EFFECT OF ROAD TRAFFIC NOISE REDUCTION BY POROUS ILB PAVEMENT FOR ROADWAY

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ABSTRACT

The effect of tire/road noise reduction was investigated by using porous inter locking block (ILB) pavements for roadway. The test pavement was formed of eight sections differing in kind of ILB and in material and construction method for laying course and base and subbase courses. The longitudinal length of each section is 20 m. Tire/road noise from the test vehicle was measured by coast-by method at the roadway side. As a result of measuring the noise level, it was confirmed that the noise level was reduced about 3-5 dB(A) by porous ILB pavement (P-ILBP) in comparison with the noise level on asphalt pavement (ASP) and that the noise level on P-ILBP was still kept lower level than the noise level on ASP even though the noise level slightly increased about 1-2 dB(A) due to clogging of voids in porous ILB after one year passed. Furthermore, the noise level in the fender was measured on deferent types of the pavement surfaces including P-ILBP. In comparison with each data , it is clear that the noise level on P-ILBP was kept relatively lower level than the other noise level in higher frequency range over 2000 Hz. On the other hand, as a result of the water permeability of P-ILBP , it was confirmed that the permeability of P-ILBP was dependent of the water permeability of base course.

1. INTRODUCTION

ILB pavements have continuos joints, and then it has been concerned that annoyance tire/road noise is generated from the joint portion with every vehicle passing on the joints. In case of the applications of ILB pavement for roadways, Japanese researcher had reported that road traffic noise on ILB pavement in dry surface condition was almost same level or slightly lower level on ASP in dry surface condition [1],[2]. Particularly, it was pointed out that the noise level on ILB pavement kept lower level about 10 dB(A) than the level on ASP in case of wet surface condition over vehicle running speed of 40 km/h [2].

Although these effective results on the noise reduction by ILB pavement were reported, it is still concerned that ILB pavement will be generated higher traffic noise. For getting better consensus with habitants lived along roads for using ILB pavements, it is necessary to develop and distribute more effective way of noise reduction by ILB pavement for roadway.

In this study, the effect of tire/road noise reduction by P-ILBP for roadway was investigated because tire/road noise is major factor of road traffic noise. And the influence of laying course material and the type of base course material on the noise reduction by P-ILBP was also studied. Furthermore, changes with time of water permeability related to the porosity of P-ILBP was measured because it was known that the noise reduction by P-ILBP was depended on the porosity.

2. TEST PAVEMENT

The test pavement was constructed and has eight deferent sections which was used two kinds of ILB, non-porous ILB and porous ILB, with two kinds of base course materials in Shirako Town, Chiba Prefecture, Japan. The length of each section was 20 m and then total length of the pavement was 160 m.

The test pavement structure is shown in Figure 1 [3]. Laying pattern of ILB was stretcher bound pattern. Dimension of ILB was about 250 mm (length)×130 mm (width)×80 mm (thickness). The joint spacing was about 3 mm after the construction of the test pavement.

As shown in Figure 1, river sand, for all sections of left side in the test pavement, and glass-cullet, for all sections of right side in the pavement, were applied as a laying course material under ILB for studying of the influence on the effect of tire/road noise reduction. Thickness of laying layer was about 20 mm. Furthermore, geotextile with 0.7 mm thickness was laid between laying course material and base course material at from section No.3 to section No.6 of the pavement.

Two kinds of base course materials were provided. One was cement asphalt emulsion stabilized material (CAE) with 10 cm thickness and other was recycled mechanical stabilized crushed stone (RMC) with 24 cm thickness.

3. TEST PROCEDURES

3.1 Measurement of Tire/Road Noise at the Roadway Side

In general, tire/road noise is occupied about 60-70% of the noise generated from vehicle in steady running speed [4]. In this study, a passenger car equipped with radial tire was used as

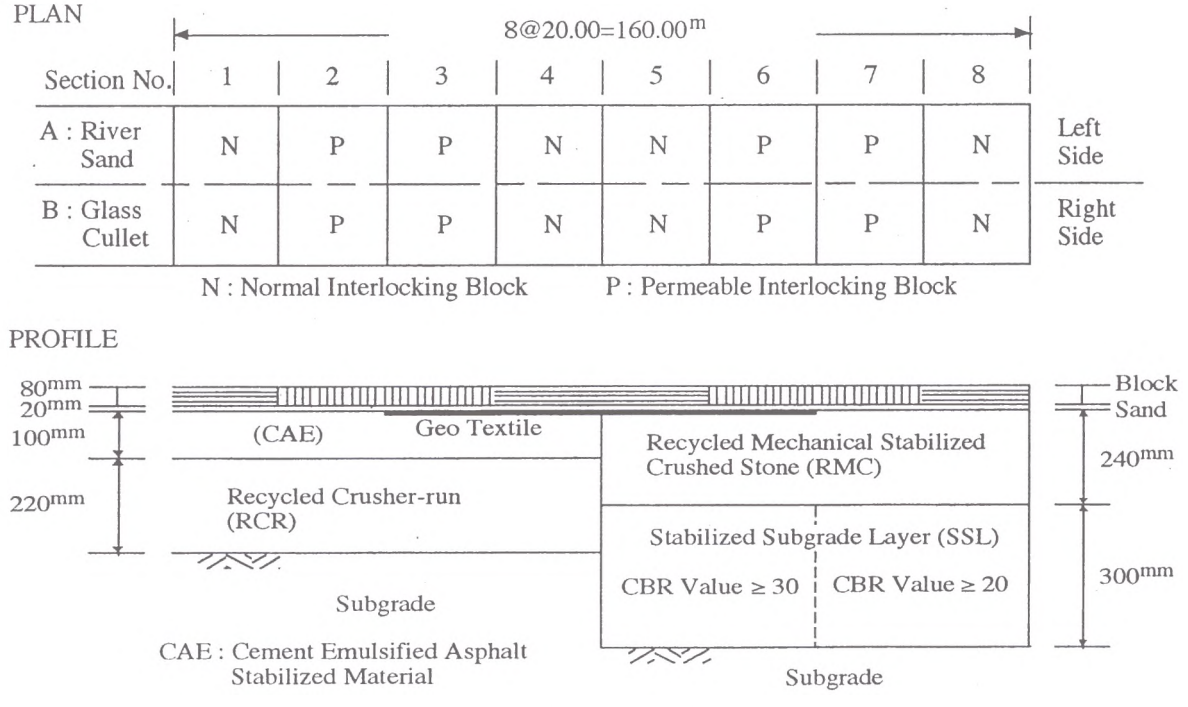

Figure 1 Test Pavement Structure (after Todoroki [3])

the test vehicle and controlled to keep steady running speed of 30 km/h, 40 km/h and 50 km/h in the coast-by when tire/road noise on each section was measured at the roadway side, respectively. The microphone of sound level meter was set up in 1.2 m height.

Two road surface conditions, dry and wet, were used for the measurement of tire/road noise. During the measurement, the wet condition was maintained by spraying water on the test pavement surface.

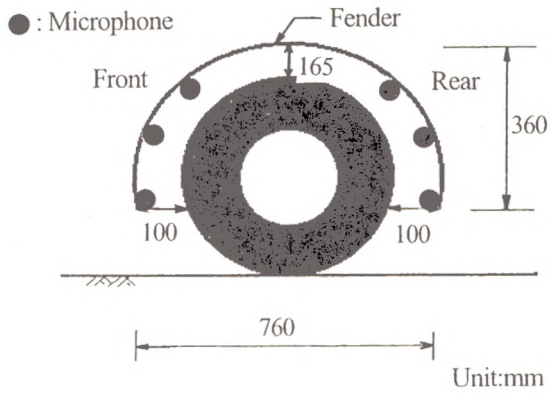

Figure 2 Microphone Position in Fender

3.2 Measurement of Tire/Road Noise in the Fender

Tire/road noise in the fender of the test vehicle was also measured on five kinds of road surfaces: ASP, drainage asphalt pavement, concrete pavement, asphalt pavement mixed with rubber-chips and P-ILBP, respectively.

The small microphones were equipped in the fender as shown in Figure 2.

For the comparison of tire/road noise in the fender, the test vehicle was equipped same radial tire and driven in the coast-by and in same running speed.

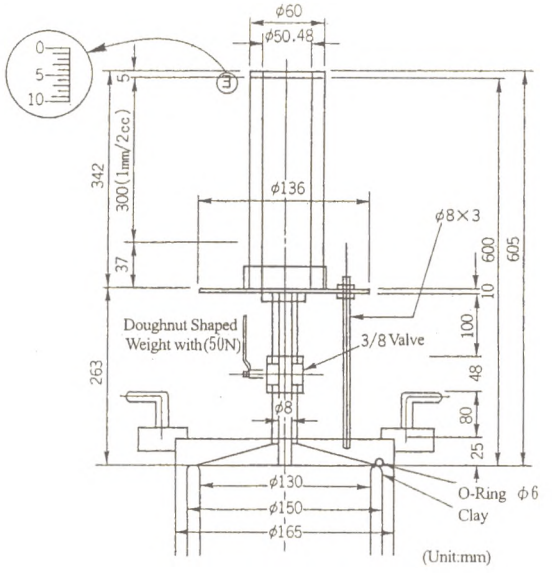

Figure 3 Field Permeability Test Equipment

3.3 Field Permeability Test

Changes with time of water permeability was measured at each P-ILBP section of the test pavement by using of field permeability test equipment as shown in Figure 3.

4. TEST RESULTS AND DISCUSSIONS

4.1 Characteristics of Tire/Road Noise at the Roadway Side

Figure 4 shows the variations of the mean sound pressure level with the vehicle speed and the kind of road surface in dry surface condition. And also, Figure 5 shows the variations of the mean sound pressure level with the vehicle running speed and the kind of road surface in wet surface condition. In these figures, the tire/road noise level on three kinds of road surfaces such as ASP, P-ILBP and non-porous ILB pavement (NP-ILBP) after the construction of the pavement and one year passed were plotted.

It is clear that the mean sound pressure level on P-ILBP and NP-ILBP is lower than the mean sound pressure level on ASP about 3-5 dB(A) in both figures. In comparison with the mean sound pressure level on P-ILBP and NP-ILBP, the mean sound pressure level on P-ILBP shows lower value than the level on NP-ILBP. It is confirmed that these results mentioned above are kept almost same tendency after one year passed.

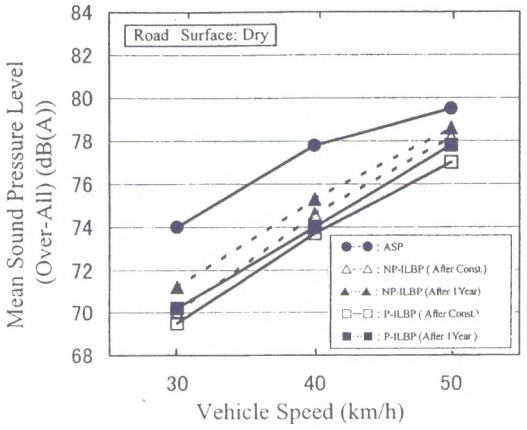

Figure 4 Relationshiop between Vehicle Speed and Mean Sound Pressure Level (Dry Condition)

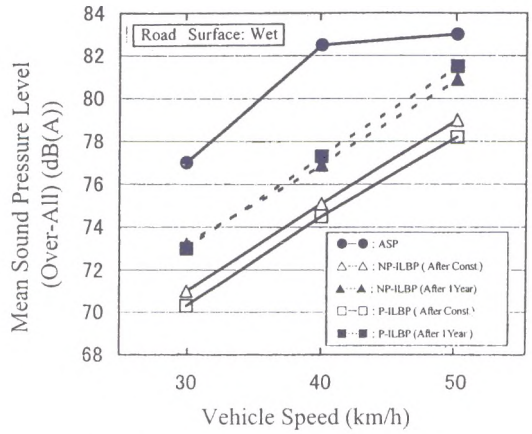

Figure 5 Relationshiop between Vehicle Speed and Mean Sound Pressure Level (Wet Condition)

Figure 6 and Figure 7 show the results of the 1/3 octave band frequency analysis on ASP, P-ILBP and NP-ILBP under vehicle running speed of 50 km/h. In dry surface condition, the mean sound pressure level over the frequency of 800 Hz on P-ILBP and NP-ILBP shows lower than the level on ASP as shown in Figure 6. Particularly, P-ILBP lowers the mean sound pressure level more than other pavements over the frequency of 600 Hz.

In wet surface condition, the mean sound pressure level over the frequency of 1000 Hz on ASP increases due to generation of splash at water stayed on it surface as shown in Figure 7. However, the mean sound pressure level on P-ILBP and NP-ILBP still keeps as same as the mean sound pressure level in dry surface condition due to drainage of water on it surface through the joints and continuous voids in ILB. Particularly, it is confirmed that P-ILBP remarkably shows as same as above tendency.

After one year passed, the mean sound pressure level on P-ILBP increases rather than the measured level after the construction of the pavement in the domain of high frequency due to clogging of voids in ILB. In wet surface condition, the increase of the mean sound pressure level on P-ILBP is remarkably shown in Figure 7.

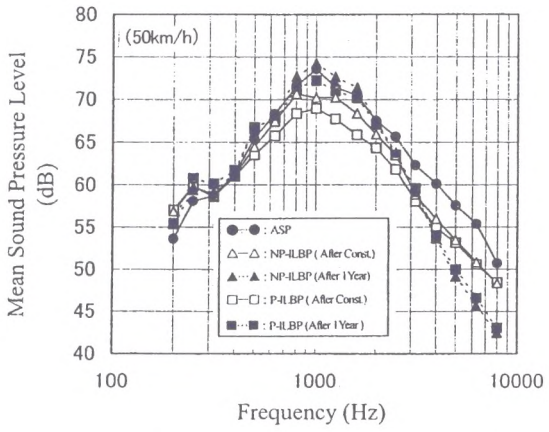

Figure 6 Result of 1/3 Octave Band Frequency Analisis (Dry Condition)

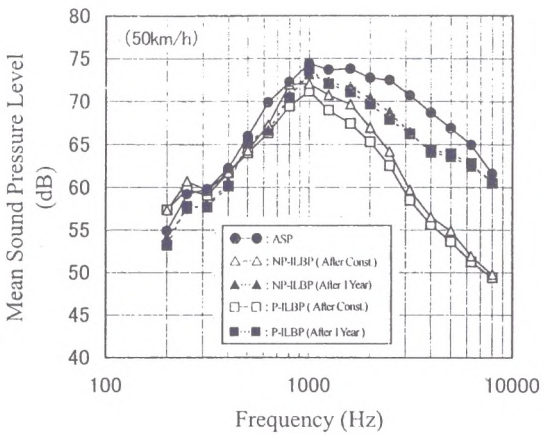

Figure 7 Result of 1/3 Octave Band Frequency Analisis (Wet Condition)

Figure 8 shows the influence of laying course material on the generation of tire/road noise after the construction of the pavement. The mean sound pressure level in case of using glass-cullet increases rather than the level for using river sand. Particularly, the increase of the level is remarkable in wet surface condition. These phenomena after one year passed is kept almost same as the condition after construction of the pavement.

Figure 9 shows changes with time of the surface deflection at the loading center point out of the surface deflections measured by FWD (Falling Weight Deflectometer). The surface deflection decreases with time. In case of the application of glass-cullet for the laying course material, the surface deflection shows lower than the deflection for using river sand. On the other hand, it is confirmed that the surface deflection is independent of the existence of geotextile and the difference of base course material.

Figure 10 shows relationship between the surface deflection and the sound pressure level on P-ILBP in all sections. The sound pressure level decreases with increasing of the surface deflection. It is likely that the decrease of the surface deflection causes the increase of the sound pressure level in case of using glass-cullet for the laying course material.

Figure 11 shows the variations of the sound pressure level of tire/road noise with frequency and the existence of geotextile after the construction of the test pavement. It is clear that the sound pressure level is independent of the existence of geotextile. It is confirmed that the result mentioned above is kept almost same tendency after one year passed.

Figure 12 shows the variations of the sound pressure level of tire/road noise with frequency and base course materials. It is clear that generation of tire/road noise is independent of difference of base course material. It is confirmed that the result mentioned above is kept almost same tendency after one year passed.

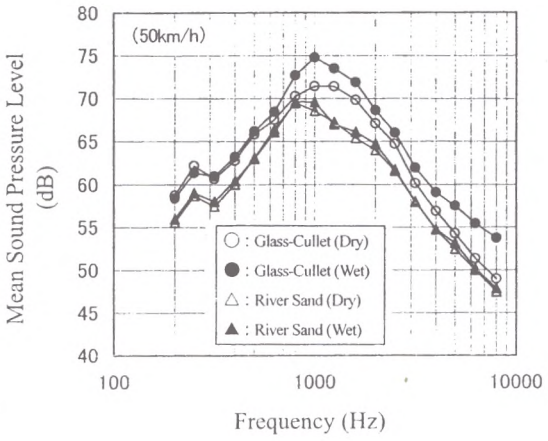

Figure 8 Result of 1/3 Octave Band Frequency Analisis for Laying Course Materials

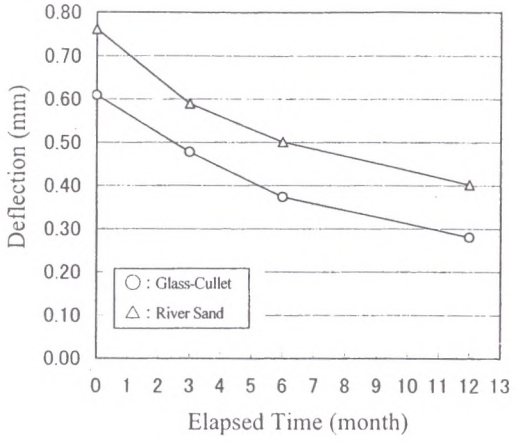

Figure 9 Changes with Time of Surface Deflection

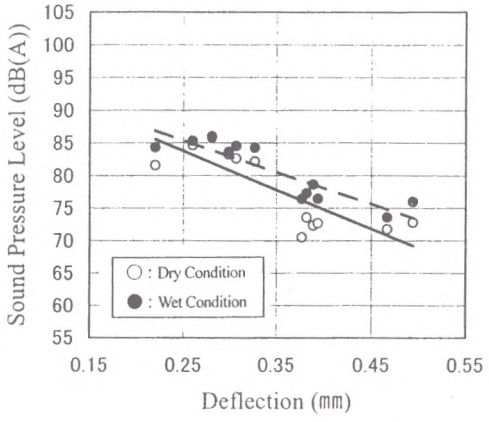

Figure 10 Relationshiop between Surface Deflection and Sound Pressure Level

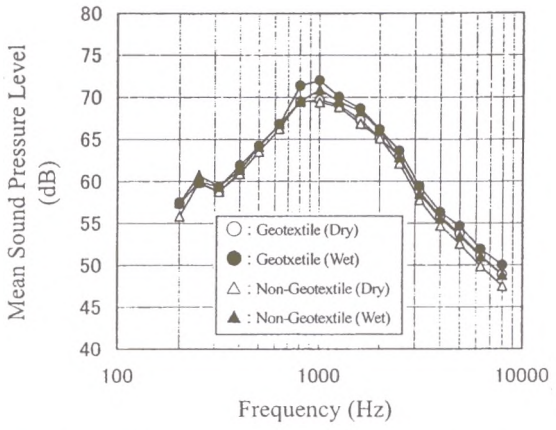

Figure 11 Result of 1/3 Octave Band Frequency Analisis for Base Course

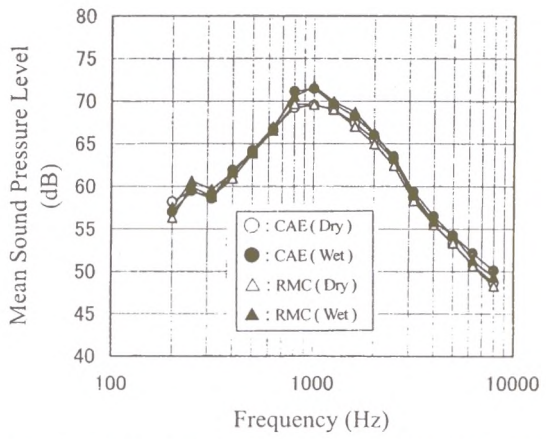

Figure 12 Result of 1/3 Octave Band Frequency Analisis for Geotextile

4.2 Characteristics of Tire/Road Noise in the Fender

The variations of the sound pressure level of tire/road noise in the fender of the test vehicle with road surface are shown in Figure 13. It seems that the increase of the sound pressure level under the frequency of 500 Hz on each road surfaces was caused by the wind pressure in the fender. It is likely that the peak point of the sound pressure level around the frequency 1000 Hz was generated by pattern noise which was caused by the shape pattern of tire tread block.

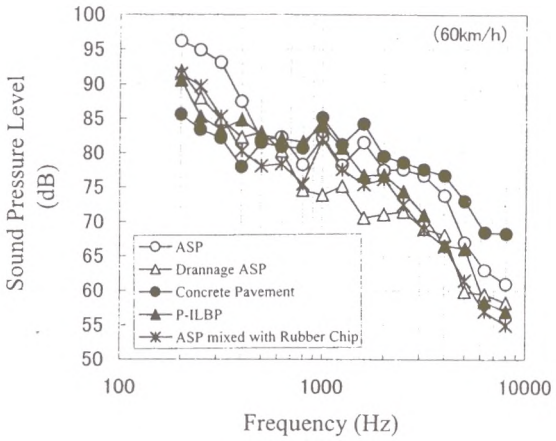

Figure 13 1/3 Octave Band Frequency Analisis on Five Kinds of Pavement Sureface

Drainage pavement relatively keeps lower sound pressure level than the level on other road surfaces and concrete pavement generates the highest sound pressure level as shown in Figure 13. P-ILBP after one year passed generates higher sound pressure level compared with other road surfaces under the frequency of 1000 Hz, relatively. However, P-ILBP keeps the low sound pressure level as same as drainage pavement and ASP mixed with rubber-chips over the frequency of 2000 Hz in spite of clogging of voids in ILB (see Figure 6 and Figure 7).

4.3 Changes of Water Permeability of Porous ILB Pavement

Figure 14 and Figure 15 show changes with time of permeable water volume per 15 seconds when river sand and glass-cullet were applied as the laying course material, respectively. Permeable water volume decreases with elapsed time as shown in both figures. It seems that decrease of permeable water volume is caused by clogging of voids in porous ILB.

In this study, it was not able to say whether water permeability of P-ILBP is affected by the difference of laying course materials because data of permeable water volume for glass-cullet vary widely.

However, it is clear that P-ILBP with RMC for base course material has a higher water permeability as shown in Figure 14 and Figure 15 because RMC has a higher water permeability than CAE's water permeability . It is conformed that a whole water permeability of P-ILBP is dependent of the characteristics of water permeability of base course and subgrade course materials.

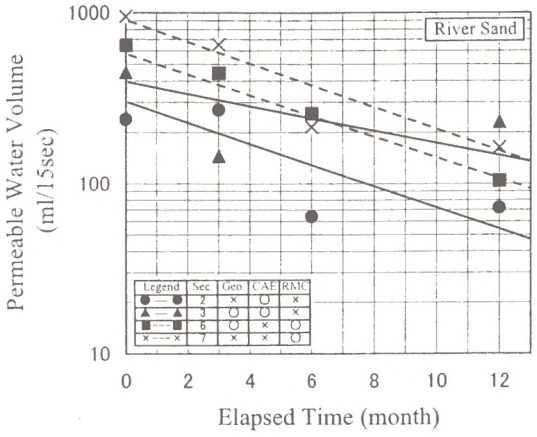

Figure 14 Changes with Time of Permeable Water Volume (River Sand)

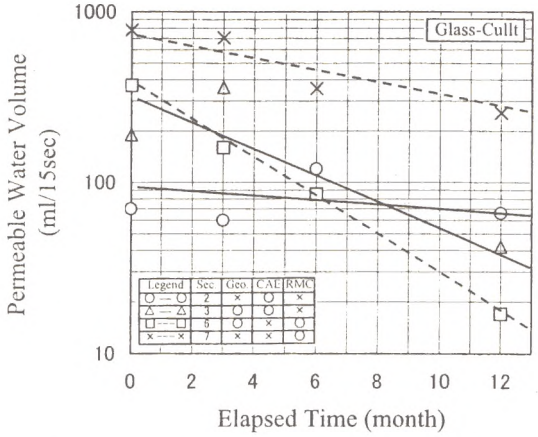

Figure 15 Changes with Time of Permeable Water Volume (Glass-Cullt)

5. CONCLUSION

It has been pointed out that stone pavement which has been widely utilized in European countries generated higher road traffic noise [5]. It seems that this recognition may lead concern about the higher noise generation, if block pavements will be applied for roadway.

However, in past some studies [1],[2], it was found out that ILB pavement for roadway did not generate higher road traffic noise due to ILB pavements have more surface smoothness than stone pavement. Furthermore, as shown the results of this study, it was found out that the noise level was reduced about 3-5 dB(A) on P-ILBP in comparison with the noise level on ASP and that the noise level on P-ILBP was still kept lower level than the noise level on ASP even though the noise level slightly increased about 1-2 dB(A) due to clogging of voids in porous ILB after one year passed.

Furthermore, in comparison with each data of tire/road noise which was measured in fender of the test vehicle on five kinds of pavements including P-ILBP, it was clear that the noise level on P-ILBP was kept relatively lower level than the noise level on other road surfaces in higher frequency range over 2000 Hz.

On the other hand, as a result of the field permeability test of P-ILBP , it was also confirmed that the water permeability of P-ILBP was dependent of a permeability of base course.

In conclusion, it was confirmed that P-ILBP for roadway has an adequate effect of tire/road noise reduction. We hope that these results on P-ILBP will sweep off the wrong recognition on noise generation by block pavement mentioned above.

ACKNOWLEDGEMENT

The authors would like to acknowledge the help of the NIHON-KOUGYO, OKUTAMA-KOUGYO, TOYOBO and ILB companies in providing materials in large quantities and great cooperation of the TOA-DORO-KOUGYO, MIT, WATANABE-GUMI and ART-ENGINEERING companies in conducting construction of the test pavement and investigations after the construction of the pavement. Lastly, the overall cooperation of Professor Yuji Miura, Professor Yukio Todoroki, Assistant Kazuo Arai and the undergraduate course students of Professor Miura's laboratory in Nihon University are highly appreciated.

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