Effect of various road surfaces on vehicle running noise on public roads in Japan

-- Distribution of tyre/road noise level by type of road surface --

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Summary

Measures taken on road surfaces, such as the introduction of low-noise road surfaces, are considered to be one of the most effective in reducing road traffic noise. Although such measures have also been applied in some areas in Japan, the potential of road surface measures to reduce noise is yet to be clarified sufficiently. The CPX method is widely used in European countries for evaluating the effect of road surfaces on road traffic noise, but it has not been introduced in Japan so far due to various reasons.

Accordingly, in order to understand the road surface situation of domestic public roads and to investigate the potential for reducing noise, tyre-proximity noise measurements were carried out on public roads using a simple method with reference to the self-powered vehicle method of CPX.

The applicability of the method for evaluating the vehicle pass-by noise was first confirmed by tests performed on test tracks, before it was applied to public roads. Measurements were then carried out on public roads paved with several kinds of pavement: dense asphalt, porous asphalt, double-layer porous asphalt and heat-insulating pavement. Heat-insulating pavement has been employed in recent years in central Tokyo in order to lower the road surface temperature.

Based on the measurement results, the distribution of sound pressure level of tyre-proximity noise for each type of road surface was determined quantitatively. The results further showed that heat-insulating pavement greatly reduces car running noise, which is considered possible due to the surface grinding process used to construct this type of pavement.

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1. Introduction

The introduction of vehicle noise regulations has reduced the power unit noise during vehicle running, but this has resulted in an increase in the contribution of tyre/road noise. So the reduction of tyre/road noise has become increasingly important. UN Regulation No. 117 is being introduced in stages in Japan to reduce the tyre noise, but it is also important to reduce noise due to the road surface in order to reduce road traffic noise on public roads. Although many studies on the effects of road surface on road traffic noise have been conducted in European countries, there have been few such studies in Japan and such effects have not been clearly quantified.

This paper reports the results of investigating the effects of road surface of public roads in Japan on vehicle running noise for cars.

2. Road surface evaluation method

2.1. Measurement method

As a method of evaluating the effects of road surface on road traffic noise, the Close Proximity (CPX) method has been standardized and is widely used internationally [1]. The standard prescribes the use of a CPX trailer or a self-powered vehicle. However, there are no CPX trailers in Japan and domestic regulations prohibit the attachments of objects such as microphones that project outward from the vehicle body, preventing CPX measurement on public roads in the country.

Accordingly, we investigated a simple method which can be applied on public roads in Japan [2], based on the CPX method. An overview of the

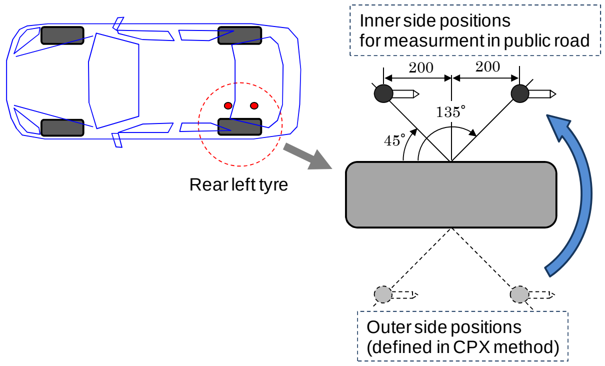


Figure 1. Measurement method

	
tyre P1	tyre H1
SRTT (ASTM F2493) P225/60R16	AVON AV4 185R14

Figure 2. Test tyres

method is shown in Figure 1. A typical front-wheel drive passenger car was selected as a test vehicle. The positions of the measurement microphones were changed to the inner side, opposite to that of the CPX method. The two types of reference tyre stipulated in the CPX method were used as shown in Figure 2 [3]. The data processing procedure basically conformed to ISO 11819-2. The energy average of the level of the measurements at the front and rear positions was used as the level of tyre/road noise. Overall levels were calculated in the one-third octave band center frequency range from 315 Hz to 5000 Hz.

2.2. Validity of measurement method

Since the measurement positions are located under the vehicle body, it is not possible to avoid the negative effects caused by reflection at the vehicle underbody or by the noise radiated from the opposite–side tyre. Therefore, we investigated the validity of using this method to evaluate the effects of the road surface.

A comparison between the noise level measured at outer side of the tyre, i.e. the CPX position, is shown in Figure 3. The levels measured by this method are 0.3 to 1.6 dB higher than those measured at the CPX position. In comparing the frequency spectrums, we can see that the levels at

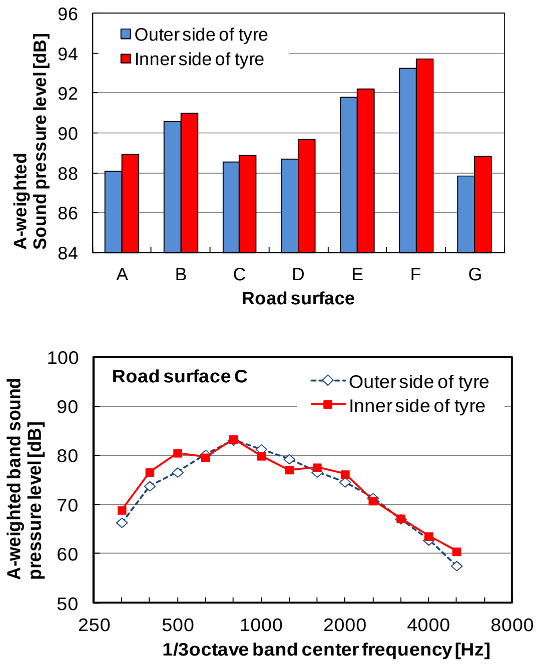


Figure 3. Comparison of noise levels by measurement positions for tyre P1 at a speed of 50km/h

the inner side are higher than those at the CPX position in some bands but are lower in other bands. These differences are considered to be caused by the effect of the sound field under the vehicle body.

Secondly, the relation between tyre/road noise at the inner side of the tyre and the pass-by noise at 7.5 m to the left of the center of the lane was investigated at a constant speed of 50 km/h. tyres P1 were fitted on all four wheels of the vehicle. surfaces on public roads in addition to seven road surfaces on a test track. The results are shown in Figure 4. Although some dispersion can be observed, a strong correlation was observed between both levels since the contribution of power unit noise is very small at a constant running speed.

Thus, after judging that this method is valid for evaluating the effects of road surface on vehicle running noise, we used the method to evaluate the effects of road surface of public roads, although the treatment of the frequency spectrum requires attention.

3. Effect of road surface on vehicle running noise

In order to identify the effects of road surface of public roads in Japan, tyre/road noise was

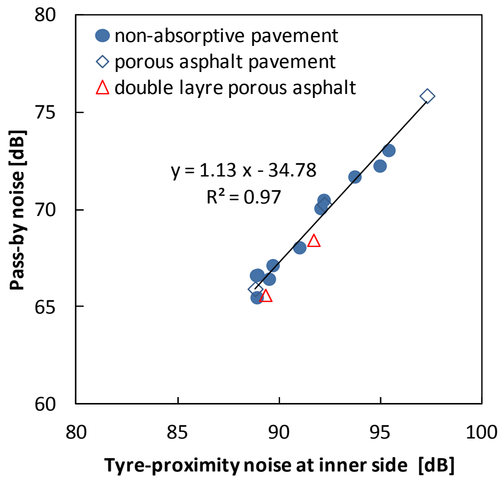


Figure 4. Relation between tyre-proximity noise at inner side of tyre and pass-by noise at a speed of 50km/h in for tyre P1

measured at various sites with typical pavement types.

3.1. Measurement sites

The number of measured sites for each pavement type is shown in Table 1. The total number of sites was 26, and sites with different surface condition for each pavement type were selected for the measurement.

3.2. Measurement results

The results of tyre/road noise measurement for tyre P1 are shown in Figure 5. The sound pressure levels vary with road surface type, and also vary somewhat for each pavement type.

Based on these results, the sound power levels at a constant running speed of 50 km/h were estimated. The results are shown in Figure 6. In the case of tyre P1, the range of sound power level is 5.1 dB for dense asphalt pavement, 6.3 dB for porous asphalt and 4.8 dB for double-layer porous asphalt. Although heat-insulating pavement is based on porous asphalt pavement with a maximum chipping size of 13 mm, the power level of heat-insulating pavement is as low as that of double-layer porous asphalt. In the case of H1 tyres, the range of power level for the same type of pavement tended to be smaller than that of tyre P1 . This tendency was especially significant for dense asphalt pavement, and the ranking of sites was very different from that for tyre P1.

Table 1. Number of measured sites by type of pavement

pavement type	sites
dense asphalt (13mm)	8
dense asphalt (20mm)	3
porous asphalt (13mm)	6
double layer porous (5/13 mm)	6
heat insulating pavement (13mm)	3

3.3 Consideration

(1) Power levels of vehicle running noise

The range of estimated sound power level is compared in Figure 7 with that of ASJ RTN-Model 2013 (ASJ model) which is the standard method of assessing environmental noise in Japan [4]. The sound power level for cars calculated by the equation in the ASJ model is indicated for dense asphalt pavement and porous asphalt pavement in the figure. In the case of DAC, the value of the ASJ model is almost in the middle of the estimated range. In the case of PAC, the ASJ model defines a change in level with aging. In the case of porous asphalt pavement, the sound power levels of one–

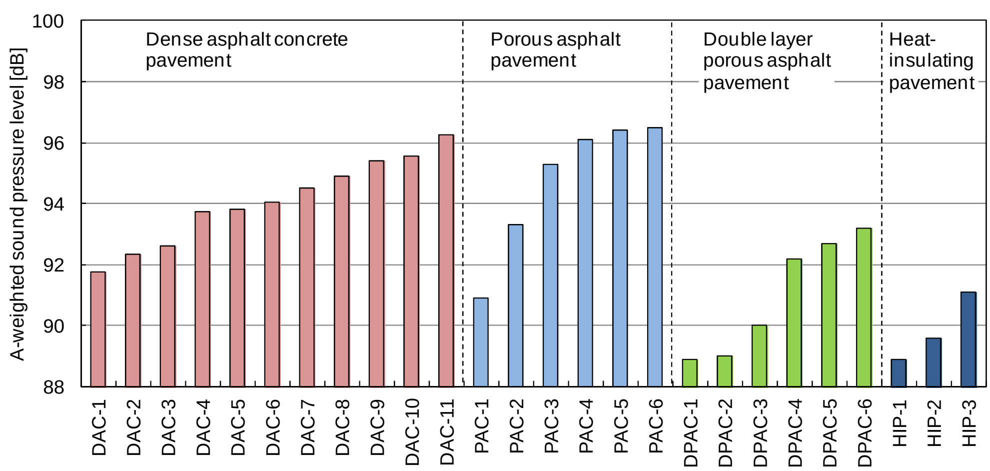
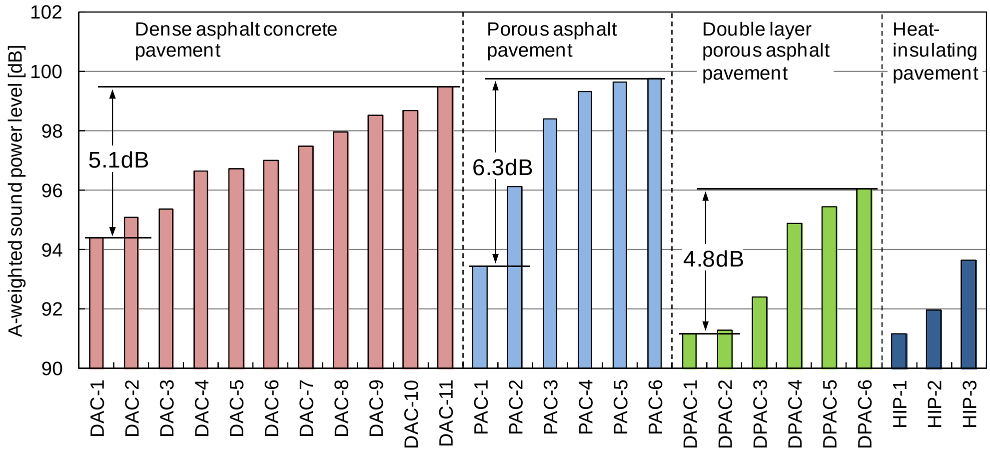
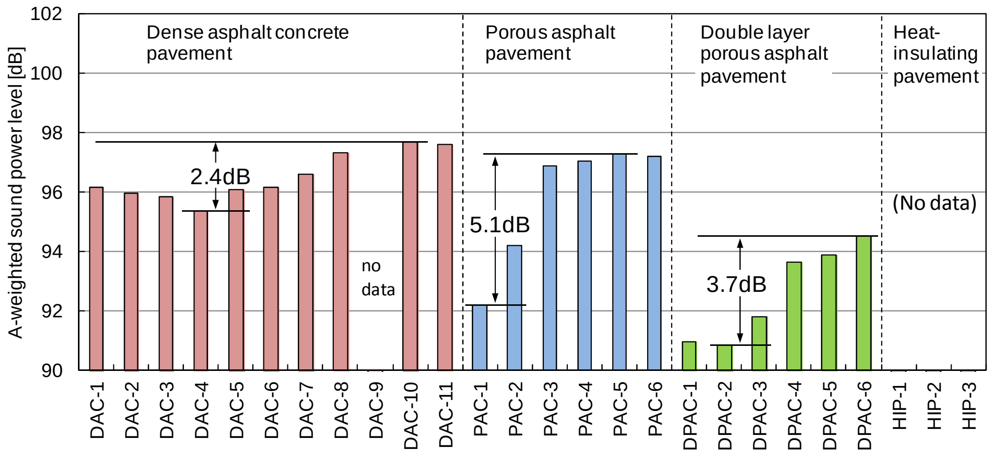


Figure 5. A-weighted sound pressure level of tyre proximity noise at a constant speed of 50km/h for tyre P1



(a) Tyre P1



(b) Tyre H1

Figure 6. Estimated sound power level of pass-by noise at a constant speed of 50 km/h

year-old pavement and ten–year-old pavement calculated by the ASJ model are indicated in the figure. The lower and upper limits of the estimated range nearly correspond to the one-year and ten-year levels of the ASJ model. Although the measurements were based on a specific tyre (tyre P1), these results are in good agreement with the power level definition in the ASJ model.

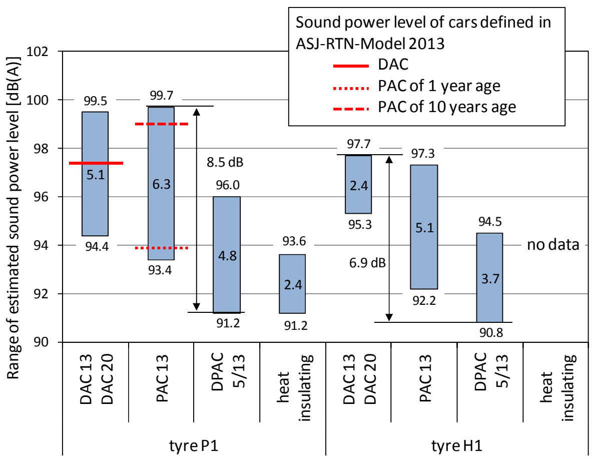


Figure 7 Estimated range of sound power level of a car running at a speed of 50km/h

(2) Noise reduction by heat-insulating pavement

The sound power level on heat-insulating pavement was low, similar to that of double-layer porous asphalt. This type of pavement has been used for several years in central Tokyo to reduce road surface temperature as shown in Figure 8. Although this pavement type is based on porous

Figure 8. Condition of heat-insulating pavement

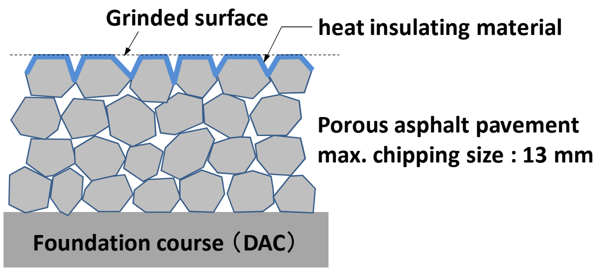


Figure 9. Structure of heat-insulating pavement

asphalt concrete with a maximum chipping size of 13 mm, the road surface is grinded during the construction process as shown in Figure 9 to improve the fixation of the heat-insulating material. It was reported that the grinding process reduces tyre/road noise [5]. One of the reasons why the noise level is low on heat-insulating pavement may be the flatness of the top of the road surface formed by this grinding process.

4. Conclusion

The effects of the road surface on vehicle noise on public roads in Japan were investigated based on measurements of tyre/road noise close to the tyres. The results were as follows:

- It was confirmed that there was a difference in sound power level even for the same type of pavement, including dense asphalt pavement.

- The ranges of sound power level were obtained for typical domestic pavements.

- It was found that the noise reduction effect of heat-insulating pavement is similar to that of double-layer porous asphalt. The reason for the low noise is considered to be the flatness of the top of the road surface formed by the grinding process.

References

[1] ISO 11819-2: Acoustics -- Method for measuring the influence of road surfaces on traffic noise -- Part 2: Close-proximity method (2017)

[2] H.Koike, Akiyoshi Ito, " Effect of road surfaces on road traffic noise on the public roads of Japan", Proc. of internoise 2014, No. 603 (2014)

[3] ISO /TS 118-9-3:2017: Acoustics -- Method for measuring the influence of road surfaces on traffic noise -- Part 3: Reference tyres (2017)

[4] Model 2013": Report of Research Committee on Road Traffic Noise", Acoust. Sci. & Tech. 36, 2 (2015)

[5] Sandberg, Ulf, et al, " Reduction of noise and rolling resistance by horizontal grinding of asphalt pavements, Proc. of Inter-Noise 2015 (2015).