (A-weighted) for averaged values for all tyres at 80 km/h.

MEASUREMENT RESULTS: ROLLING RESISTANCE

It was feared that the combination of rubber, sand and stones would create energy losses (probably frictional) during the compression/expansion of the material under tyre load. However, this appeared not to be the case, as Figure 9 shows. In fact, the PERS material gave almost as low rolling resistance as the Safety Walk surface (glued on a steel structure).

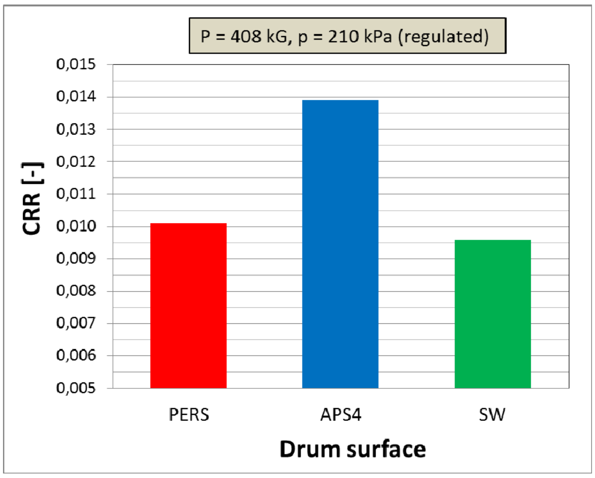

Figure 9. The rolling resistance coefficient (RRC) for the three tested drum surfaces, at 80 km/h. SW is the Safety Walk surface (sand paper).

In the so-called MIRIAM project, a robust relation was determined between rolling resistance and the MPD parameter; see [Sandberg et al, 2011]:

Rolling resistance coefficient = Constant + 0.0020·MPD where the constant depends on tyre and test conditions, but usually is approximately 0.01 for an average of car tyres at normal loads and inflation.

Since Safety Walk has an MPD around 0.2 mm, while actual road surfaces of common types have MPD:s in the range 0.4-1.2 mm, one may then estimate that the latter would have 4-25 % higher rolling resistance than Safety Walk.

Therefore, it follows that PERS, which has only 4 % higher rolling resistance coefficient than Safety Walk according to Figure 9 has equal or lower rolling resistance than any known road surface (possibly except some exceptional pavements which are too smooth to be safe). Note that this is despite the PERS surface is much softer than any other road pavement due to its exceptional proportion of rubber.

COMPARISON WITH MEASUREMENTS IN AN EARLIER PROJECT

Similar measurements were made by TUG using the same facilities in 2004 in the Swedish project mentioned above. The test tyre was different (Nokian NRVi 225/45R17) and the PERS sample was different—it was a so-called Rosehill material [Sandberg et al, 2010]. In the early experiment, the PERS sample had a rubber content of approximately 85 % by weight and no hard aggregate at all.

Figure 10 shows the results of 2004 in the same diagram as the new results. The results from 2004 are shown with dotted lines, and include a fourth surface: a replica of a surface according to ISO 10844:1994. The noise measurements on the drum in 2004 were never published before.

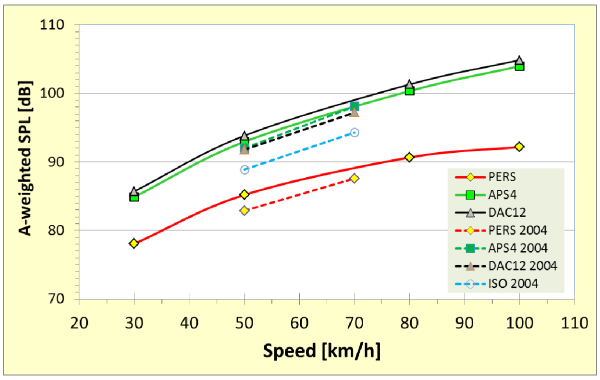

Figure 10. Same data as in Figure 6 but similar data from 2004 are included and shown as dotted lines.

It is quite amazing how similar the results are, despite 9 years of time difference. The generally lower noise levels of 2004 by 1-2 dB are probably due to a somewhat quieter test tyre used then, but the difference between PERS and the other surfaces is essentially the same.

In 2004, the same PERS material was laid on a street and CPX measurements were made on this and a couple of other PERS materials and compared to a DAC12 pavement. This gives a possibility to compare the noise reductions measured on a drum facility with such made on actual roads.

In 2004 the noise level difference between DAC12 and PERS on the drum was 9 dB at 50 km/h and 10 dB at 70 km/h (Figure 10). The noise level difference on the actual road appeared to be 8 dB at 50 km/h and 9 dB at 70 km/h [Sandberg & Kalman, 2005]. It shows that laboratory drum measurements fairly well correspond to what one measures on the road with the CPX method.

Consequently, we can expect that the PERS material that we have tested in this experiment is predicted to give 8 dB at 50 and 9 dB at 80 km/h when it will be tested on the road. This is close to the 10 dB(A) target mentioned in the beginning of this paper.

When it comes to rolling resistance, Figure 11 compares results measured in 2013 with those in 2004; the latter on “Rosehill” which was another type of PERS. Yet, the results of 2004 are almost the same as the results of 2013.

The test tyre used in 2004 for rolling resistance measurements was the Nokian NRVi, which was also used for noise measurements, as mentioned above. However, the SW results in 2004 are the average for 89 car tyres. The tyre loads and inflation were a little different in 2004 and 2013, but this should not have a significant effect on the comparison of surfaces.

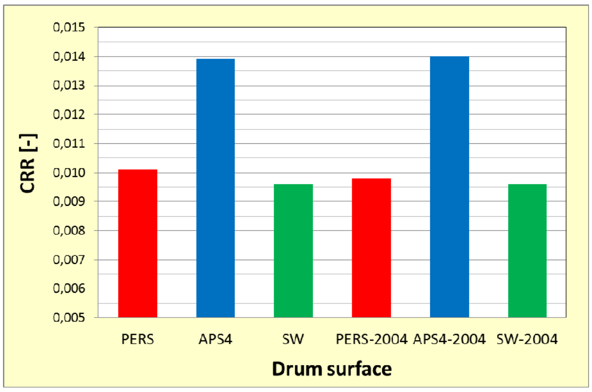

Figure 11. The rolling resistance coefficient (RRC) for the three tested drum surfaces, at 80 km/h. SW is the Safety Walk surface (sand paper). Test results in 2013 in the left half and test results in 2004 in the right half of the diagram.

The rolling resistance measurements on the drum in 2004 were never published before.

DISCUSSION

Effect of drum curvature

It is known that the curvature of drum on laboratory facilities, and the associated distortion of the tyre deflection, influences both noise and rolling resistance to some extent. However, this deflection distortion is the same for all drum surfaces, and then should also have approximately the same *effect* for all drum surfaces; thus comparison between surfaces is not essentially different than if the drum had an infinite radius. However, it must be admitted that this is more based on many years of experience rather than on systematic studies.

Another effect of the finite drum curvature is that when the PERS is bent around the drum the top of the material is expanded and the bottom of the material is compressed. The expansion/compression is not large, but it will unavoidably distort somewhat the porosity in the material; increasing air voids in the top and reducing air voids in the bottom. This should have some effect on the sound absorbing properties.

Noise reducing mechanisms

It is interesting to try analysing which noise generation and enhancement mechanisms that are responsible of the extremely low tyre/road noise emission on the PERS pavement. The following discussion is based on the mechanisms described in [Bernhard & Sandberg, 2005].

The maximum aggregate size of the mix is low (approximately 4 mm), and the material has been packed in a way which gives a relatively flat surface being in contact with the tyre; this gives a low excitation of radial tyre vibrations excited by road surface texture.

The air voids content (porosity) is very high, and due to the small aggregate the pores between the larger aggregates have access to the surface tight together. This will essentially eliminate the air pumping mechanism.

The very high porosity and the thickness of the porous material will result in sound being absorbed in the material, with a peak absorption probably at the observed "valley" in the frequency spectrum at 1000-2000 Hz; and most pronounced at 1250 Hz. This is exactly what was measured by the tube method (ISO 10534) for the 29 mm thick PERS material tested in 2004 in Sweden and reported in [Sandberg & Kalman, 2005]. The pores winding among the small aggregate probably give a high tortuosity which enhances sound absorption more than in common porous asphalt surfaces.

The porosity and resulting acoustical impedance of the PERS surface is such that it practically eliminates to horn effect at the trailing and leading edges of the tyre/road contact. A horn with one of its walls being "acoustically transparent" will be an inefficient horn.

The same porosities will also eliminate possible air resonances in the tyre tread pattern, such as "organ pipes" and Helmholtz resonances.

The stick-snap mechanism is probably not very important due to the large fraction of rubber in the surface. According to measurements presented in [Sandberg et al, 2005] the adhesive forces between a tyre tread rubber surface and the PERS "full-rubber" material of 2004 are one-to-two magnitudes lower than between tyre tread rubber and a dense asphalt surface. However, the new PERS tested in PERSUADE has a lower rubber content, so the stick-snap reduction is likely to be lower than in 2004.

The much lower mechanical impedance of the PERS, compared to ordinary asphalt or cement concrete pavements, may result in lower texture impact excitation to the tyre [Sandberg et al, 2005]. However, in the 2004 experiments the PERS was a "full-rubber" pavement, and the PERS in our present experiment has much lower rubber content. Thus the mechanical impedance (not yet measured) must be somewhere in-between of a full-rubber material and an asphalt pavement, which is probably too different from that of a tyre, which results in at most a marginal effect of the mechanical impedance in this case.

However, the PERS is much softer than an asphalt pavement and one can visually observe that under a tyre load there is some deflection (compression) in the material (when using a stiff heel of a shoe and pressing it onto the PERS one will notice a depression). That means that for a rolling tyre, the deflection which must take place in the tyre/road contact patch is not only taking place in the tyre (which is the case when the tyre meets a totally stiff surface), but to some extent also takes place in the PERS material. This means lower deflection in the tyre and that the momentary tyre deflection at the trailing and leading edges of the contact patch will occur with a lower angular change per time unit.

The above suggests that the acoustical advantage of the PERS material is a combination of most of the generation and enhancement mechanisms working in the same favourable direction: the PERS includes the best features of most if not all of the mechanisms.

But is there no acoustical disadvantage or problem with the PERS? Yes, there will be at least one potential problem: any deviations from perfect homogeneity or constant thickness of the material will result in local variations in stiffness and thickness, which under the load of tyres will result in excitation of vertical vibrations in the tyre. The spatial wavelengths of these are likely to correspond to the megatexture of asphalt and cement concrete pavements (texture wavelengths of 50-500 mm). In Figure 8 one can notice that at 100—125 Hz there is no advantage of the PERS versus the DAC, which may be due to the stiffness (or thickness) variation. However, energy at that frequency does not influence the A-weighted overall levels. But if the peak at 800 Hz of PERS in Figure 8 is partly affected by the stiffness/thickness effect, then it will be really critical. Nevertheless, it is very important that the material be homogene and equally thick everywhere. This is a critical requirement in the manufacturing process.

Rolling resistance reducing mechanisms

As stated earlier, the rolling resistance appeared to be more favourable than expected for a soft pavement. The mechanisms for this would include those listed above which reduce radial vibrational excitation to the tyre.

However, for low rolling resistance it is most important that the dynamic deflection in the tyre is as low as possible. Therefore, the soft PERS may be less of a disadvantage and more an advantage, as it results in lower tyre deflection. That said, the deflection, i.e. the dynamic compression and expansion of the PERS under tyre load must be as purely elastic as possible in order to avoid energy losses. This feature of the PERS material has not yet been measured, but as the rolling resistance is low it must mean that the losses are negligible.

Other properties than noise and rolling resistance

Skid resistance is a key parameter for any pavement. Everybody knows that rubber against rubber and water in-between gives poor skid resistance. Of course, high porosity which keeps water away from the tyre/road interface will ease the problem, but not entirely. Therefore, skid resistance must be considered carefully in this project. Laboratory testing on PERS samples have been made so far using the British Pendulum Tester. However, at the time of writing, the PERS material considered in this paper is not yet tested, as the material has not yet been available for this purpose. However, considering the high proportion of hard aggregate which is in the mix, combined with high air voids content, it is expected to perform reasonably well with regard to wet skid resistance.

A durability test on this PERS sample material has been made by the Belgian Road Research Centre (BRRC), by testing the resistance to ravelling in a laboratory facility using the Aachener Ravelling tester (ARTe). This PERS material then came out as neither good nor bad, among a lot of other PERS samples as well as reference pavement materials. In the project, many other tests related to durability are made, but not yet on this particular material. However, only upcoming testing in real traffic will finally and most realistic determine whether the ravelling and other durability properties will be acceptable or not.

Chemical substances contained in PERS materials have been studied extensively and found to constitute no significant problem. A couple of fire tests have been made, comparing the spreading of fire after an assumed car collision with spillage of petrol on PERS compared to conventional asphalt. Surprisingly it has been found that PERS provides much better anti-fire properties than conventional asphalt surfaces. It has also been found that the fumes close to such a fire are not posing more serious threats to life and health than on a conventional asphalt pavement. Reports and articles regarding these studies are being produced.

Possible improvements to the PERS material

As Figure 8 shows, there is a relatively prominent peak in the frequency spectrum at 800 Hz. This dominates the overall noise level and will be the key to achieving even more noise reduction. How to get rid of this peak? These suggestions could be tried:

Following the discussion about the potentially detrimental effects of varying stiffness and/or thickness of the PERS material, one shall make sure that the material is as homogene and equally thick as possible, especially over texture wavelengths corresponding to 800 Hz of tyre/road noise frequency; i.e. 20-40 mm.

It is known that increasing thickness of a porous material will shift the frequency of the absorption peak to a lower frequency [Beckenbauer, 2008]. If the 800 Hz peak can be shifted to 630 Hz or even 500 Hz, probably several more dB of noise reduction would be gained. This would probably require that the PERS thickness be increased to at least 40 mm (for 630 Hz) or 50 mm (for 500 Hz); a measure which would increase costs substantially.

Essential differences between PERS of 2013 and PERS of 2004

The PERS material tested in this experiment has the advantage over the PERS tested in 2004 that it includes a lot of hard aggregate which is expected to provide much better skid resistance. The disadvantage is that it may have marginally lower noise reduction; especially since the so-called Tokai PERS in 2004 had approximately 3 dB(A) better noise reduction than the Rosehill PERS mentioned above.

What happens hereafter, and final remark

Later in 2013, the PERS material tested in 2013 in the laboratory will be laid on one or a few actual, trafficked roads or streets. Its long-term durability, even to studded tyres, will also be tried in a laboratory facility at VTI. The results reported here serve as a decision support for the continuation of the project.

A paper regarding another mixture of PERS, laid manually as a few square metres on a rest area beside a highway, appears in [Bendtsen et al, 2013]. However, when this is written, that material has been removed. It was never tested for tyre/road noise properties.

CONCLUSIONS

A prefabricated material described and intended as a poroelastic road surface (PERS) has been tested and discussed in this paper. This material features very high porosity (air voids), small maximum aggregate size, a smooth surface, and is made of rubber, sand and small stone granules bound with polyurethane. The rubber content is more than 10 times as high as it is in the pavement material known as asphalt rubber, resulting in a relatively soft pavement, which deflects under the load of car tyres. This material is designed with the intention to provide a better option for traffic noise reduction than noise barriers, providing equally high noise reduction but in a larger area and without the visual intrusion which barriers mean.

For the testing the PERS material was mounted on a steel drum designed for testing of tyre/road noise and rolling resistance in a laboratory environment. A number of test tyres were run on the drum and noise measurements were done with the tyres running on the PERS as well as on a few other pavement reference materials.

It was found that the PERS resulted in 9 to 10 dB of noise reduction in comparison to a replica of a dense asphalt pavement having 12 mm max aggregate size. Frequency spectra showed that noise reduction was particularly high in the 1000-2000 Hz range.

The rolling resistance measurements showed that the PERS gave almost as low rolling resistance as a sandpaper surface on the steel drum, which means that the rolling resistance properties seems to be more favourable than on most if not all conventional road pavements. This result may seem surprising since it has been assumed by some that the softer the surface is the higher is the rolling resistance.

Both the noise and rolling resistance properties measured here were found to be consistent with measurement results in an earlier project in Sweden, but where the PERS material was very different from the present mixture.

A discussion concerning the noise reducing mechanisms suggests that for most of the potential generation and enhancement mechanisms the PERS has very favourable characteristics. The combined action of all of them therefore provides the high noise reduction recorded.

This experiment has shown that the PERS tested here has excellent acoustical and energy-related operational properties which justify testing the material on real roads subject to traffic.

Many other properties of the PERS than the ones in focus in this paper are important for its performance on actual roads, something which will be tested beginning in 2013.

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