

The Seventh Western Pacific Regional Acoustics Conference

WESTPRA VII

Kumamoto, Japan, 3-5 October 2000

A MEASURING INSTRUMENT FOR ROAD SURFACE ABSORPTION COEFFICIENTS BY USE OF A TIME STRETCHED PULSE SIGNAL

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ABSTRACT

An in-situ measurement instrument for the road surface absorption coefficient is developed. A band limited time stretched pulse signal is used as the source. This paper presents the system layout, the principle of the measurement and some measurement results. A time stretched pulse signal is radiated through a loudspeaker. The continuous wave picked up by the microphone is transformed into two impulsive signals by a signal processing technique to discriminate the incident and the reflected waves. The sound absorption coefficients are computed for 1/3 octave bands using the cross spectral technique. The major difficulties in the in-situ measurement is how to obtain an enough signal-to-noise ratio and the separation of the incident and the reflected waves. Both problems are solved by use of the time stretched pulse signal. Some measurement results are presented as well as the results obtained by the impedance tube method.

KEYWORDS: Absorption Coefficient, Road Surface, Time Stretched Pulse, Signal Processing

INTRODUCTION

There are two main methods for the in-situ measurement of the road surface

sound absorption coefficient. The first one is the reverberation chamber method. A box is placed on the road surface with one surface of the box with an opening facing the road surface. Another one is the impedance tube method, which is placed vertically on the road surface. Both methods have some practical difficulties.

We have developed another system to avoid the above mentioned difficulties. The ratio of the power reflected by the actual road surface and the power reflected by an ideally rigid surface is used for computing the absorption coefficient in our method. We used a impulse signal as the source signal to separate the reflected wave and the incident wave[1]. However, an impulse with considerably high instantaneous power was necessary to get a sufficiently large signal-to-noise ratio. A rugged loudspeaker was necessary.

To reduce the peak power, a use of the maximum sequence is proposed in the ISO draft[2]. But still there is some problems. To solve them, this paper presents a new method using a band-limited time stretched pulse (TSP) as the source signal.

INSTRUMENTATION AND MEASUREMENT METHOD

Figures 1 and 2 show the outline of the geometry and the instrumentation, respectively. The sound wave is radiated by the loudspeaker and reflected by the surface. The microphone picks up the incident and the reflected waves.

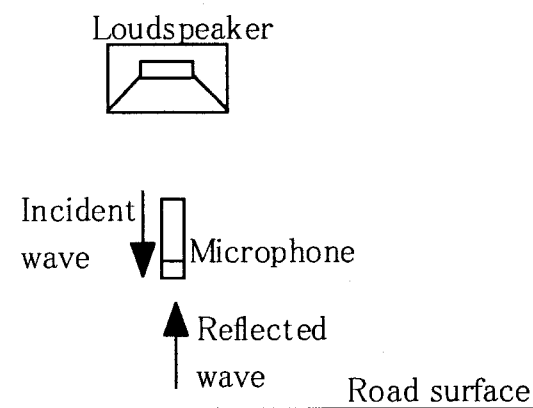


Fig.1 Arrangement of the loudspeaker and the Microphone.

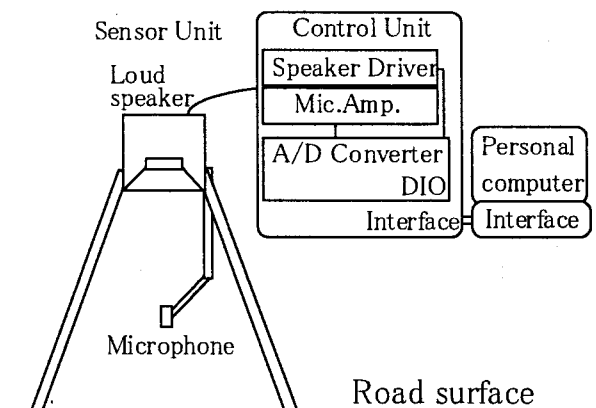


Fig.2 Outline of the measurement system

Those waves are mixed each other but they can be separated if the following signal is used as the source signal,

$$x(n) = \sin \pi \frac{f_H}{f_s} \frac{n^2}{N} \quad (1)$$

where, f_H / f_S : the ratio of the highest frequency to the sampling frequency,
 n : the discrete time (sample number) and
 N : the number of samples in a sequence

Figure 3 shows the waveform of the source signal expressed by Eq(1). A voltage with the same waveform is applied to the loudspeaker through a power amplifier.

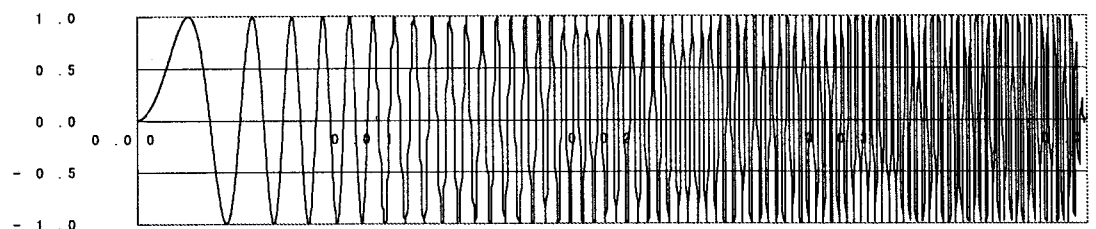


Fig.3 Waveform of the time stretched pulse

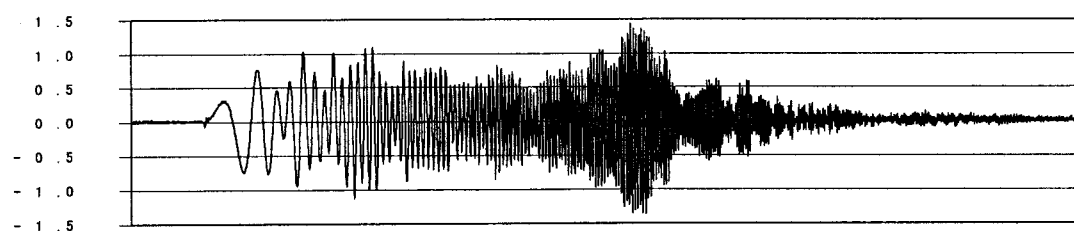


Fig.4 Response to the source signal picked up by the microphone

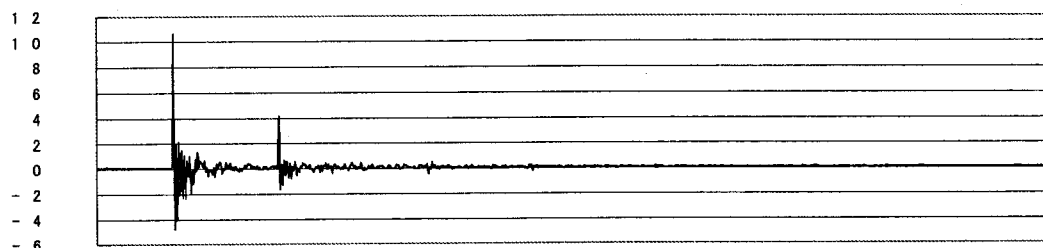


Fig.5 The time domain signal after the signal processing

The first measurement is carried out for a reference surface which has a nearly 100% reflection coefficient. The second measurement is carried out for the surface to be measured.

The response to the source signal picked up by the microphone shown in Fig.4 is transformed into a sequence of the impulsive signals using the cross-spectral technique, where the complex conjugate of the spectrum of the driving signal is multiplied by the spectrum of the output signal of the microphone.

Figure 5 shows the time domain waveform after the signal processing. The incident and the reflected waves are separated on the time domain. The 1/3 octave band power spectra are computed for the incident and reflected waves. The power ratio of the reflected wave to the incident wave is computed for each frequency band.

The ratio R of the power ratio obtained by the first measurement to the power ratio obtained by the second measurement is computed. R can be considered as the reflection coefficient of the objective surface. The sound absorption coefficient is $1R$.

RESULTS OF THE MEASUREMENTS

Figure 6 shows the sound absorption coefficients measured by the present method and the coefficients measured by the conventional impedance tube method for three types of sound absorption materials. The results obtained by the two methods show good agreement with each other.

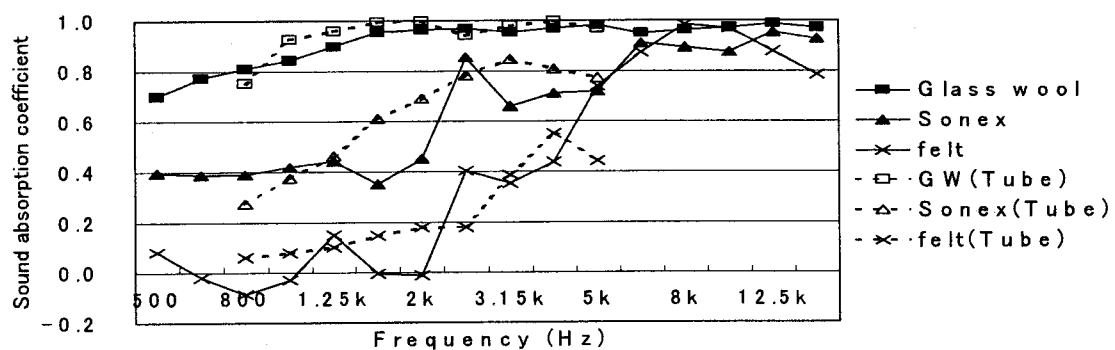


Fig.6 Results of the sound absorption coefficients obtained by the present method and the impedance method.

CONCLUSION

A use of the time stretched pulse and the cross spectral technique for the in-situ measurement of the road surface sound absorption coefficient was proposed. The usefulness of the proposed method and some effects of conditions in the measurement were experimentally investigated. It is confirmed that the absorption coefficients measured by the proposed method coincide with those by the conventional impedance method. The height of the microphone was also investigated. The height should be higher than 70 cm from the surface of the material contrary to the proposed value of 25 cm in the ISO Draft[2].

Literatures:

- [1] Mikami et.al., "DEVELOPMENT OF A MEASURING INSTRUMENT FOR ROAD - SURFACE ABSORPTION COEFFICIENTS," proc. inter-noise2000.
- [2] Acoustics - Measurement of sound absorption properties of road surfaces in situ - Draft International Standard ISO/DIS 13472-1, ISO/TC 43/SC 1,