Noise reduction effect and durability of double layer drainage asphalt pavement

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ABSTRACT: Ministry of Land, Infrastructure, Transport and Tourism (MLIT) has developed three kinds of low noise pavements that are drainage asphalt pavement, double layer drainage asphalt pavement and thin layer drainage asphalt pavement.
The noise reduction effect of passing vehicles on these low noise pavements weakens in proportion with the amount of time elapsed after the pavement was laid due to pavement void clogging.
MLIT has examined these three types of pavements in a typical national highway in Chubu region since 1999, and as a result, time-dependent change of noise reduction effect on these pavements was observed during 10 years study after their construction.
This paper reports noise survey analysis in the time-dependent change of noise reduction effect on each pavement in Chubu region.
From the analysis, it is clear that there were some different results of time-dependent change of noise reduction appear on these pavements.
Time-dependent changes of noise reduction on these three pavements vary from 0.01 dB / month to 0.03 dB / month for heavy vehicles and from 0.06 to 0.07 dB / month for light vehicles.
For more accurate calculation models on road traffic noise in Japan, three kinds of mathematical models, having different sound power levels of passing vehicles for each type of pavement, are proposed in order to carry out these analyses.

KEY WORDS: Drainage asphalt, noise reduction effect, durability, time-dependent change.

1 INTRODUCTION

Ministry of Land, Infrastructure, Transport and Tourism (MLIT) has developed three kinds of low noise pavements that are drainage asphalt pavement ("Single Layer"), double layer drainage asphalt pavement ("Double Layer") and thin layer drainage asphalt pavement ("Thin Layer"). [*A, *B, *C]
The noise reduction effect on running vehicles' noise on these low noise pavements weakens in proportion to the lapse of time after the pavement was laid, because of clogged pavement voids.
MLIT has examined these three types of pavements in a typical national highway in Chubu region since 1999, and it has observed the relationship between the lapse of time and the noise reduction effect on these pavements during 10 years after their construction.
This paper reports the analysis of the time-dependent change of noise reduction effect on each pavement from the data of noise survey in a Chubu region. For accurate improvement of calculation models on road traffic noise in Japan, three kinds of mathematical models ("Power Level Models"), having different sound power levels of running road vehicles for each type of pavement, are proposed in order to carry out these analyses.

2 CONDITION OF EXAMINATION

2.1 Sites

Summary of sites that were used for this study is shown in Table 2.1.
We used the data of Double Layer from No.1, 3, 4, 6, 7 and 8 structures, and Single Layer from No.2 and 5, for the study of sound power levels for 1 year after the construction was completed.
We also used all the data for the study of sound power levels in connection with time-dependent change.

2.2 Traffic

According to the categories of the planned traffic volume from asphalt pavement summary book, we classified traffic volume of heavy vehicles as follows: D-grade traffic, larger than 3,000 (car/day/lane); C-grade traffic, more than 1,000 and under 3,000. From the results of continuous traffic observation for 24 hours, D-grade traffic was applied to sites No.3, 4 and 5, and C-grade traffic was to the other sites.

2.3 Method

Layout of the microphone is shown in Figure 2.1
We measured sound peak levels of general road vehicles according to four-categories, setting the microphone horizontally at 7.5m from the center of the nearest lane and vertically at 1.2m above the road surface, and calculated the sound power levels in accordance with the Peak Method.

Table 2.1 Summary of Sites

Site	Route	Construction Date	Pavement Detail Structure			
			No.	Thickness mm	Maximum Diameter mm	Disigned Air Space %
Nogoya	R302	1999/6/21	1	20	5	23
				30	13	25
			2	50	13	20
Yokkaichi	R1	2000/2/26	3	15	5	23
				45	20	23
			4	15	5	20
				35	13	20
			5	50	13	20
Kaji	R41	2002/10/25	6	20	8	23
				30	13	20
Tsu	R23	2002/11/20	7	20	8	20
				30	13	20
Fuji	R139	2003/2/24	8	20	5	23
				30	13	20

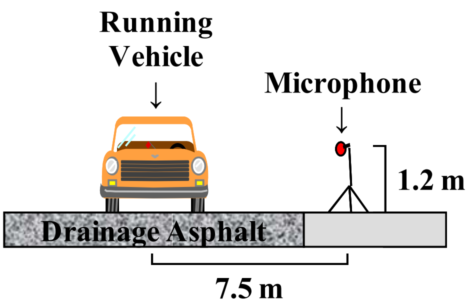

Figure 2.1 Position of the Microphone

3 STUDY OF POWER LEVEL MODELS IN RELATION WITH TIME-DEPENDENT CHANGE

3.1 Time-dependent change of Sound Power Levels on Each Road Traffic Flow

We studied the difference of time-dependent changes of sound power levels on each traffic volume. Although we used three kinds of traffic speeds -“40km/h”, “50km/h”, and “60km/h”, the tendencies of time-dependent change are nearly equal. Thus we show the result at “60km/h” case in Fig. 3.1.

As a result, there is no difference of time-dependent change of sound power levels in cases of heavy vehicles, but in cases of light vehicles, sound power levels at D-grade traffic doubled the line-graph angle against sound power levels at C-grade traffic.

[Heavy Vehicles: 60km/h] **[Light Vehicles: 60km/h]**

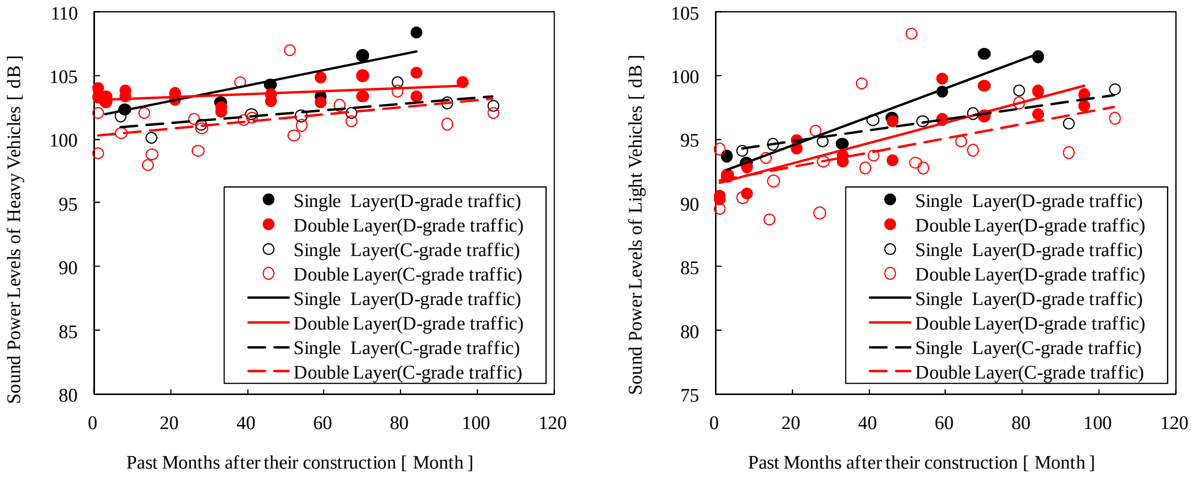

Figure 3.1 Time-dependent change of Sound Power Levels on Each Traffic Volume

3.2 Configuration of Power Level Models Considered Time-dependent change

From the result of paragraph 3.1, it was found that line-graph angles of time-dependent change depend on traffic conditions, but power level models may be quite complicated if it applies time-dependent change to different traffic conditions.

Thus we studied power level models with time-dependent change, without considering the differences in traffic conditions.

[Heavy Vehicles: 60km/h] **[Light Vehicles: 60km/h]**

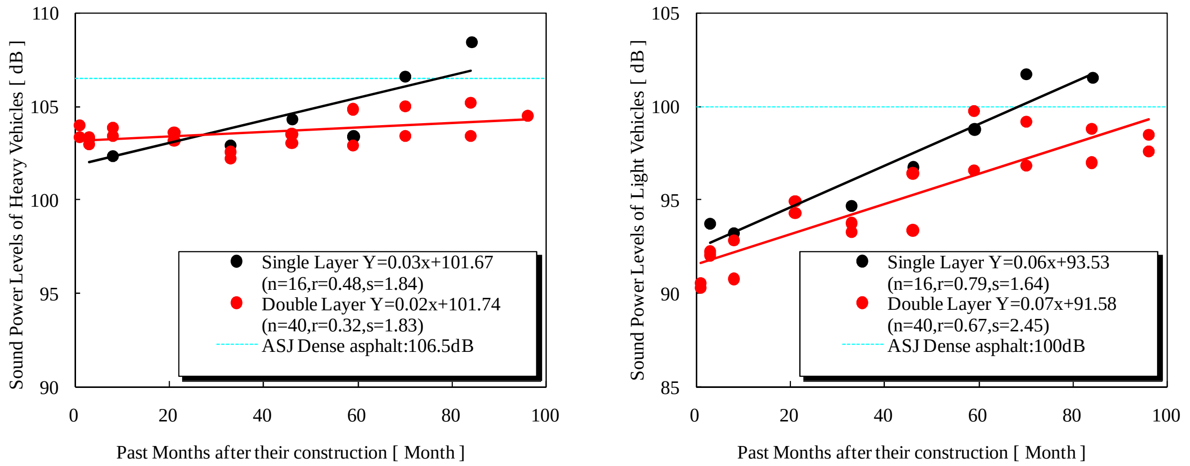

Figure 3.2 Time-dependent change of Sound Power Levels on Each Pavement

Based on the result of the above study, we established power level models applying time-dependent change on each pavement. New models are composed of two terms, the theoretical term for dense asphalt pavement proposed by “ASJ RTN-Model 2003”[*D] as L_{WAT} and the correction term of sound power levels applying time-dependent change on each pavement as L_{WAC}. The formula is shown in Table 3.1.

$$L_{WA} = L_{WAT} + L_{WAC} \qquad (1)$$

Table 3.1 Correction of Sound Power Levels with Each Vehicles and Each Pavement

Term Type	Vehicle Type	Pavement Type		Sound Power Levels Formula	A*
Correction Term	Heavy	Drainage Asphalt	ASJ RTN-Model 2003	L_{WAC}=-10logV*+14.9+(0.3/12)X*	-
			Single Layer	L_{WAC}=-13logV+19.5+AX	0.03
			Double Layer	L_{WAC}=-12.2logV+17.6+AX	0.02
			Thin Layer	L_{WAC}=-19.8logV+32.2+AX	0.01
	Light		ASJ RTN-Model 2003	L_{WAC}=-6logV+5.7+(1.0/12)X	-
			Single Layer	L_{WAC}=-4.7logV+3.3+AX	0.06
			Double Layer	L_{WAC}=-7.2logV+4.7+AX	0.07
			Thin Layer	L_{WAC}=-4.5logV+3.5+AX	0.07
Theoretical Term	Heavy	Dense Asphalt	ASJ RTN-Model 2003	L_{WAT}=30logV+53.2	-
	Light		ASJ RTN-Model 2003	L_{WAT}=30logV+46.7	-

V:Running speed of vehicle, X:Number of Past months after their construction, A:Invariable

3.3 Time-dependent change of Noise Reduction Effect Based on Power Level Models

By applying formula (1), we calculated noise reduction effects of sites in Table 3.2, which are remainder from effect of dense asphalt pavement, classified by the percentage of heavy vehicles against all vehicles and past years after the construction.

From Table 3.2, we understood that the noise reduction effect continues for 7 years in case of the “single layer”, and for 8 or 9 years in case of the “double layer” depending on the percentage of heavy vehicles.

Table 3.2 Time-dependent change of Noise Reduction Effect Based on Power Level Models

Parcentage of heavy vehicle		Past years after their construction 0*	5	6	7	8	9	10
Single Layer Asphalt	Under 10%	-4	-1	0	0	1	2	2
	Over 10% and Under 20%	-4	-1	0	0	1	2	2
	Over 20% and Under 30%	-4	-1	0	0	1	1	2
	Over 30% and Under 40%	-4	-1	0	0	1	1	2
	Over 40%	-4	-1	0	0	1	1	2
Double Layer Asphalt	Under 10%	-7	-3	-2	-1	-1	0	1
	Over 10% and Under 20%	-6	-3	-2	-1	-1	0	1
	Over 20% and Under 30%	-6	-3	-2	-1	-1	0	1
	Over 30% and Under 40%	-6	-3	-2	-1	-1	0	0
	Over 40%	-5	-3	-2	-1	-1	0	0

*Immediately after their construction

4 SUMMARY

This paper described the results about noise reduction effect and durability of double layer drainage asphalt pavement.
From analysis, it was clarified that there are few difference of time-dependent change of noise reduction effect on each pavement.
Noise reduction effect continues for 7 years in case of the “single layer”, and for 8 or 9 years in case of the “double layer”, depending on the percentage of heavy vehicles against all vehicles.
Time-dependent change of noise reduction effect on each pavement are as follows: for heavy vehicles from 0.01 dB / month to 0.03 dB / month; for light vehicles from 0.06 to 0.07 dB / month.
It is noted that this paper was prepared analyzing the limited data collected in a Chubu area, thus it will be necessary to collect additional data in future, particularly on several general public roads, in order to examine the correction formula with higher accuracy.

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