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Study on secular change of sound power spectrum in PO pavement

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ABSTRACT

It has been confirmed that the effect of noise reduction on Porous asphalt pavements changes over time after construction. In the study on the secular change of the sound power level in porous asphalt pavements, comparison of the measured value after construction and predicted value by ASJRTN model on sound power level was conducted. As a result, the difference between the actual measurement value and the ASJRTN model was confirmed for both of the three model routes. In this study, we focused on the power spectrum of noise generated from a vehicle traveling on a porous asphalt pavements, and confirmed the difference between the measured value and the predicted value of the ASJRTN model. As a result, the measured dominant frequency was higher than the predicted value. At the A characteristic relative band power level of 1 kHz to 2 kHz, the measured sound pressure level tended to rise more than the predicted value.

Keywords: Noise, Porous asphalt pavements, power spectrum

1. INTRODUCTION

Porous asphalt pavements increases the safety of driving in rainy weather due to the voids on the surface, and has the effect of reducing automobile noise. Therefore, it is widely paved on highway and general roads in Japan.

However, it is also well known that the noise reduction effect after construction changes with the passage of time due to surface deterioration such as air gap collapse and air gap clogging due to running of a car. In ASJ RTN-Model 2013 widely used in Japan's environmental impact assessment and environmental monitoring etc., the effect of reducing the power level L_{WA} of the driving noise due to such porous pavement is proposed as the correction amount L_{surf} doing. Surveys targeting porous asphalt pavement on highway are being carried out continuously, but there are few findings measured on general roads. And, in order to improve prediction accuracy, we believe that it is necessary to confirm the effect of noise reduction on porous asphalt pavement on the existing road that is being paved.

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Therefore, we conducted a survey of the power level L_{WA} of the process vehicle for the general national road constructed in 2011-2014, and compared the actual measurement after the construction with the prediction by the RTN-Model.

2. Calculation method by ASJ RTN-Model 2013

2.1 Power level of Porous asphalt pavement

L_{WA} in Porous asphalt pavement on the general road proposed by ASJ RTN-Model 2013 has been proposed as follows using the correction amount $\triangle L_{surf}$.

$$L_{\mathrm{WA}} = a + b\log_{10}V + \Delta L_{\mathrm{surf}} \quad (1)$$

Small-sized vehicle : $\Delta L_{\mathrm{surf}} = -5.7 + 7.3\log_{10}(\mathrm{y}+1)$ (2)

Large-sized vehicle : $\Delta L_{\mathrm{surf}} = -3.9 + 3.6\log_{10}(\mathrm{y}+1)$ (3)

a : constant term for each type of vehicle,
b : speed dependence coefficient (= 30)
V : traveling speed [km / h],
y : an elapsed years after construction [years].

In order to set the constants a given for each type of vehicle in Equation 1 in Table 1.

Table 1 constant term for each type of vehicle

2 tyeps	*a*
Small-sized vehicle	46.7
Large-sized vehicle	53.2

2.2 Power spectrum of Porous asphalt pavement

The power spectrum of the running noise of a car was calculated as follows based on the measurement data measured in a highway for less than 1 year and 15 years after construction.

$$\Delta L_{\mathrm{WA,drain}}(f) = \Delta L_{W}(f) + \Delta L_{\mathrm{drain}}(f) + \Delta L_{\mathrm{A}}(f) + \Delta L_{\mathrm{adj}} \quad (4)$$

$$\Delta L_{\mathrm{W}}(f) = -20\log_{10}\left[1 + \left(\frac{f}{2500}\right)^2\right] \quad (5)$$

$$\Delta L_{\mathrm{adj}} = -10\log_{10}\sum 10^{(\Delta L_{\mathrm{W}}(f)+\Delta L_{\mathrm{drain}}(f)+\Delta L_{\mathrm{A}}(f))/10} \quad (6)$$

L_W (f) : correction amounts in frequency [dB]
L_A (f) : frequency weight characteristic A [dB]
L_{adj}: A characteristic relative band power level adjustment value [dB]
L_{drain} (f) : correction amount for asphalt pavement [dB]

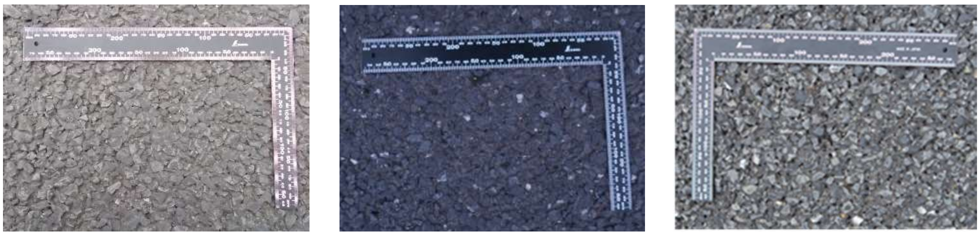
Table 2 Correction amount for asphalt pavement [dB]

frequency [Hz]		1/3 octave band		octave band	
			less than 1yrs		less than 1yrs
63	50	0	0	0	0
	63	0	0		
	80	0	0		
125	100	0	0	0	0
	125	0	0		
	160	0	0		
250	200	0	0	1.1	0
	250	1	0		
	315	2	0		
500	400	3	0	3.7	0
	500	4	0		
	630	4	0		
1000	800	4	−3	2	−4.7
	1000	2	−5		
	1250	−2	−7		
2000	1600	−4	−7	−4.0	−6.4
	2000	−4	−6		
	2500	−4	−6		
4000	3150	−4	−5	−3.4	−4.6
	4000	−3	−5		
	5000	−3	−4		

2.3 Measuring point

In this survey, three porous asphalt pavements constructed in 2011, 2013 and 2014 were selected and measurements were made for two days from June 20, 2018.

The years after construction of the porous asphalt pavement that was the subject of survey are 5 years 4 months (DP - 01), 4 year 1 month (DP - 02), 7 years 3 months (DP - 03) respectively.



(a) DP-01(5.4yrs)　　(b) DP-02(4.1yrs)　　(c) DP-03(7.3yrs)

Figure 1 Surface of measuring point

2.4 Measuring method

As shown in Fig. 2, the measurement of the running noise of the car was carried out by placing the microphone of the sound level meter 7.5 m in the horizontal direction from the center of the lane for the solely traveling vehicle. The sound level meter height was 1.2 m, the time weighting characteristic was FAST, and the frequency weight characteristic was A, and its output was recorded in a data recorder (25.6 kHz, 16 bit).The running speed V [km] of the vehicle to be measured is also recorded at the same time.

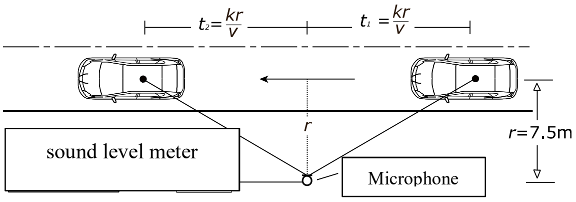


Figure 2 Measuring methodt

First, from the recorded data, the 1/3 octave sound pressure level L_{p100ms} at 50 to 5 kHz at intervals of 100ms from the real time analysis program was calculated, and the noise level L_{A100ms} was calculated. The power law L_{WA} (f) of the traveling vehicle is calculated from the peak method (equation 7), the power spectrum L_{WA} (f) is calculated by the square integral method (equations 8 and 9) using the data L_{p100ms} within -10 dB from the maximum value of L_{A100ms}.

$$L_{\mathrm{WA}} = L_{\mathrm{A,Fmax}} + 20\log_{10}r + 8 \qquad (7)$$

$$L_{\mathrm{WA}}(f) = L_{\mathrm{AE}}(f) + 10\log_{10}(vr) + 3 - \Delta L_{err} \qquad (8)$$

$$\Delta L_{err} = 10\log_{10}\left(\frac{2tan^{-1}k}{\pi}\right) \qquad (9)$$

L_{AFmax} : The maximum value of LA, 100ms of the traveling vehicle [dB]
r : The shortest distance from the center of the traffic lane to the measurement point [m]
LAE (f) : A characteristic single tone pressure exposure level [dB]
v : traveling speed [m / s]

Table 3 Number of actual measurement

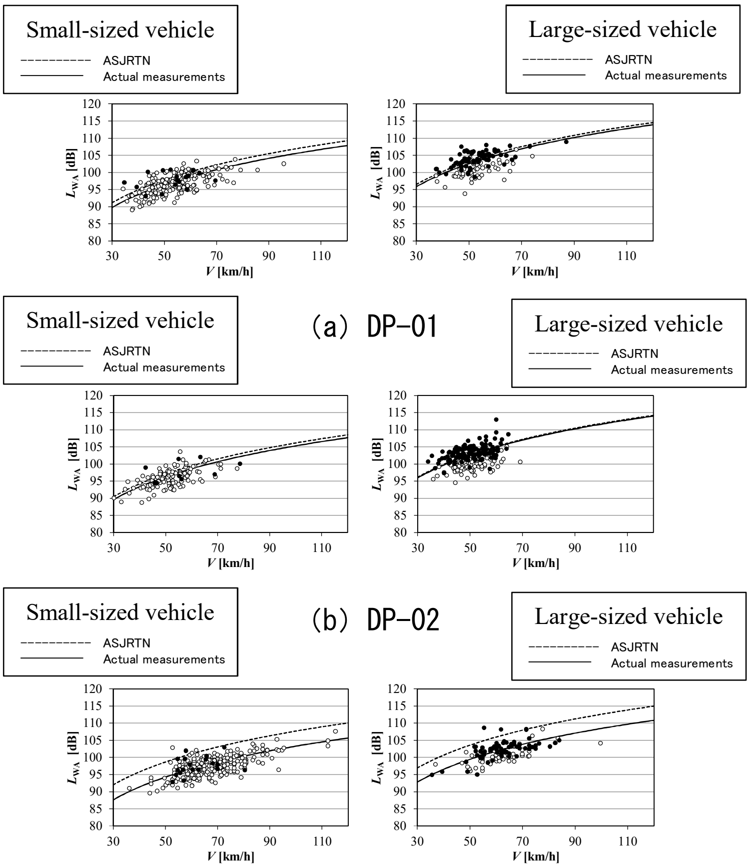
Vehicle types	DP-01	DP-02	DP-03
Small-sized vehicle	201	126	275
Large-sized vehicle	115	205	120
Total	316	331	395

3. Result

3.1 A characteristic sound power level

We compared the L_{WA} of the two vehicle classification obtained by this measurement with the calculated value of L_{WA} by RTN-Model considering the elapsed years after construction. Fig. 3 shows the result of arranging for each measurement location.

The broken line in the figure is the calculated value by RTN-Model, and the solid line is obtained from the measured data of L_{WA} from the constant a (energy mean value of L_{WA}) when the speed dependence coefficient b is fixed to 30. As seen from these results, the L_{WA} data measured this time is lower than RTN-Model at all points, and the difference between the two in compact cars is DP-01, -02 Was about -1.0 dB, DP - 03 was -4.4 dB. Especially for DP-03, although the number of years has elapsed compared to other places after 7.3 years of construction, the tendency that the noise reduction effect by porous asphalt pavement, L_{surf}, is sustained rather than the proposed expression of RTN-Model Was observed.



(a) DP-01

(b) DP-02

(c) DP-03

Figure 3 Comparision of L_{WA}

3.2 Power Spectrum

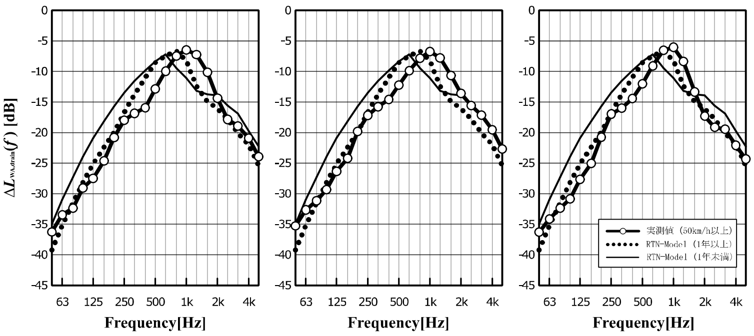
In order to compare the power spectrum L_{WA} (f) of a vehicle traveling on porous asphalt pavement with that of RTN-Model, the A characteristic when the composition ratios of small cars and large vehicles are set to 8: 2 relative band power level $L_{WAdrain}$ (f) was determined. The measurement data used for the study was limited to those with the traveling speed shown in Table 4 of 50 km / h or more.

Figure 4 shows the relative sound pressure level of 1/3 octave band for each measurement point and ⊿ $L_{WA\ drain}$ (f) obtained from measured data for less than 1 year and 15 years after construction in RTN-Model like in L_{WA}. The power spectrum of the car running noise measured at each place decrease the sound pressure level of the frequency of 1.6 kHz or more. In addition, compared to the spectrum of RTN-Model, the dominant frequency spectrum is 1 kHz, which is slightly higher than that of RTN-Model.

However, overall the spectrum tendency 15 years after construction are similar to road less than 1 year after.

Table 4 Number of actual measurement

Vehicle types	DP-01	DP-02	DP-03
Small-sized vehicle	126	71	267
Large-sized vehicle	73	103	111



(a) DP-01　　(b) DP-02　　(c) DP-03

Figure 4 Comparision of $L_{Wadrain}$

4. Conclusion

The power level of automobile driving noise showed a tendency lower than the power level of RNT-Model plus correction amount of porous asphalt pavement.

Frequency characteristics similar to porous asphalt pavement were found in the power spectrum of the running vehicle, but the dominant frequency was slightly higher than the spectrum of RTN-Model at 1 kHz.

Measures to reduce road traffic noise by porous asphalt pavement are widely adopted not only on highway roads but also on general roads. However, there is little knowledge about the effect of noise reduction on porous asphalt pavement on general roads, and it can be said that it is necessary to continuously measure automobile running noise.

5. REFERENCES

1: ASJ Prediction Model 2008 for Road Traffic Noise : Report from the Research Committee on Road Traffic Noise in the Acoustical Society of Japan

2: Road traffic noise prediction model ‘‘ASJ RTN-Model 2013’’:Report of the Research Committee on Road Traffic Noise, Shinichi Sakamoto

3: Road traffic noise prediction model "ASJ RTN-Model 2013" proposed by the acoustical society of Japan - Part 2: Study on sound emission of road vehicles, Y. Okada, T. Tajika, S. Sakamoto