Tyre/Road Noise Characteristics of Several Asphalt Pavements

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ABSTRACT: Porous asphalt pavement has been well known as a noise reducing surface course such that the air voids reduce tyre/road noise.
Therefore, the porous asphalt pavement has been popular as a low noise surface course in Japan. However, it has also been recognized that the function of the porous asphalt pavement depends on surface materials or aggregate size. In order to understand the factors of the influencing noise level, it was necessary to examine the tyre/road noise in each asphalt pavement type by noise measurement vehicle.
This paper presents the difference of the tyre/road noise occurring on asphalt surface, and the change in the noise level through regular investigations. In this study, four types of asphalt mixtures as porous asphalt, dense-graded asphalt, stone mastic asphalt (SMA) and double layer porous asphalt were studied through field investigations, and the following results were obtained. In terms of noise reduction, it was found that the porous asphalt had an effect on the noise reduction, while the SMA contributes to the slight reduction in the noise level.
The results also provided that the double layer porous asphalt showed better performance than the porous asphalt. With regard to the noise measurement, it was understood that the results obtained from tyre/road noise of several pavements.

KEY WORDS: Tyre/road noise, low noise surface, double layer porous asphalt, SMA

1 INTRODUCTION

In recent years, porous asphalt pavements are generally used in the Japanese national highway. In Japan, the porous asphalt pavement has the history of 25 years since it was used for the first time in 1986. It was used for the purpose of road safety at first, but it came to be known that there would be a noise reduction effect later. The porous asphalt pavement has the air voids and it was proved that the air voids reduced the tyre/road noise.
This paper presents the continuation measurement results of the tyre/road noise, to measure the tyre/road noise reduction effect and period of this surface.

2 THE NOISE BY THE VEHICLE

In the past, it was defined that the road noise was the combination of vehicle noise and neighbouring area noise. However, today, due to the much increase of number of vehicle and vehicle size and driving speed, the ratio of vehicle noise drastically increased. Hence, today, it is recognized that the road noise is vehicle noise.

3 MECHANISMS OF THE TYRE /ROAD NOISE

Vehicle noise is categorized into power unit noise and running noise such as tyre/road noise. Tyre/road noise is influenced by a tyre tread pattern and road surface texture (Low Noise Pavement Workshop, 2001). The occurrence factor of vehicle noise is shown in Figure 1. Tyre/road noise generally called “Air pumping noise”. The air is compressed by the tyre ditch and surface when the vehicle passed just before. Air pumping noise is occurring noise by expansion of compressed the air passed tyre just after.

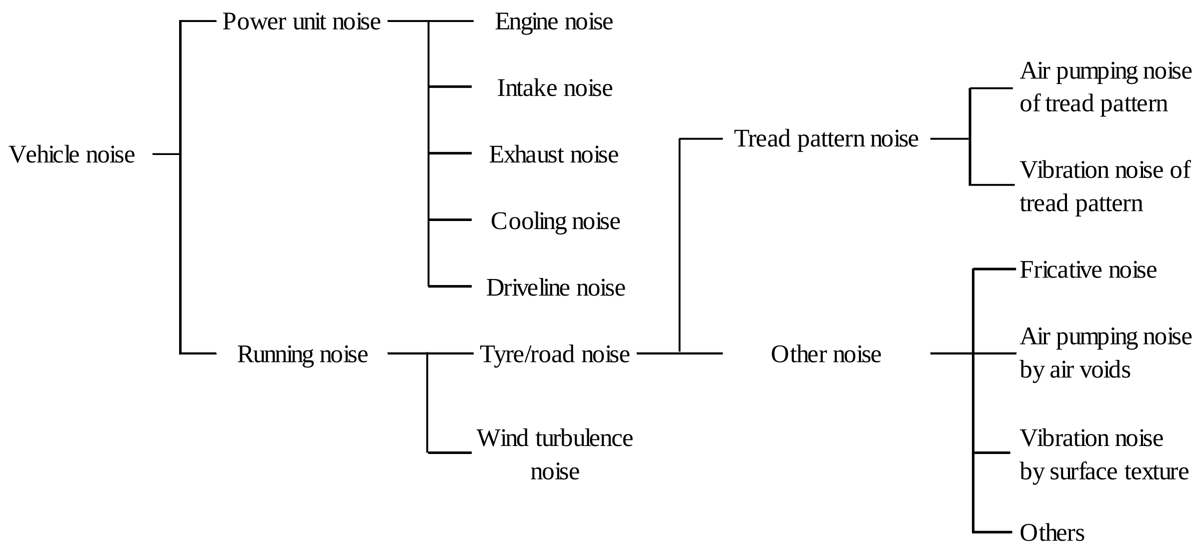

Figure 1: Occurrence factor of vehicle noise

4 MEASUREMENT SUMMARIES

There are two measurement methods of noise by the vehicle passed. One is to measure the tyre/road noise directly by the microphone close to the tyre namely “tyre/road noise”. Another is to measure from the road end namely “road traffic noise”. Both methods were conducted and results were obtained.

4.1Measurement method of tyre/road noise

It can be said that the measurement method of the tyre/road noise directly by the microphone close to the tyre is effective to measure the only tyre/road noise. This method has small influence by the power unit noise such as the engine noise and so on. Furthermore, it has the advantage that the vehicle speed at the time of the measurement can be controlled. The measurement image is shown in Figure 2. In addition, the schematic of vehicle mounted measuring devices is shown in Photo 1.

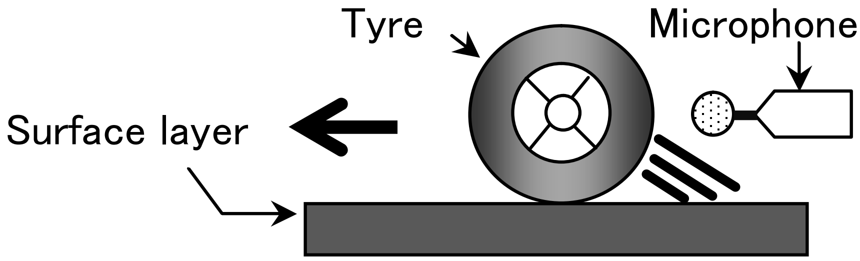

Figure 2: Measurement image of the tyre/road noise

Photo 1: Measurement vehicle of tyre/road noise

4.2 Measurement conditions

The measurement conditions are shown below.

- The position: a rutting of the left side.
- The speed: at a speed of 50 km/h.
- The surface condition: dry condition kept at least 24 hours.
- The sampling interval: 0.1 s.
- The sampling number: about 7/10m.
- The frequency revision circuit: " A-weighting".

The noise of tyre contacted by 3.4 kN loading to pavement surface by adjusting tyre air pressure was measured by microphone. The measurement position was a rutting of the left side (about 0.7 m from the outside-line), and the measurement speed was at a speed of 50 km/h. To avoid the effect of water drainage, if the road surface was wet, the measurement was postponed more than 24 hours until the surface condition becomes dry. The frequency band noise level was extracted from 50 Hz to 5000 Hz of measurement section. The equivalent sound level was calculated by the data, and the equivalent sound level was revised to 20 C. The tyre/road noise went up the band noise level on passing surface indication and a manhole laid by surface. A signal was input at the time of the passage to avoid the influence and was considered to be exclusion section at the time of analysis.

4.3 Measurement method of "road traffic noise"

The fixed point course road traffic noise was measured in the section that measured the tyre road noise mentioned above (JIS Z 8731, 2006). The height of the microphone was a position of 1.2m (JIS D 1024, 1995). The road traffic noise measurement was measured at a fixed point. That is why it is needed much time and labour to measure several places. In addition, the noise value measured by this method was included in the power unit noise such as engines and noises by the vehicle besides tyre/road noise, thus it received the influence of neighbouring background noise. However, it is very important to measure road traffic noise; (1) to grasp the basics in the future road plan and management, (2) to grasp the achievement situation of the environmental standard of the automatic vehicle noise, (3) and to grasp the excess situation of the limit to request it for. The measurement image is shown in figure 3. An environmental standard about the road traffic noise determined in Japan and the request limit are shown in table 1 (Low Noise Pavement Workshop, 2001). The environmental standard is administrative policy target.

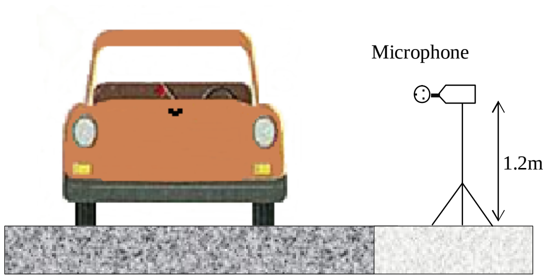

Figure 3: Measurement image of the road traffic noise

Table 1: Standard about the road traffic noise and the request limit (Low Noise Pavement Workshop, 2001)

	Site		Time division: Day time (6 AM-10 PM) (dB)	Time division: Night time (10 PM-6 AM) (dB)
Environmental standard	A area and more than 2 lane		60	55
	B area and more than 2 lane, and C		65	60
	Near the main road		70	65
	Site	**Lane**	**Time division: Day time (6 AM-10 PM) (dB)**	**Time division: Night time (10 PM-6 AM) (dB)**
Request limit	a	1	65	55
		2	70	65
	b	1	70	65
		2	65	55
	c	1	75	70
		2	75	70
	Main road	National equally	75	70

If mayors, town managers, and village headmen admit that living environment around the road is lost remarkably by vehicle noise, and also is road traffic noise exceeds the request limit then, road manager should take an action to reduce the noise.

5. The pavement types for road noise measurement

Tyre/road noise of the dense-graded asphalt pavement and general porous asphalt pavement, high-performance SMA, double layer porous asphalt pavement was measured to grasp a noise reduction effect. In comparison with the dense-graded asphalt pavement, double layer porous asphalt pavement most spread in the low noise pavement. It is known that the general porous asphalt pavement has a noise reduction effect of 3 – 4 dB just after construction. However, the general porous asphalt pavement does not have a long-term noise reduction effect due to a change of the texture of the road surface and the confinement of the air voids. It was desired to increase the effect of noise reduction at early stage in order to sustain the effect of noise reduction longer. Furthermore, it was expected to control the change of surface texture by making the better pavement structure so that air voids keep longer (Kondo, N., Ohnishi, H., 2001). For these reasons, double porous asphalt pavement was developed in Japan. Conventionally, the double layer porous asphalt pavement has been used for only the top layer.
An early further noise reduction effect is expected by assuming double layer. The double porous asphalt pavements become smaller the size of air voids by using the aggregate of the small size in the top layer. The vitality improvement of the noise reduction effect was

expected by the air voids being hard to crush. Furthermore, the roughness of the road surface was improved by using the aggregate of the small size in the top layer, and the reduction of the tyre road noise is expected. It was impossible that the vehicle noise release by using the noise reduction pavement in the top layer.
The birthplace of Stone Mastic Asphalt pavement (SMA) is Germany, and the Japanese version was improved to suit the Japanese traffic condition and weather condition. The measured pavement is called a high-performance SMA pavement. With high-performance SMA, the porous layer is used for the upper part, and the SMA with the durability is used for the middle and lower part, and it is constructed by one layer. Therefore, the surface of SMA resembles the porous asphalt pavement, and as a result reduces tyre/road noise which is most characteristic feature of Japanese SMA.

6. MEASUREMENT RESULTS

The measurement results of each site are shown below.
The tyre/road noise was measured at site A - C. The road traffic noise was measured at the site A and the high-performance SMA pavement of site B and the double layer porous asphalt pavement of site C.

6.1 Measurement results of tyre/road noise

Site A consists of High-performance SMA pavement, Porous asphalt pavement, Dense-graded asphalt pavement.
It is snow cold site recording the many snow of centimetres in the winter season. The site A is a road of four traffic lanes that one-way daily traffic volume of full-size vehicle is more than 3,000. The passed-year variation of tyre/road noise in site A is shown in figure 4. The high-performance SMA pavement resembled the porous asphalt pavement in the early years at the site A. However, it became at the same level as dense-graded asphalt pavement in 4-5 years.

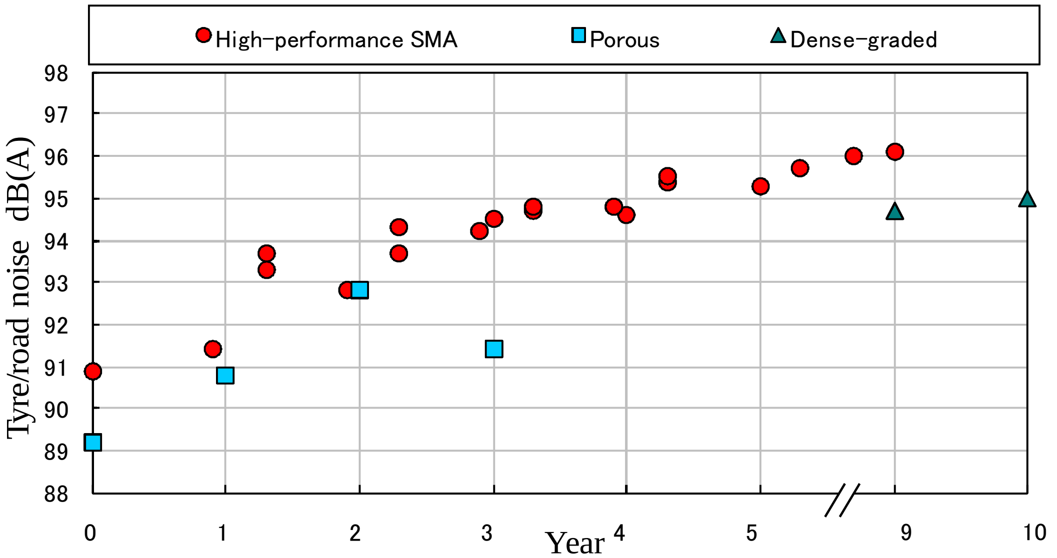

Figure 4: Passed-year variation of tyre/road noise in site A

Site B consists of High-performance SMA surface, Porous asphalt surface, Dense-graded asphalt surface.
Site B is the heavy snow area with much traffic volume, and many of full-size vehicle wrap the chain to tyres in the winter season. The passed-year variation of tyre/road noise in site B is shown in figure 5.
After the winter, it was guessed that the noise value of all pavements grew large by a tyre chain so that the pavement surface was damaged.

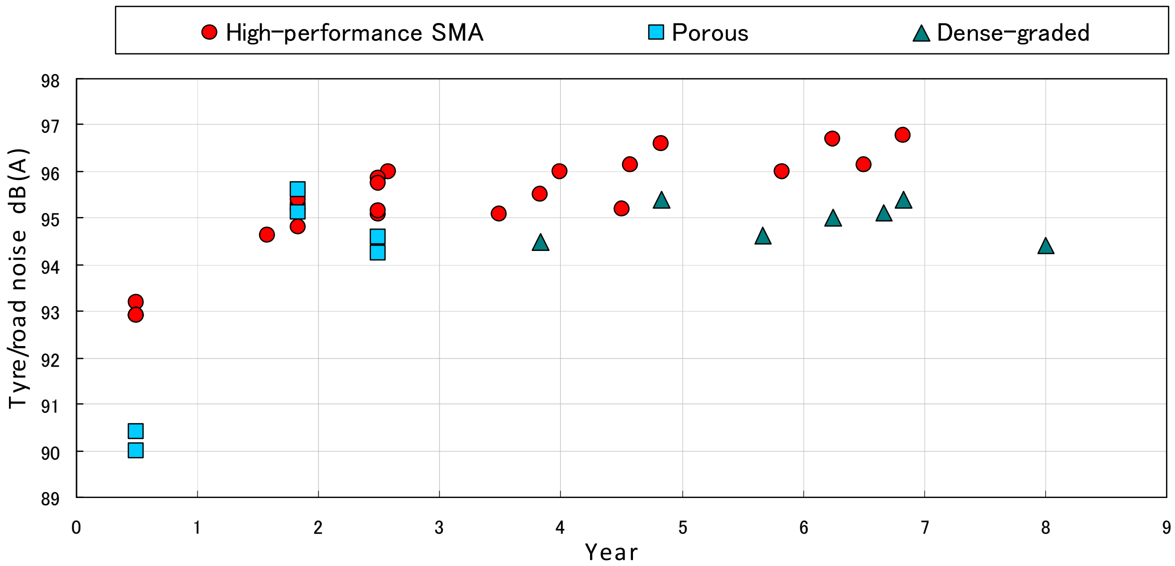

Figure 5: Passed-year variation of tyre/road noise in site B

Site C is Double-layer porous asphalt surface.
The field that measured the tyre/road noise of double layer porous asphalt pavement was a lot of traffic density all day long. It was measured at the six spots in the same route. Moreover some of the field was held-up on traffic capacity over. The passed-year variation of tyre/road noise in site C is shown in figure 6.

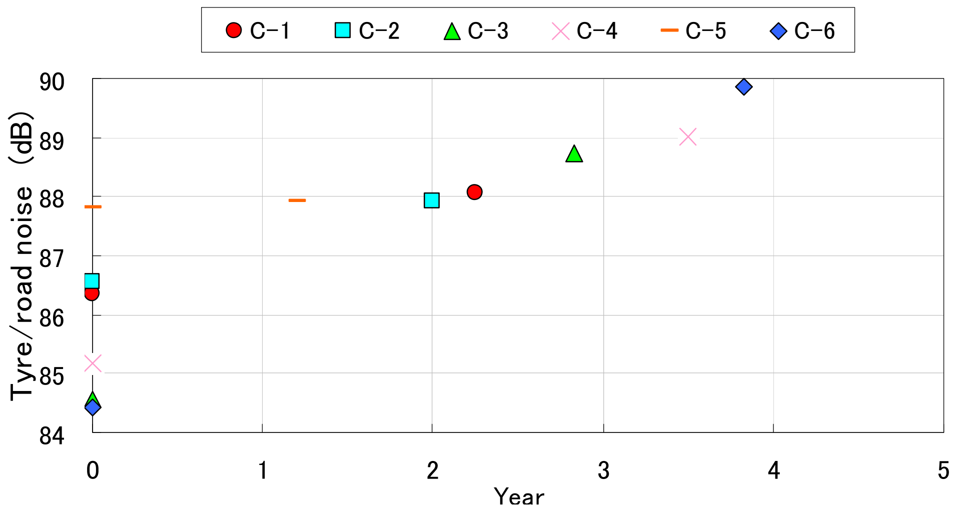

Figure 6: Passed-year variation of tyre/road noise in site C

The tyre/road noise of the double layer porous asphalt pavement was measured before and after construction in two places of site A and C. In addition, before construction pavement structure was dense-graded asphalt pavement with two places(C-4, C-5). The noise reduction value of before and after construction in spot A and C-4 and C-5 is shown in figure 7.
The reduction of about 8.7 dB was confirmed with spot C -4, and about 8.1 dB with spot C -5.

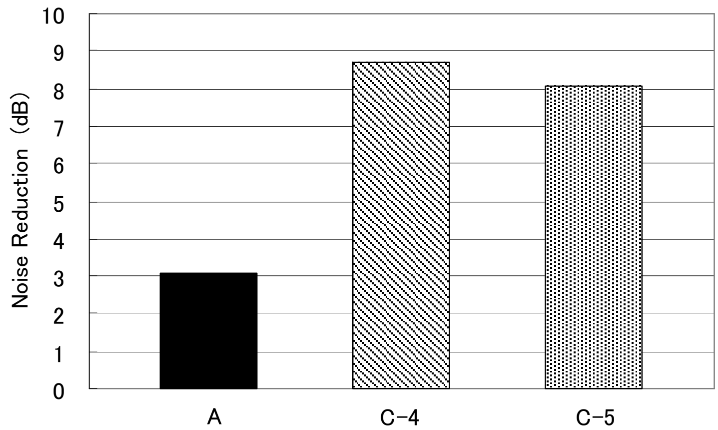

Figure 7: Noise reduction value of before and after construction in spot C-4 and C-5

6.2 Measurement results of road traffic noise

The results of the road traffic noise before and after the construction of high-performance SMA pavement are shown below.
In high-performance SMA section of the site A, the road traffic noise was measured by construction before and after at two spots. The noise reduction value of before and after construction at spot 1 and 2 in site A is shown in figure 8. Because it was the same route at spot 1 and 2 in site A, a similar tendency was observed. High-performance SMA was just after construction, and reduction of about 5 dB was confirmed when compared it with measurements of the dense-graded asphalt pavement that was the top layer before the construction. In addition, it was confirmed the reduction of the about 3 dB even two years passed after construction. Additionally, the noise reduction effect was maintained even if it passed more than three years.

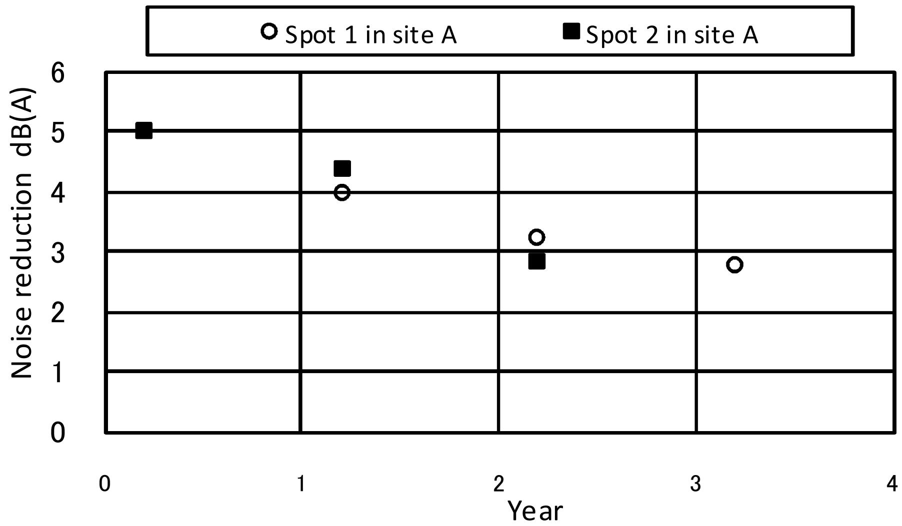

Figure 8: Noise reduction effect of high-performance SMA pavement at spot 1 and 2 in site A

In porous asphalt pavement section of site C, the road traffic noise was measured by construction before and after. The noise reduction value of before and after construction is shown in figure 9. The reduction of the road traffic noise before and after the construction of porous asphalt pavement was about 3 - 5 dB.

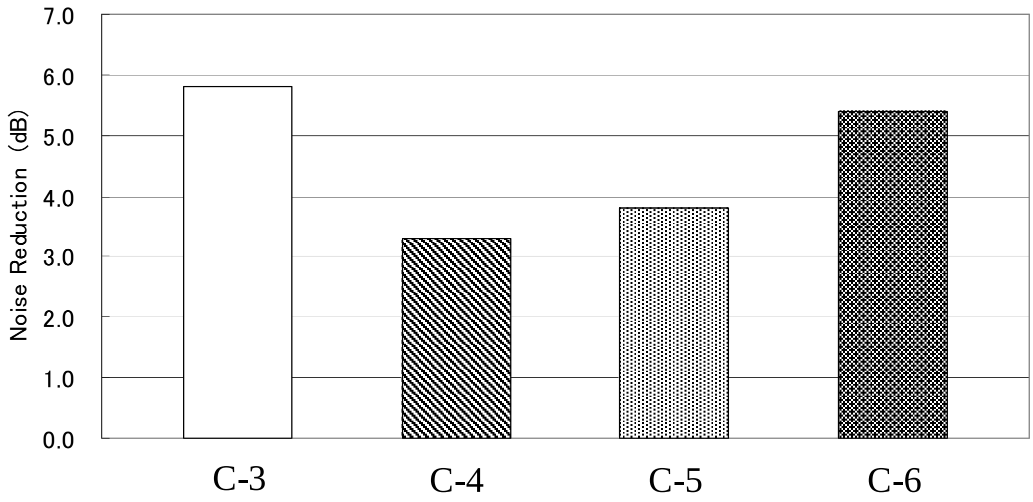

Figure 9: Noise reduction effect of double porous asphalt pavement

7. CONCLUSIONS

Summarized conclusions described in each section are shown below.

(1) Although each spot of the result was uneven, the road traffic noise at the high-performance SMA pavement was confirmed reduction effect about 5 dB lower than existing dense-graded asphalt pavement. It had effect of noise reduction about 3 dB after two years, and it was confirmed that noise reduction affected more than three years.

(2) The road traffic noise at the double layer porous asphalt pavement maintained the effect of reduction about 3-5 dB. The double layer porous asphalt pavement is difficult to intrusion blockage by using the aggregate of the small size in the top layer. For this reason, it may be easy to maintain air voids than normal porous asphalt pavement.

(3) The tyre/road noise of the high-performance SMA showed a value at the same level as dense-graded asphalt pavement of four or five years service. The tyre/road noise of the double layer porous asphalt pavement maintained the noise reduction effect after three or four years.

(4) The high-performance SMA pavement maintained the effect of reduction of tyre/road noise before and after construction about 3 dB. The double layer porous asphalt pavement was about 8 dB.

(5) The high-performance SMA was superior to the durability and had moderate high-performance. It was confirmed that the high-performance SMA was effective to the heavy snow area. It was confirmed that the tyre/road noise reduction effect of the double layer porous asphalt pavement was longer than the general porous asphalt pavement and high-performance SMA.

(6) There is the difference in effect of reduction among different types of pavement. Although function of noise reduction is lost gradually after the certain serviceability, there is the noise reduction effect of the double layer porous asphalt pavement.

Additionally, there is the noise reduction effect of the double layer porous asphalt pavement more than four years.

If a follow-up survey is continued in future, it seems that the function continuance of the double layer porous asphalt pavement is important. Additionally, it is necessary to continue the follow-up survey of the tyre/road noise and the road traffic noise in the future.

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