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PSYCHOPHYSICAL CRITERION TO DETERMINE THE EFFECTIVENESS OF LOW-NOISE PAVEMENTS

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1 INTRODUCTION

Environmental noise has become an important issue in western European countries. From numerous questionnaires it was concluded that road traffic noise is the major stress factor of inhabitants in cities. Not only does traffic noise seriously jeopardize the quality of urban live, also the non-urban areas are more and more covered with a blanket of noise[1].
Silence is becoming a rare species. Therefore, extended national and international legislation has been implemented to limit the noise emission levels from road systems. This stimulated the development of low-noise pavements. Especially 2-layered Porous Asphalt (2l PA) seemed to be very promising. But soon it turned out that the acoustical theory behind it was wrong, costs are extensive, and durability proved to be very limited.
At present, in most cities in the Netherlands it is forbidden to apply 2l PA. This has led to the development of Thin Layers. These surface types are cheaper than 2l PA and their noise reductions are even higher. Thin Layers have proven that acoustical absorption does not play any role in noise reduction at low speeds. Therefore, they almost do not need additional maintenance against clogging. At this moment, there is a great variety of low-noise pavements available[2].
Most important is that inhabitants greatly appreciate Thin Layers because of their typical nature of noise. There are several measurement methods to determine, accurately and objectively, the quantity of noise emitted from traffic on a certain road. The usefulness of developing and improving objective, representative, and comparable methods is without doubt. However, the results from these methods correlate poorly with impression of inhabitants living adjacent to this road: road surfaces can be perceived “louder” as well as “softer” than what could be expected from objective measurement results.
In this paper, the first test results of a new method will be presented. This method includes acoustical perception into the quantising of the overall effect of low-noise pavements.

2 SALIENCY

As it has often been suggested, various “subjective” measures like loudness correlate better to each other than to the real impression. Therefore, a new measure had to be found. This measure had to include processes that occur at higher levels in the human auditory system. In order to find such a measure we have to look closer at the emission spectrum of low-noise pavements.
In figure 1 the unweighted octave band spectrum of a reference road type (AC surf) and a Thin Layer are shown.

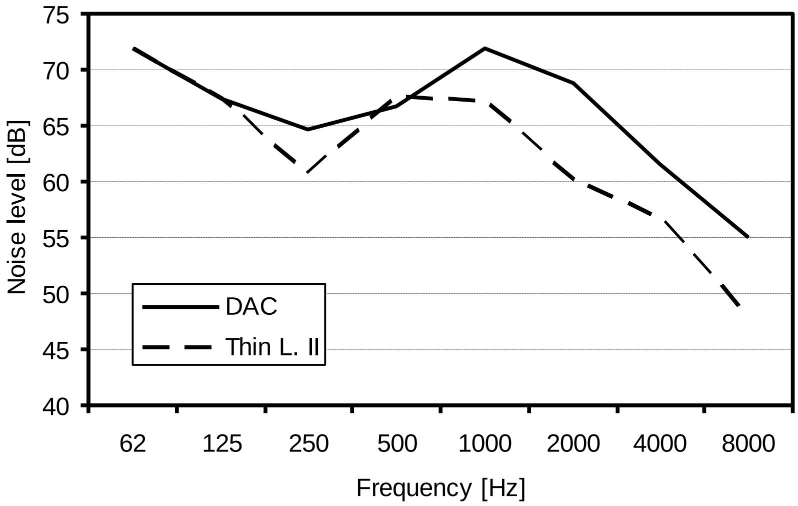

Figure 1: The unweighted octave band spectra of a reference road type (DAC) and a Thin Layer

From figure 1 it can be seen that the overall shape of the spectra are similar. That is why a loudness based method does not significantly improve judgement compared to dB or dB(A).
Per frequency band, however, the differences can be more than 5 dB. Based on psychophysics a theory has been developed that predicts the so-called Auditory Saliency A0[3]. This A0 criterion determines the saliency of differences in sounds as detected by the human ear. The A0 criterion is determined by comparing the peeks in a spectrum of a certain road surface and AC surf, respectively.

3 PROJECT OF THE HAGUE

3.1 Introduction

In the city of The Hague three test tracks and a reference track (Test track 1) have been put.
In table 1 an overview of the surface types can be seen. All were so-called gap graded mixtures with various open air contents.
The respective open voids contents are also presented in the table.

Table 1: overview of the applied surface types

No	Test track 1	Test track 2	Test track 3	Test track 4
surface type	“Zaans”	Thin Layer I	SMA 0/6	Thin Layer II
void contents	low	middle	low	high

In Figure 1 a photo of the test location can be seen.

Figure 1: photo of the test location (Laan van Nieuw Oost-Indië)

On these tracks various noise measurements have been performed. The results have been correlated to results of a questionnaire. This questionnaire was developed by the city of Copenhagen[4]. In this paper only global results of the questionnaire will be presented. In a following paper more extensive results will be presented[5].

3.2 Noise measurements

On the test tracks standard SPB and CPX measurements according ISO 11819 1/2 have been performed. In table 2 the average noise reductions have been presented. The averages follow from the Conformity of Production (COP) procedure which is standard in the Netherlands. Also the respective noise labels have been presented in this table.

Table 2: average noise reduction for passenger cars at 50 km/h

test track		noise reduction [dB(A)]	
no	surface type	COP	noise label
1	"Zaans"	2.1	0*
2	Thin Layer I	3.3	3.4
3	SMA 0/6	1.8	1.1
4	Thin layer II	4.1	4.6
*expected value, no noise label			

In figure 2 all the measured average noise reductions and the noise labels are presented graphically.

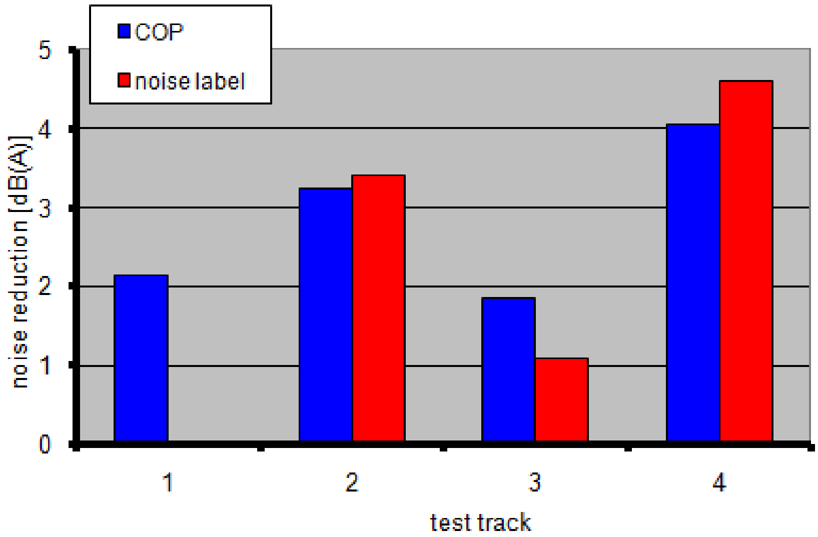

Figure 2: The measured noise reductions and noise labels

From table 2 and figure 2 it follows that most measured noise reductions are within 1 dB(A) equal to the noise labels. Only the noise reduction of test track 1 (“Zaans”) is quite higher than the expected 0 dB(A).

3.3 Psychophysical judgement

Based on the results of the COP, the A0 criterion for saliency has been calculated for each track separately. In table 3 the results have been presented. These results are unscaled.

Table 3: Saliency A0 for passenger cars at 50 km/h

test track		Saliency A0 [dB]
no	surface type	
1	“Zaans”	18.8
2	Thin Layer I	21.0
3	SMA 0/6	19.1
4	Thin Layer II	20.5

In Figure 3 the results form table 3 have been presented graphically.

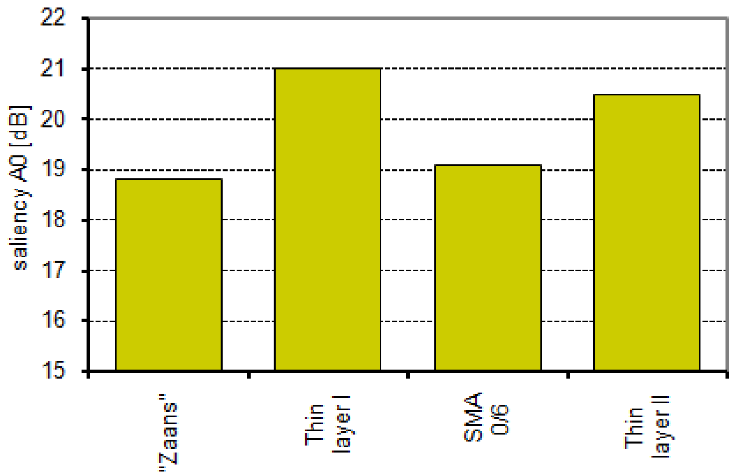

Figure 3: The saliency A_0 for the different test tracks

From table 3 and figure 3 it follows that the Thin Layers are most salient, as found in the previous global study[3]. In this case it means that they sound more "pleasant".

3.4 Questionnaire

The results from the questionnaire proved to be very difficult to interpret. As can be seen in figure 1 there are also trams present at the test location. Furthermore, the layout of the road was changed and respondents replied not for the better. The data was therefore biased. However, respondents adjacent to the silent test tracks were more positive than those adjacent to the less silent tracks. The results showed no significant difference between Thin Layer I and Thin Layer II. These results corroborate the results form the psychophysical analyses.

4 CONCLUSIONS

Low-noise pavements have been proven to contribute to more acceptable noise situations in cities. However, their effectiveness is hardly proven until now. In earlier projects it has been shown that de (A weighted) noise level correlates very poorly to the subjective impression of people living adjacent to the road. The new A0 criterion for saliency seems to correlate better since it incorporates psychophysical knowledge. However, improvements are necessary to increase its reliability. These improvements are subject of ongoing study. Furthermore, questionnaires are very difficult to interpret, especially when other factors like safety are important.

5 REFERENCES

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