

Double-layer porous asphalt – Performance of innovative noise-reducing variants

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Background

Since 2010, double-layer porous asphalt (DPA) has been used on motorway E4 through the Swedish city Huskvarna near Jönköping. The pavement has been a great success despite the challenge to use porous pavements in a country where studded tyres are used in wintertime, something resulting in excessive surface wear and subsequent clogging of pores. In this paper, seven interesting trials on this road related to the noise reduction of the pavement are reported.

Test site

The main part of the noise-reducing section is 2.7 km long with two lanes in each direction, while there is also a single-layer porous pavement a few hundred metres long. The posted speed limit is 90 km/h and AADT is appr. 26 000, with 15 % heavy vehicles. The latter are dominated by 25 m long articulated trucks with a GVW of 35-60 tons. A picture of the main section is shown in *Figure 1*.



Figure 1: Overview of motorway E4 through Huskvarna (just north of Jönköping).

Tested pavement variants

1. Paving DPA hot-on-hot: Commonly, when paving DPA, it is considered necessary to do this “hot-on-hot” which means that the top layer must be applied while the bottom layer is still hot. Is this really necessary?

2. Rejuvenating the surface may almost totally clog the pores in the top layer. In an attempt to extend the technical lifetime, the slow lane was rejuvenated by application of a Fog Seal.

3. The effect of the bottom layer is analysed in relation to the top layer and both in combination. One part of the section had a single-layer PA, the performance of which could be compared to another section where the same PA layer had been laid on a bottom layer, thus creating a DPA.

4. Reusing the bottom layer: On one part of the new pavement laid in 2017, only the top layer of the old DPA section was milled-off and then repaved with a new top layer, while the bottom layer was reused.

5. Steel slag has been used instead of stone aggregate in the top layer in one trial. The performance of this trial is analysed in comparison to the conventional aggregate.

6. Grinding off the peaks in the surface may have a favourable effect on both noise reduction and rolling resistance. This is a way to produce an “extra negative texture”.

7. End-of-life noise reduction: After a few years, the top layer is clogged. Does it still provide a noise reduction exceeding that of a corresponding dense asphalt concrete?

Measurement methods

Noise measurements were performed annually, and sometimes more than one time per year, by using the “Close Proximity (CPX) method”, as standardised in ISO 11819-2 (*Figure 2*). The measured values have been processed and presented as the difference between DPA and a reference pavement, the latter being a “middle-aged” SMA 16. In reality, the reference values are averages from measurements made annually on 3-6 different SMA 16 pavements of age varying between 1 and 9 years. Measurements were made with the reference tyres shown in *Figure 3*.

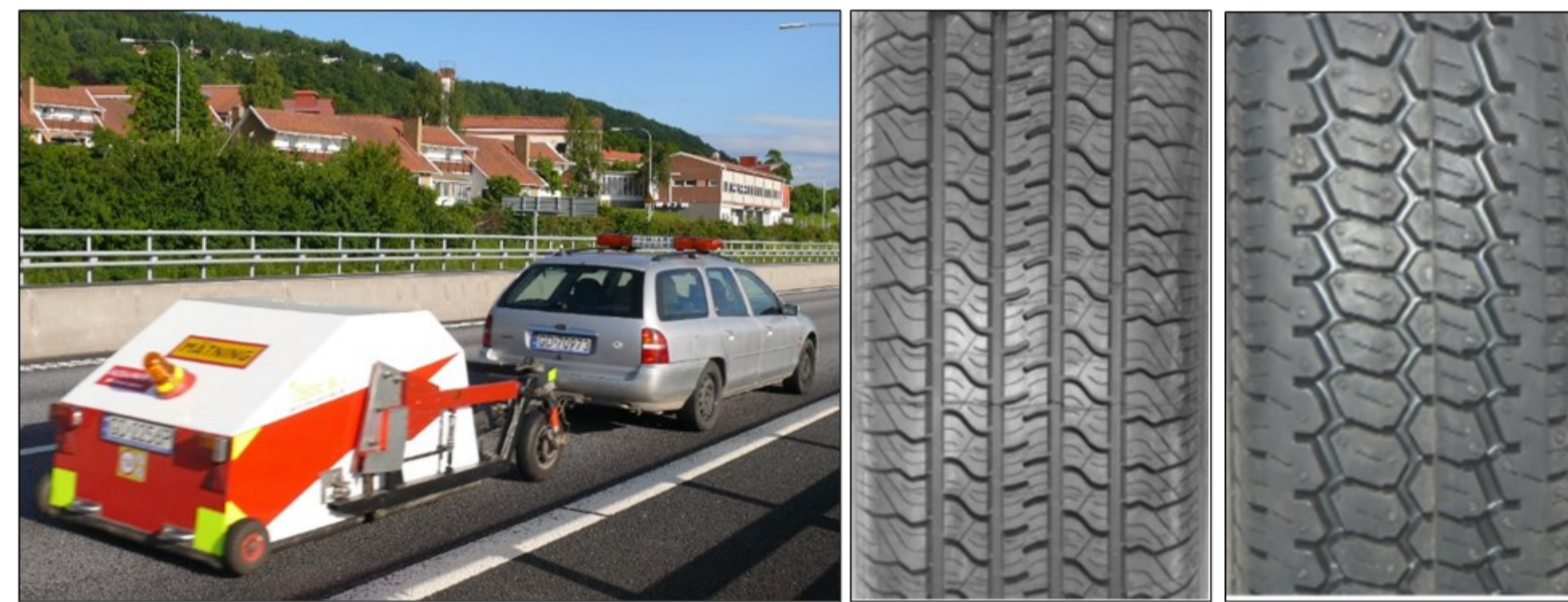


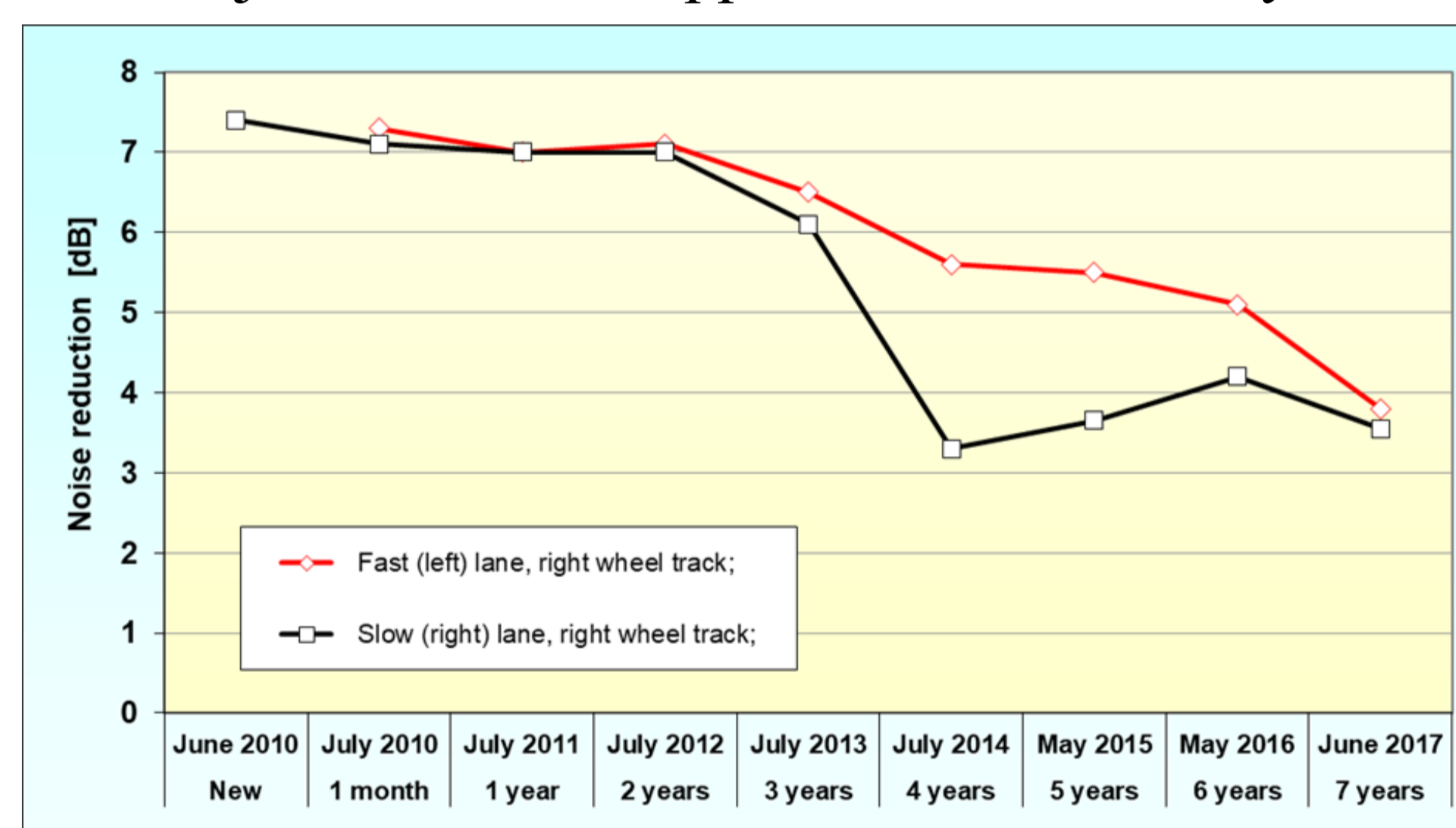
Figure 2 (left): CPX noise measurements with the TUG Tiresonic Mk4 trailer on the DPA pavement on E4, Huskvarna according to ISO 11819-2. The test tyre is mounted in the middle of the trailer enclosure.

Figure 3 (right): Tread patterns of the two reference tyres used during the CPX noise tests (ISO/TS 11819-3). From left to right: SRTT (P1) and Avon AV4 (H1).

Results and discussion

1. Paving DPA hot-on-hot: This project has shown that it works fine to pave the two layers in two different days (in summertime). “Hot-on-hot” is not needed.

2. Rejuvenating the surface filled the remaining porosity which resulted in a great loss of noise reduction, while the acoustical lifetime was not extended. *Figure 4* shows the dramatic loss of noise reduction between years 3 and 4 in the slow lane, where “Fog Seal” rejuvenation was applied between those years.



5. Steel slag used instead of stone aggregate in the top layer in one trial. Compared to conventional aggregate, the steel slag (black curve) showed a more constant noise reduction over time, see *Figure 6*.

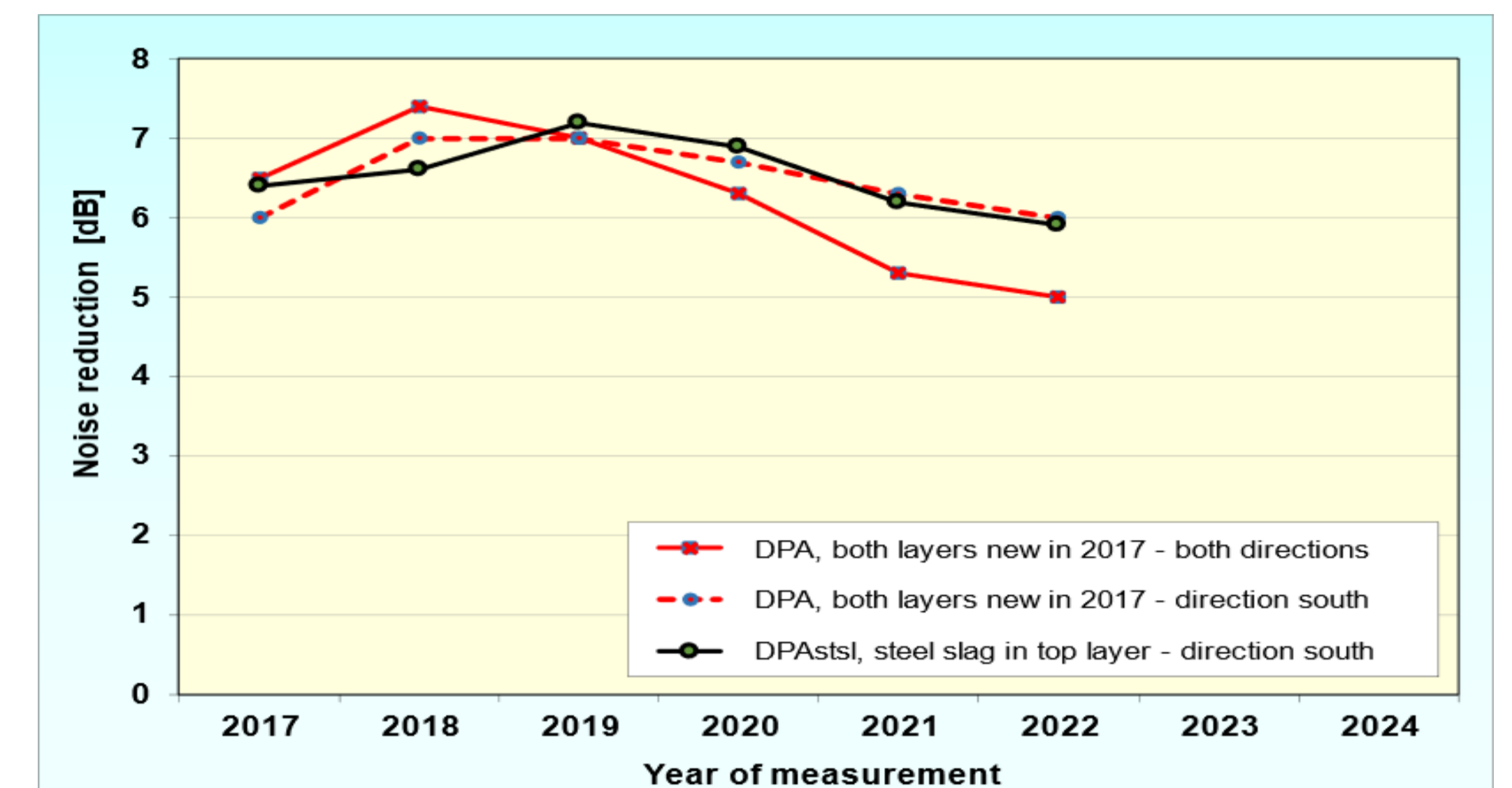


Figure 6: Measured noise reduction over time, starting with paving (in 2017) and ending with the situation the previous autumn (2022).

6. Grinding off the peaks in the surface is a way to produce an “extra negative texture”. Comparison of ground and non-ground surfaces showed that grinding increased noise reduction by up to 2.4 dB and reduced rolling resistance by up to 13 %, depending on tyre. However, with wear of studded tyres the effect diminishes with time.



Figure 7: Non-ground surface (left picture) and ground surface (right picture). The coin has a diameter of 25 mm. The photos are shot at similar but not exactly identical locations.

7. End-of-life noise reduction: After a few years, the top layer is clogged; yet the pavement provides some noise reduction. Surprisingly, 1-3 dB of noise reduction remains compared to the reference (dense AC) pavements, even when there is full clogging and no sound absorption left.

Conclusions

- DPA pavement layers can be paved on different days.
- Rejuvenating (seal) a DPA may ruin its noise reduction.
- Approx. 2/3 of the noise reduction of the DPA in new condition is due to the bottom layer; this effect continues.
- By reusing the old bottom layer of DPA one time, noise reduction is sacrificed by only 0.5-1 dB over the lifecycle.
- Using steel slag as the aggregate in the top layer may lead to a more stable noise reduction over time.
- Grinding of the peaks of the top layer’s texture will reduce both noise and rolling resistance significantly.
- A fully clogged DPA will still provide 1-3 dB noise reduction vs SMA, if ravelling is not excessive.

Acknowledgements

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References

There are several references in the full paper.



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Figure 4: Difference in noise reduction between the two lanes, where the slow lane was sprayed with Fog Seal in the autumn of 2013 while the fast lane was not sprayed. Averages of the two tyres and two directions.

3. The effect of the bottom layer: Very surprisingly, it appeared that 2/3 of the noise reduction is due to the bottom layer of the DPA; see *Table 1*.

Table 1: Results of tyre/road noise measurements (CPX method) at 90 km/h, for tyres P1 and H1, expressed as noise reductions in A-weighted dB, at three occasions.

Type of pavement	Thickness [mm]	July 2010		June 2011		July 2011	
		P1	H1	P1	H1	P1	H1
PA, single-layer	35	2.3	1.1	2.8	2.2	2.5	2.3
DPA, double-layer	30+50=80	7.6	7.3	7.8	7.5	7.8	7.6
Bottom layer effect	50	5.3	6.2	5.0	5.3	5.3	5.3

4. Reusing the bottom layer: When the top layer of the old DPA section was milled-off and repaved with a new top layer the bottom layer was reused. Noise reduction lost by reusing the old bottom layer was only appr. 0.5 dB (of initial 7-8 dB), as a time average.

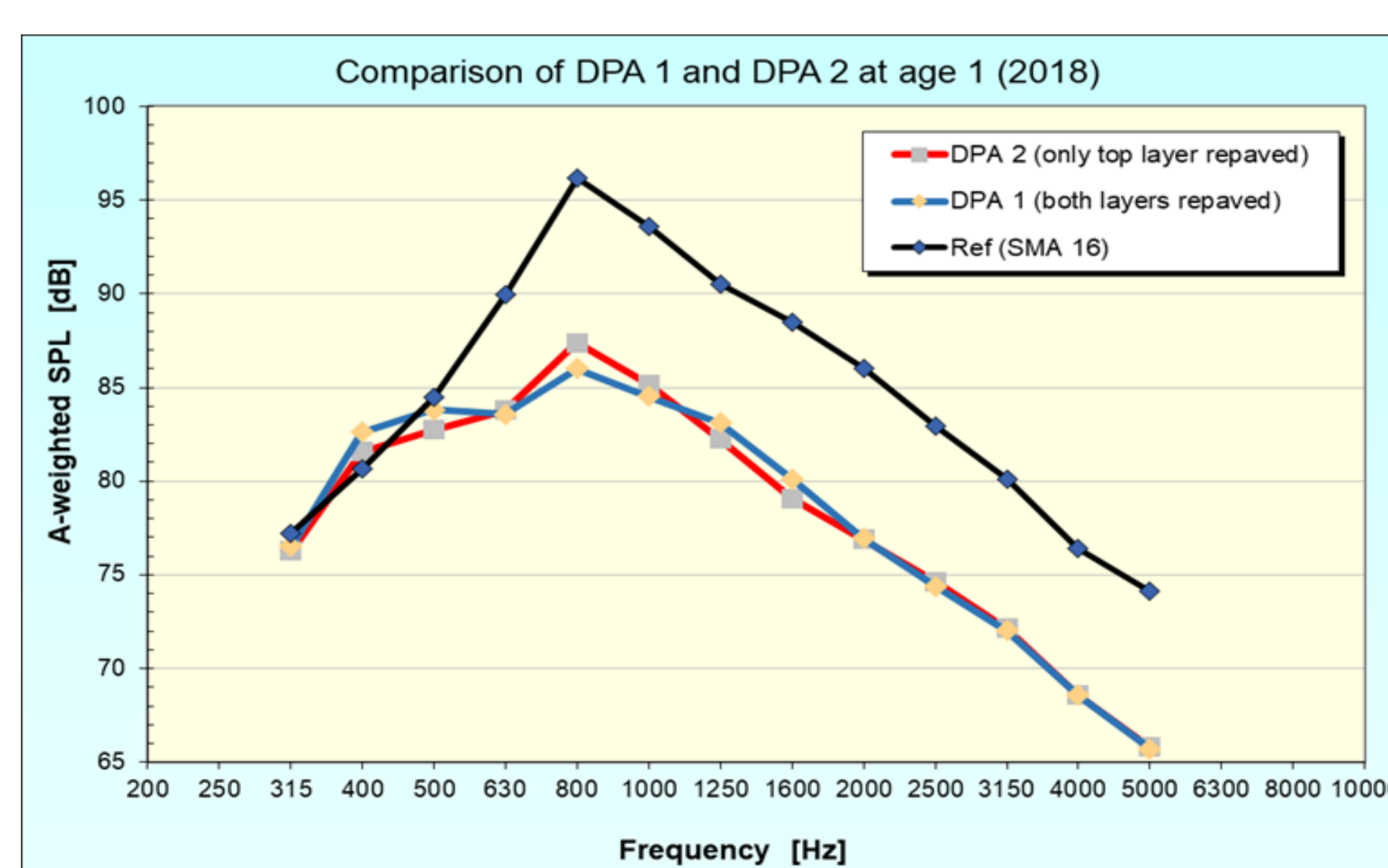


Figure 5: Frequency spectra measured at an age of one year, with SMA 16 pavements as reference. Average over tyres, lanes and directions. Similar data at age of 5 years.