

The active reflecting surface for an opening window

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ABSTRACT

Based on the boundary surface control(BSC) principle[1], a reflecting surface can be produced by controlling both the pressure and the particle velocity on the surface. We have confirmed this principle by performing several numerical simulations. In this study, we confirm it experimentally. That is, in order to confirm the practical possibility of this method, we experimented it by arranging the secondary sources at an opening window and controlling the pressure signal at the several points to reduce the noise in the room. The experimental result shows the possibility of making such a reflecting surface by the active technique based on the BSC principle.

INTRODUCTION

In the three dimensional sound field, it has been known that the point cancellation can make a quiet zone within a certain small volume around an error microphone. By increasing the number of the error microphones and locating them closely, the quiet zone can be widened. Considering a practical use, however, it is not convenient to locate the error microphones at the center of the quiet zone. As an alternative principle to make a quiet zone in the three dimensional sound field, the BSC principle enables us to locate the error microphones outside of the quiet zone because the system based on this method can make the reflecting surface at the error microphones. We have confirmed this method numerically[2]. Then, in this study, we conducted the following experiment to confirm the effectiveness of this method.

EXPERIMENT

We constructed an active noise control(ANC) system which makes a reflecting surface at the opening window to reduce the noise transferring from outside.

Principle Based on the BSC principle, if the pressure and the particle velocity are perfectly canceled at all the point on an enclosed surface, it is possible to cancel the pressure perfectly within the area enclosed by the surface. Additionally considering the uniqueness of the solution in a boundary value problem, it turns out that if one is determined, the other is simultaneously determined[3]. Therefore, by canceling only the pressure on the surface, it is possible to cancel the pressure within an area. However, it is impossible to monitor the pressure signal at all the point on the surface, because the error microphone can not be located at all the point on the surface. The other words, we must discretize the surface to locate the error microphone at each element of the surface. In the recent study, it is known that the element size should be smaller than the half-wavelength of the noise considered to obtain enough effectiveness of the ANC.

Setup An experiment was carried in a room with a dimension of 5.3 x 7.4 x 4 m and six windows as shown in Fig.1. One of the windows opened and the others closed. The size of the window was 1 x 1 m. The noise source was located outside of the room, 3m away from the opening window.

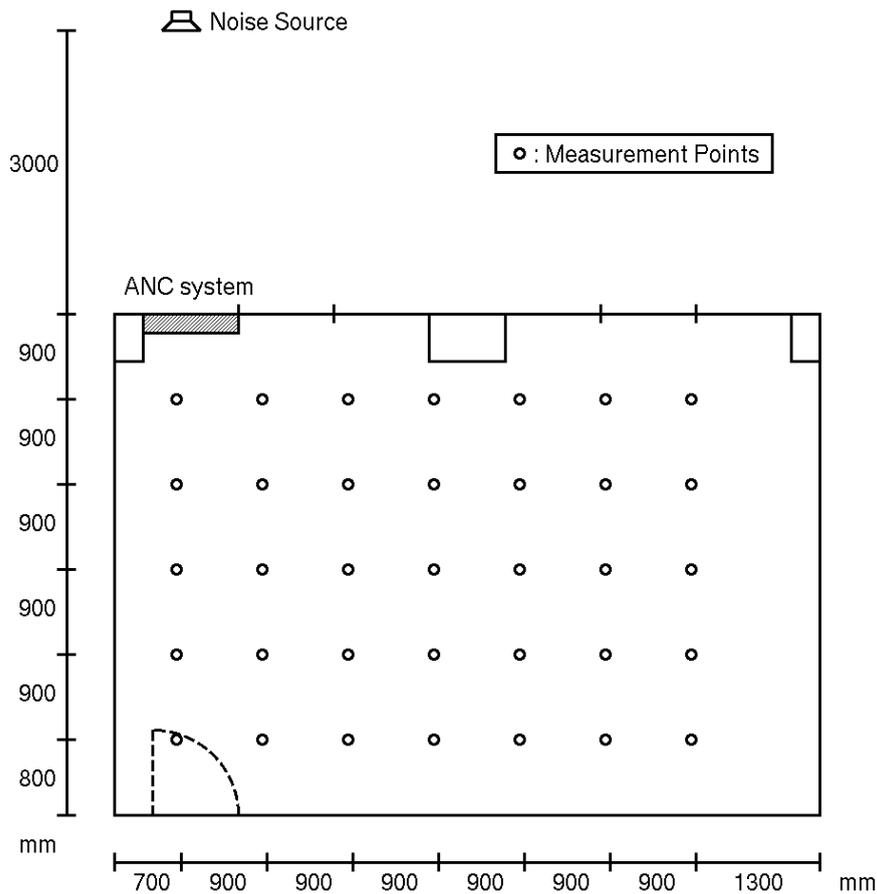


Fig.1 – Experimental setup

The ANC system, which consists of 16 loudspeakers as secondary sources and 16 microphones as error microphones, was located at the opening window. As shown in Fig. 2, 4 x 4 secondary sources and error microphones equally spaced on two parallel planes. The secondary sources were located at 5 cm away from the error microphones and faced inside. In this system, we didn't adopt the MELMS algorithm because of the save of the calculation cost. That is, the ANC system consists of 16 single channel systems and we controlled the pressure signal at the error microphone by the nearest secondary source independently by using 16 single channel controllers. Because we didn't adopt MELMS algorithm, each module can disturb the other modules. To avoid it, we located the error microphone closed to the secondary source. The control algorithm was filtered-x LMS algorithm which was implemented on an ADSP-2181 digital signal processing board. The sampling frequency was 6 kHz, the taps of the FIR filter was 768 and the step size parameter was 0.001. A picture of the ANC system is shown in Fig.3.

Because we assumed to control the traffic noise, 210-710 Hz band-limited white noise was radiated from the loudspeaker.

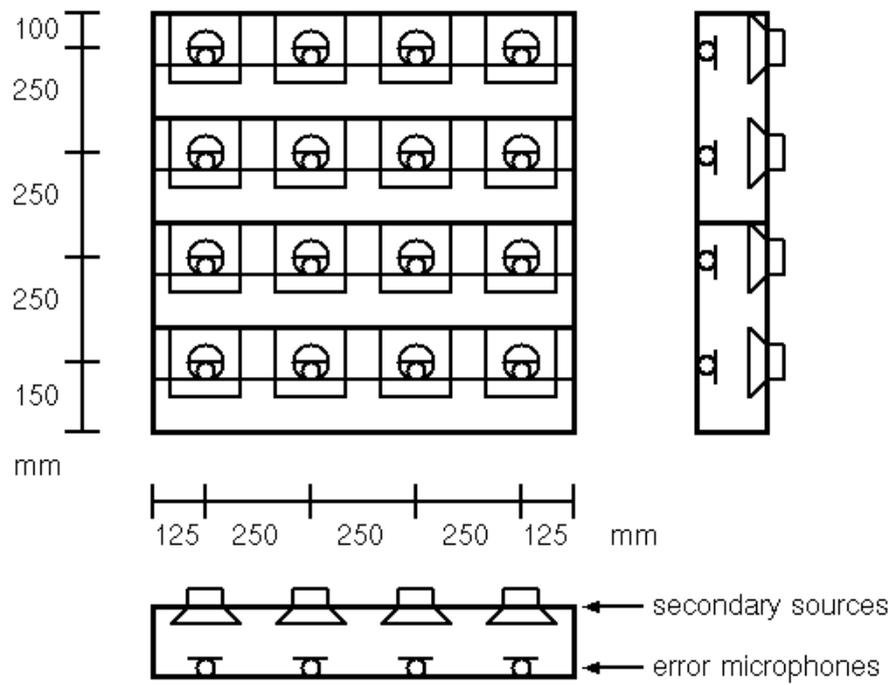


Fig.2 – arrangement of the error microphones and the secondary sources



Fig.3 – picture of the ANC system

Result Fig.4 shows the averaged relative S.P.L. of the error microphones with control and without control. The noise was reduced by about 10dB over the frequency range of the noise.

We measured A-weighted sound pressure level with control and without control at 7 x 5 measurement points arranged at intervals of 90cm on 100cm above the floor as shown in Fig.1. Fig.5 shows the contour map of the effectiveness of the ANC in the room. The largest effectiveness about 5.6dBA was obtained at the nearest measurement point to the ANC system. The effectiveness was more than 2dBA over most of the area in the measurement plane, and there was no place where the sound pressure level with control is larger than that without control. The result of our experiment shows that we can produce the active reflecting surface at the opening window by using this method.

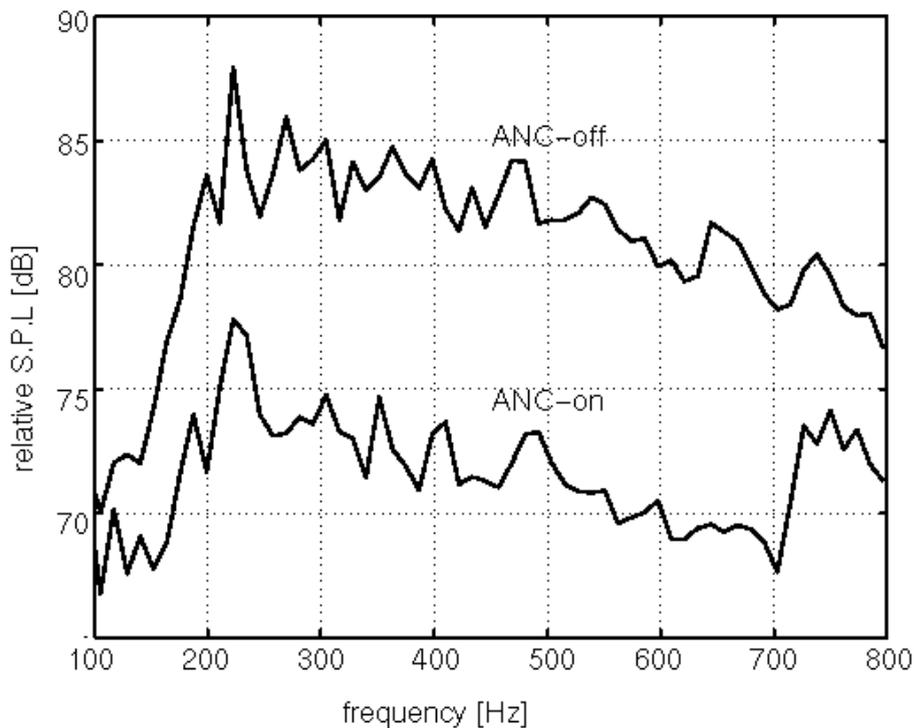


Fig.4 – the averaged S.P.L. of the error microphones

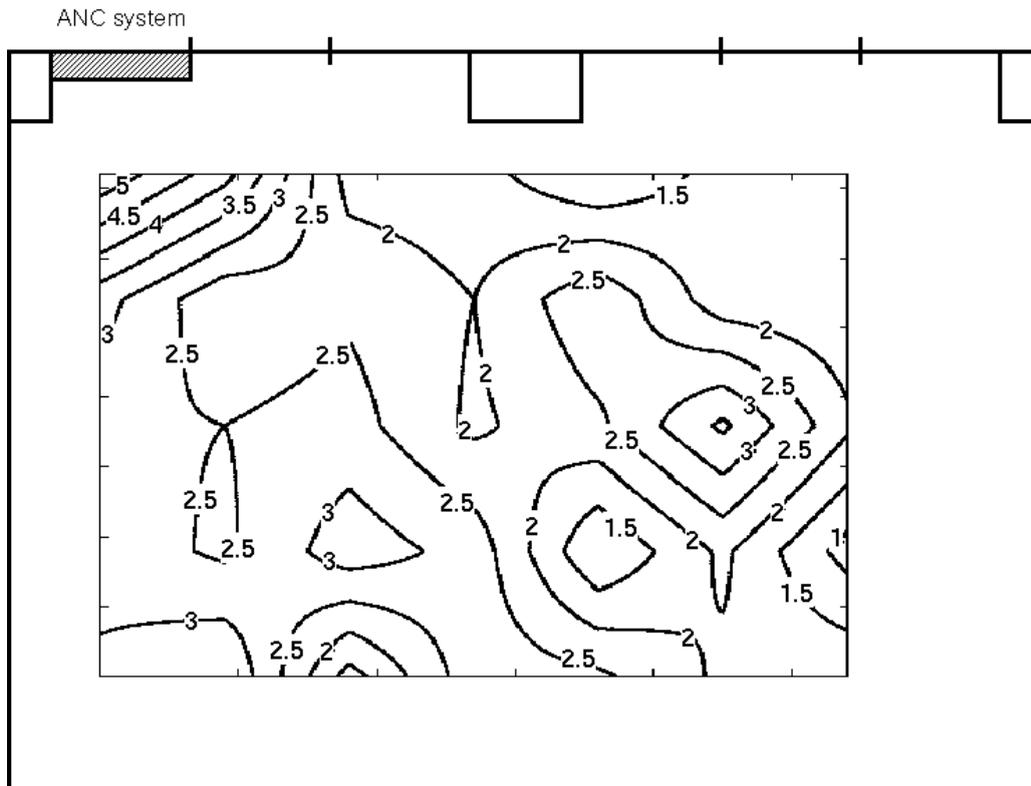


Fig.5 – contour map of the effectiveness

SUMMARY

We reported the experimental study of the active control which makes a reflecting surface by controlling the sound pressure at the opening window based on the BSC principle. From the result of our experiment, though we could not produce the perfect reflecting surface by the active technique, we indicated the possibility of it and confirmed the BSC principle.

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