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COMPARISON AMONG SOUND POWER LEVELS OF PASSENGER CARS WITH VARIOUS TYPES OF TIRES

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INTRODUCTION

Studded tires are widely used recently in winter in the northern areas of Japan. They have posed serious social problems in the areas: damage to road pavement, dust caused by the abrasion of pavement, and increase of traffic noise level.

In this study, we determined the sound power levels of noise from motor vehicles that have several kinds of tires in order to get knowledge of the influence of tire structures including studded one on noise emission.

OUTLINE OF THE MEASUREMENT

Sound power levels of vehicle noise at constant speeds were measured by the comparison method using the diffuse sound field in tunnel and the reference sound source [1].

The field measurements were carried out twice in a tunnel located on the Tohoku Expressway and of the length of about 600 meters. The section of the expressway on which the tunnel is situated, had not been opened to public at the time of the measurements. The first measurement was carried out in August 1981, when the road in the tunnel had the concrete surface. The second measurement was done at the same place in September 1982, when the road had the asphalt surface.

The schematic diagram for the measurements is shown in Fig.1. The vehicle noise as well as the reference sound was recorded at the center of the tunnel while a vehicle passed through a central section of just 100 meters in length. The recorded signals were reproduced and analyzed through 1/1 octave band filters in the laboratory.

Six kinds of tires were prepared for each of six passenger cars. They include the normal, snow and studded tires of both the radial-ply and bias-ply tires. Besided the six kinds of passenger cars (displacement:1.5-2.0 liters, gross vehicle weight:0.8-1.4 tons), an omnibus (displacement:11 liters, GVW:9.9 tons) and a sightseeing bus (displace-

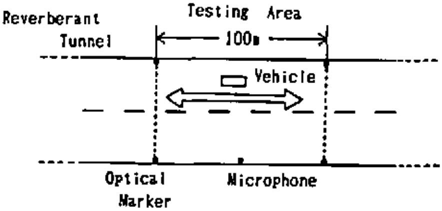

Fig.1 Schematic diagram for the measurement of the sound power levels of vehicle noise in a tunnel.

ment:16 liters, GVW:11.5 tons) were measured in the second measurement.

A driver was requested to keep a car at a constant speed when he passed through a central section of the tunnel. 12-15 steps of vehicle speeds were selected from 30-100 km/h. Actual average speeds of a running car were determined from the time durations that the car ran past 100 meter interval at the central section of the tunnel.

A-WEIGHTED SOUND POWER LEVELS OF NOISE EMITTED FROM PASSENGER CARS RUNNING AT STEADY SPEED

Since the coefficients for linear regression of a logarithm of car speed on sound power levels for every car and tire show almost the same values except for a car with an automatic transmission, the average sound power levels for five passenger cars with manual transmission should be further considered here.

Regression equation of sound power levels on the logarithm of car speed has a high correlation with measureded values (correlation coefficients 0.994 - 0.999) and its standard error is smaller (0.2 - 0.6 dB) than that in the case of their linear regression on speed itself. For this reason, we consider the following regression equation further:

$$\mathrm{PWL(A)} = a \log v + b ,$$

where v is a car speed (km/h), and both a and b are constants.

Fig. 2 shows the resultant regression lines for each tire running on the road with the asphalt surface. The line for bias-ply snow tires has a steeper slope (12.2 dB/double speed) than those of the other kinds of tires (9.8 - 10.8 dB/double speed). This difference can be interpreted to be caused by the resonance of air columns at the tread in bias-ply snow tire whose grooves of tread are deeper and wider than those of the others.

In the case of the road with the concrete surface, slopes of the lines are almost the same for all kinds of tires. As to the absolute sound power levels, normal tires running on the road with the concrete surface show a little greater noise level (0 - 1 dB) as compared with those for the asphalt surface, while studded and snow tires denote slightly smaller levels (1 - 2 dB) on the concrete surface. This effect may be attributable to the interaction between roughness of the road surface and the grooves of tire tread.

Among three types of both the radial-ply and bias-ply tires, the studded ones are the noisiest and the snow tires come to the second place. The difference in noise levels between studded and normal tires is 6

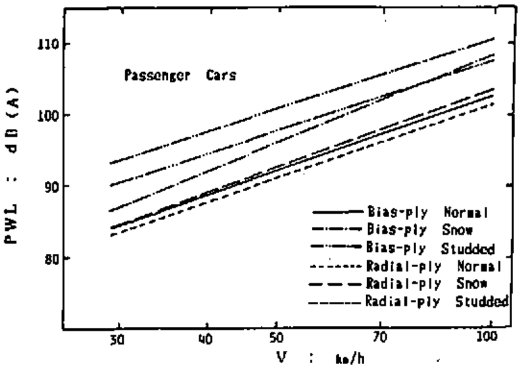

Fig.2 A-weighted sound power levels of noise from passenger cars having various kinds of tire vs their speeds.

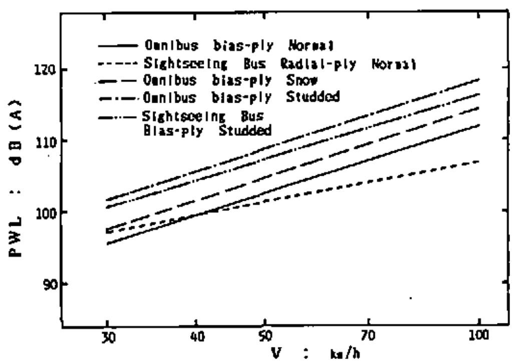

Fig.3 A-weighted sound power levels of noise from buses vs their speeds.

and 9 dB for radial-ply and bias-ply tires respectively. It is remarkable that radial-ply snow tires are almost the same as normal tires from the point of noise emission.

A-WEIGHTED SOUND POWER LEVELS OF NOISE EMITTED FROM BUSES

Fig. 3 shows the A-weighted sound power levels of noise emitted from buses as a function of their speeds. This figure shows that studded tires cause the increase in noise levels by about 7 dB. Correlation coefficients between noise levels calculated from regression equation and measured one are 0.922 for radial-ply normal tires and 0.968 for bias-ply normal tires. These values of correlation coefficient are smaller than in snow and studded tires, because the share of engine noise in the total sound energy cannot be ignored, especially at low speed. Correlation coefficients for snow and studded tires are in the range of 0.993 - 0.998. Very low noise levels generated by the sight-seeing bus with radial-ply normal tires running at relatively high speed may be attributable to the radial-ply structure and the rib pattern of tread.

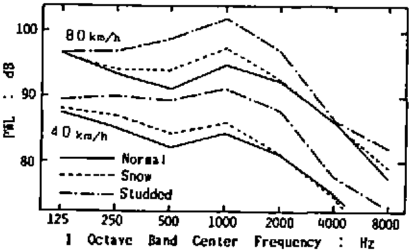

Fig.4 1/1 octave band analysis of noise from passenger cars having radial-ply tires.

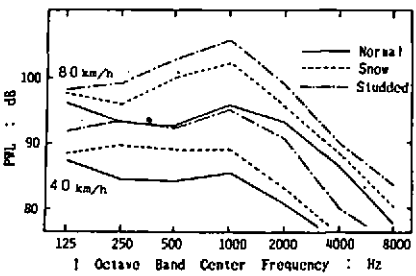

Fig.5 1/1 octave band analysis of noise from passenger cars having bias-ply tires.

5. SPECTRA OF MOTOR VEHICLE NOISE

Figs. 4 and 5 show the results of 1/1 octave band analysis of the noise. Those figures are concerned with radial and bias-ply tires respectively. If the lug treads are deep and regularly arranged, collisions between the tire and the road surface generate noise with pitch whose frequency is proportional to the product of vehicle speed and density of lug tread of tires. This frequency is about $5v$ - $10v$ (Hz), where v is a vehicle speed in km/h. Actually, the width of lugs is slightly varied so that the pitch of tire noise is obscure, and its frequency spectrum is rather flat and has an indistinct broad peak around 1 kHz. This peak is eminent in motor vehicles with studded tires running at high speed.

CONCLUSION

It is shown that the use of studded tires instead of normal ones raises the A-weighted sound power levels of vehicle noise by 6-10 dB, and its frequency spectrum has a broad peak around 1 kHz and rapidly falls in frequency range above 2 kHz.

ACKNOWLEDGEMENT

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REFERENCE

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