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Effect of temperature on road pass-by noise of light vehicle

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Abstract. Traffic noise is an important evaluation index of urban environmental quality. The level of traffic noise is affected by many environmental factors. Compared with close proximity method (CPX method) in measurement for calculating temperature coefficient, using statistical pass-by method (SPB method) is more suitable for traffic noise evaluation. In order to verify the influence of temperature on road traffic noise, we use SPB method and light vehicles to track and test different types of road noise in a period of time, and record the road temperature and air temperature at the same time. The experimental results show that the vehicle pass-by noise decreases with the increase of temperature, and the noise level of porous asphalt pavement changes little with temperature compared to dense graded pavement.

1. Introduction

With the development of engine technology and the popularization of new energy vehicles, tire/road noise will gradually become the main source of traffic noise. It has the characteristics of low frequency, slow attenuation and long transmission, which brings great psychological and physiological harm to residents' daily life [1]. Many countries research and practice experience show that improving road surface characteristics is one of the most effective measures to reduce tire/pavement contact noise. Reducing traffic noise by using quiet road surface is of great significance to the realization green traffic development plan.

In the construction of quiet pavement, temperature differences lead to different acoustic performance of the same type of pavement in different areas [2]. Therefore, when calculating the performance of a quiet road using tire-pavement noise model, it is necessary to consider the influence of climate temperature on the acoustic performance of the road. Usually, the temperature coefficient is used to modify the calculated results of the tire-pavement noise model.

Because of the limitation of measurement conditions, the noise of tire pavement measured by close proximity method (CPX) method [3] is often used to calculate the temperature coefficient. In practical application, the results obtained by SPB method [4] are closer to the actual traffic noise situation. In this paper, we measure pass-by noise in different road test lanes, and calculate the temperature coefficient based on SPB method.

2. Temperature coefficient

In former research, the relation between temperature and noise level is often in the form [5]:

$$L_{Amax}(20^{\circ}C) = L_{Amax}(T) + \alpha(T - 20) \quad (1)$$



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Where L_{Amax} the A-weighted maximum pass-by is noise level, T is the air temperature in degree Celsius and α is temperature coefficient.

From many investigations, the work of temperature coefficient carried out by many researchers usually conclude that temperature coefficient with using CPX method has a wide range, from 0.01dB/°C to -0.14dB/°C, for asphalt surfaces. In general, the increase of pavement temperature leads the reduction of noise levels [6].

3. Road surface and experiment

3.1. Road surface

The road surface is mainly determined by the aggregate specifications and types of asphalt. The aggregate specification is the proportion of various particle size particle proportion, usually expressed as percentages of the quality through the standard sieves total of total quality. The effect of the maximum particle size and the nominal maximum aggregate size (NMAS) is particularly large for asphalt pavement texture structure, compaction, strength and stability. Four type road surfaces used for the measurement of temperature with their NMAS all are 13, their mixture design ratio are shown in table1.

Table 1. Design ratio of four road surface mixture

Aggregate size (mm)	Design ratio %									
	16	13.2	9.5	4.75	2.36	1.18	0.6	0.3	0.15	0.075
I	100.0	98.0	60.6	34.8	25.4	17.7	13.4	9.9	8.8	7.1
II	100.0	97.9	58.1	30.3	21.2	15.3	12.0	9.4	8.5	7.0
III	100.0	97.7	54.7	24.9	16.7	14.0	12.5	11.4	11.0	9.7
IV	100.0	97.5	51.4	19.4	10.4	7.0	5.2	3.8	3.3	2.7

The main difference of four type mixtures is the ratio of aggregate of 4.75mm, Class I, II, III are dense pavement and Class IV is porous pavement. The appearance of four type road surface is shown in figure 1. Through the figure 1, porous pavement (Class IV) is obviously different to other three road surface, so we can consider that its temperature coefficient may have a different trend to others.

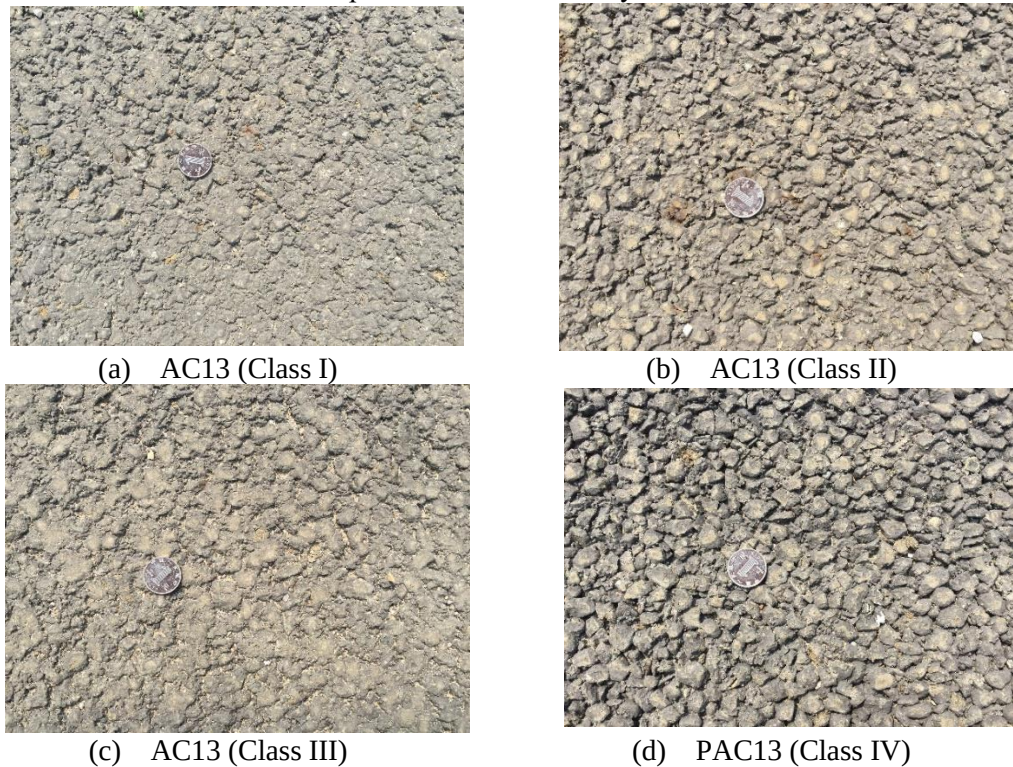


Fig 1. Different sieve passing ratio of road surfaces

3.2. SPB method

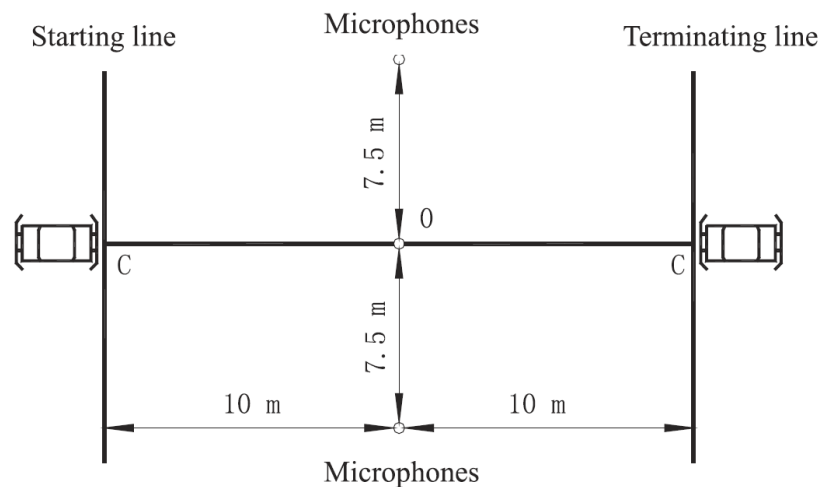


Fig 2. SPB method for pass-by noise

We used SPB method to measure the tire/road noise as described in ISO 11819-1 through these sections of test tracks. The received positions located at the road side of test sections to measure the maximum pass-by noise level, which is 7.5m from the center of the vehicle lane and 1.2m above the lane surface. The measurement points of SPB method are shown in figure 2.

In experiments, two regular cars (Pajero 2003 3.0 and Passat 2008 1.8T) with regular tires are used. As shown in figure 3, (a) shows the tire of Pajero and (b) shows Passat's, where the dimension of Pajero is 265/65/R17 and Passat is 205/65/R14, both tires have run less than 10,000km.



(a) the tire of Pajero



(b) the tire of Passat

Fig 3. Tire used for experiments

The measurement acquisition time is obtained from the front of vehicle into the test section and the tail left. Test vehicles move at a three uniform speed (40km/h, 60km/h and 80km/h) through the test sections.

3.3. Temperature

The experiment dates are Jan 31st, Mar 31st, May 31st and Aug 22st. Except temperature, these four days had the same weather conditions, e.g. humidity, wind and background. Experiments time were all around 13:00 at noon. Before experiments, we recorded the average pavement temperature of each test track, air temperature, wind speeds and background noise as shown in table 2.

Table 2. The weather condition of experiments

date	Pavement temperature (°C)	Air temperature (°C)	Wind speed (m/s)	Background noise (dB)
Jan 31st	5	1	1~3	50.3
Mar 31st	22	15	0~2	49.8
May 31st	40	31	3~5	52.1
Aug 22st	52	33	1~3	51.3

As shown in table 1, when pass-by noise measuring, the range of wind speed is below 5m/s, all background noise are around 50dB, which all below measurement value 15dB or more. This eliminates the interference of other environmental factors on the measurement results. It is notice that pavement temperature doesn't have a linear relation with air temperature.

4. Result and analysis

Each test condition measured 5 times and averaged the results. All the measurement results are shown in table 3 to table 6. Table 3 shows the Class I pavement pass-by noise in different temperature, vehicle and speed, and tables 4, 5 and 6 list the pass-by noise measurement results of three pavement types: Class II, Class III and Class IV.

From Table 3 to Table 6, it can be clearly seen that with the increase of temperature, the vehicle pass-by noise level decreases. The noise level of Class IV pavement is less than other three types, this is because Pavement IV is a porous asphalt pavement. The voids in the pavement can absorb the noise generated during the vehicle driving, thus reducing the pass-by noise in the environment.

Table 3. The pass-by noise of Class I pavement

Temperature	Pass-by Noise dB					
	Passat			Pajero		
	40km/h	60km/h	80km/h	40km/h	60km/h	80km/h
1°C	66.26	68.23	71.66	66.78	69.14	73.05
15°C	65.05	66.90	70.47	65.51	67.99	72.39
31°C	63.94	66.06	69.66	64.54	66.96	70.91
33°C	63.02	65.04	68.61	63.45	65.95	70.12

Table 4. The pass-by noise of Class II pavement

Temperature	Pass-by Noise dB					
	Passat			Pajero		
	40km/h	60km/h	80km/h	40km/h	60km/h	80km/h
1°C	65.52	67.94	70.43	66.21	68.85	72.55
15°C	64.25	66.84	69.53	65.45	67.67	71.67
31°C	63.47	66.13	68.34	64.18	66.85	70.58
33°C	62.54	65.05	67.81	63.28	65.94	69.73

Table 5. The pass-by noise of Class III pavement

Temperature	Pass-by Noise dB					
	Passat			Pajero		
	40km/h	60km/h	80km/h	40km/h	60km/h	80km/h
1°C	65.02	67.30	70.17	65.96	68.45	71.97
15°C	63.94	66.08	69.13	65.05	67.68	71.13
31°C	63.44	65.30	68.50	64.13	66.81	70.22
33°C	62.34	64.77	67.76	63.21	65.84	69.46

Table 6. The pass-by noise of Class IV pavement

Temperature	Pass-by Noise dB					
	Passat			Pajero		
	40km/h	60km/h	80km/h	40km/h	60km/h	80km/h
1°C	59.44	62.32	64.36	59.42	62.25	64.84
15°C	58.70	61.59	63.79	58.69	61.71	63.89
31°C	58.50	61.32	63.53	58.39	61.25	63.84
33°C	58.11	60.90	63.16	57.96	60.92	63.52

As shown in table 7 and table 8, the measurement results of pass-by noise level used in the regression are calculated temperature coefficients in each operation condition. The table 7 shows the temperature coefficient of pajero, and table 8 shows that of Passat. Although two cars noise are not in the same level, temperature coefficients are approximately equal.

Table 7. The temperature coefficient of Pajero

	AC13 (I)	AC13 (II)	AC13 (III)	PAC13 (IV)
40km/h	-0.0912	-0.0838	-0.0758	-0.0393
60km/h	-0.0882	-0.0798	-0.0711	-0.0379
80km/h	-0.0862	-0.0795	-0.0707	-0.0347

Table 8. The temperature coefficient of Passat

	AC13 (I)	AC13 (II)	AC13 (III)	PAC13 (IV)
40km/h	-0.091	-0.0814	-0.0692	-0.0355
60km/h	-0.0868	-0.0769	-0.0723	-0.0381
80km/h	-0.0825	-0.0777	-0.0657	-0.0325

It can be seen from Tables 7 and 8, the temperature coefficients of the two kinds of vehicles are basically the same under different speeds and road types, which means that tire patterns and vehicle types have less correlation with the temperature coefficients. With the increase of speed, the absolute values of temperature coefficients of Class I, Class II and Class III pavement all show a decrease trend. The range of temperature coefficients is from -0.09dB/°C to -0.07 dB/°C. This indicates that with the increase of speed, the influence of temperature on pass-by noise will decrease. Compared with Class I, Class II and Class III pavement, Class IV pavement belongs to porous asphalt pavement, and its temperature coefficient is about -0.035 dB /°C. It can be found from Tables 7 and 8 that the temperature coefficient of porous pavement has little relationship with speed.

5. Conclusion

In conclusion, the measurement results show that the pass-by noise levels of the two vehicles are different, but the temperature coefficients are almost the same. As the temperature rises, the pass-by noise level will be decrease. For densely graded pavement, the range of vehicle noise reduction is related to the design ratio of pavement mixture. The range of absolute value of temperature coefficient is -0.09dB/°C to -0.07 dB/°C, which decreases according to the change of speed (40km/h to 80km/h). Compared with densely graded pavement, the absolute value of temperature coefficient of porous asphalt pavement is less than that of densely graded pavement, which is around -0.035 dB /°C and hardly changes with the speed.

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