inter•noise 94
YOKOHAMA-JAPAN, AUGUST 29-31

ACTIVE SUPPRESSION OF SOUND DIFFRACTED BY BARRIER : -EXPERIMENT IN THE OUTDOORS-

Akira Omoto,* Kazuhiro Takashima,* Kyoji Fujiwara*,
Masao Aoki†, Yasuo Shimizu‡

*Kyushu Institute of Design, Shiobaru 4-9-1, Minami-ku, Fukuoka 815, Japan
†Aoki Applied Acoustics Co., Ltd., Mikata-dai 1-7-7301, Nishi-ku, Kobe 651-22, Japan
‡NICHIAS Corp., Shibadaimon 1-1-26, Minato-ku, Tokyo 105, Japan

31.1, 38.2

INTRODUCTION

In the current study, we implemented an active control technique, developed in previous studies, for reducing the sound diffracted by a barrier.[1,2] The technique is based on the cancellation of sound pressure at a diffraction edge, which behaves like a virtual source to the diffracted field. We conducted the experiment outside with a specially made noise barrier and adaptive signal processing hardware.

Our previous study showed that increasing the number of points of cancellation along the edge was the most effective way to expand the area of sound reduction.[2] Two independent controllers were therefore used to minimize the sound pressure at ten points on the diffraction edge.

MATERIALS AND METHODS

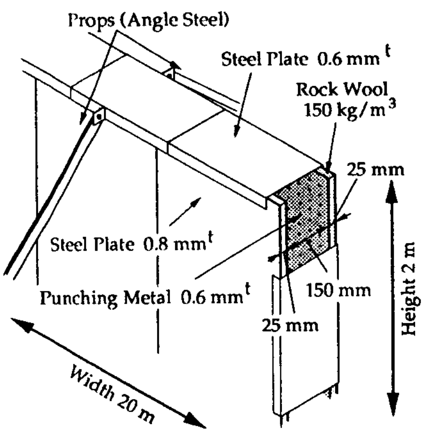


Fig. 1 Construction of the barrier.

The diffraction barrier was constructed of two panels, which were the 150 kg/m³ rock-wool sadwiched between steel plates (Fig. 1). This 2 m (H) × 20 m (W) × 0.2 m (D) barrier was located in the rice paddy field.

Figure 2 shows the experimental setup, with the primary (noise) source located on the ground (y = 0) at z = 0, 4.0 m from the diffraction edge and at an angle of 60° from it.

The two adaptive signal processing system were designated 'System-1' (4 channels) and 'System-2' (6 channels). The systems worked independently and each system minimized the sum of the mean square of the sound pressure at 4 and

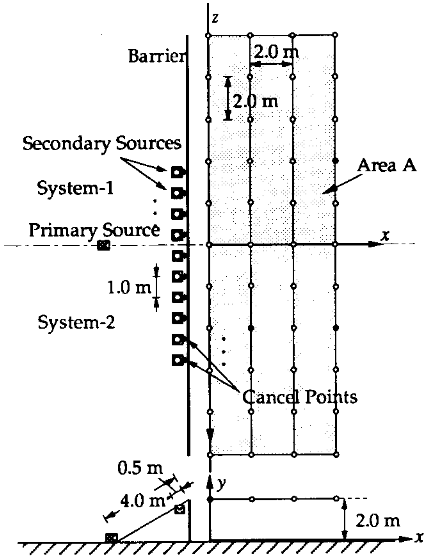


Fig. 2 Experimental setup.

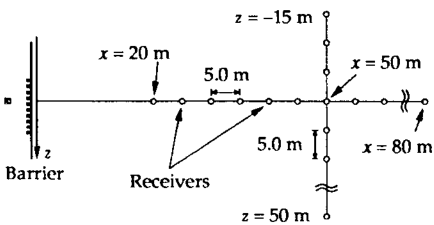


Fig. 3 The distant receiver locations.

6 points on the diffraction edge respectively. The algorithm used by the systems was the MEFX-LMS with Error-Scanning[3] method. The sampling frequency was 1 kHz. The tap length of the adaptive filter and the *FIR* filter which generated the 'filtered-x' signal were 50 in System-1, and 64 in System-2.

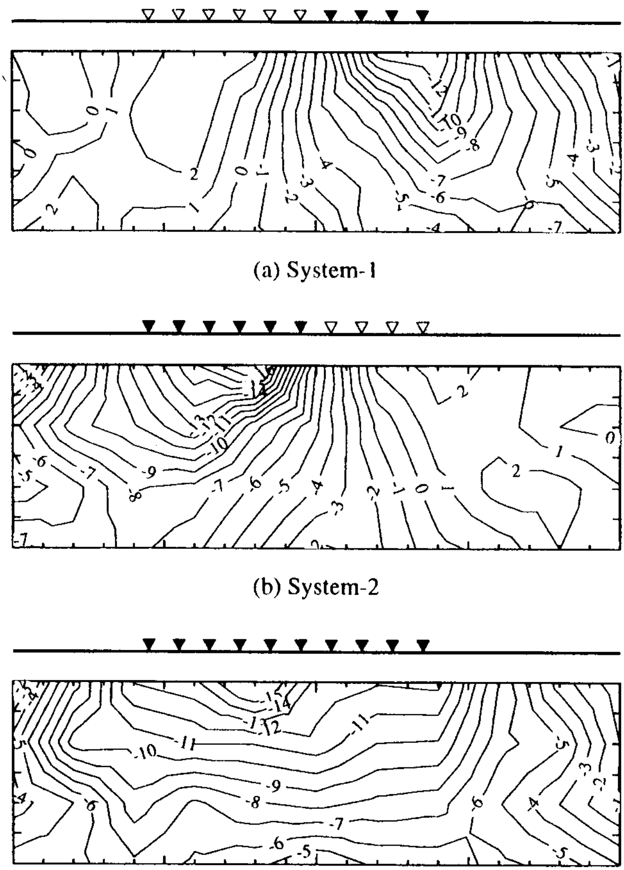
The secondary sources were located 0.5 m distant and at an angle of 60° from the diffraction edge. They were spaced along the barrier at intervals of 1 m. Each point of cancellation on the diffraction edge (source side) had the same z coordinate as the corresponding secondary source. The receiver area A was comprised of an 11 × 4 grid with 2-m spacing. More distant measurements were made along the line $z = 0$ at 5-m steps from $x = 20$ to 80 m and along the line $x = 50$ m at 5-m steps from $z = -15$ to 50 m (Fig.3). All the receiver points had the same height as the barrier ($y = 2$ m).

The primary source was driven with a noise signal centered at 125 Hz and of bandwidth one octave. This signal was also input to signal processing controller. The sound pressure levels were measured with the secondary sources both on and off.

RESULTS AND DISCUSSION

Figure 4 shows the distribution of the sound attenuation measured in the Area A in the cases of (a) only System-1 (4-channels) functioning; (b) only System-2 (6-channels) functioning; and (c) with both systems. With only one system functioning, the greatest attenuation was attained near the barrier and toward the center of the functioning system. System-2 gave a greater maximum attenuation than System-1. This difference of the maximum attenuation seems to be due to the difference of the number of the channels, and of the tap length of the adaptive filters. The attenuation reduced gradually with distance from the functioning system, and amplification occurred at some of the more distant points.

Figure 4 (c) shows that, with both systems functioning, more than 6 dB attenuation was attained a most of the receiver points. The simultaneous



(a) System-1

(b) System-2

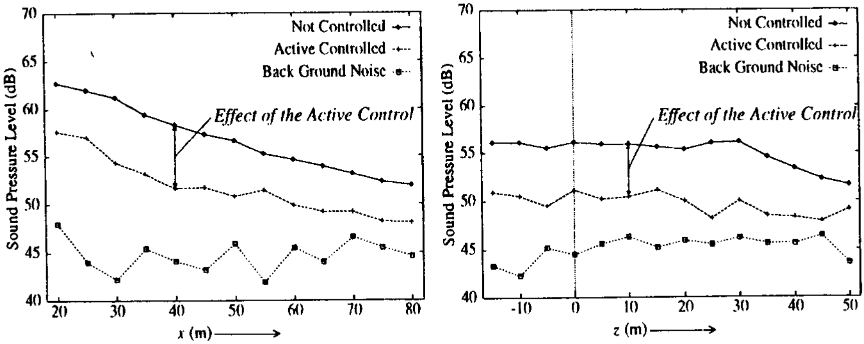
(c) System-1 and 2

Fig. 4 The distribution of the sound attenuation in the area *A*.
(▼ means the functioning System.)

operation of the two systems extended the area of effective attenuation. This supports the theoretical prediction resulting from the convergence of the adaptive algorithm which occurs in such cases.[2,4] The results also suggest that increased efficacy could be achieved by the use of more than two active control systems.

Figure 5 shows the sound pressure level measured at the more distant receiver locations described in the previous section. The three plots show the sound pressure with the active control turned on, with the active control turned off, and of the background noise (primary and secondary sources off).

In Fig. 5 (a), the sound pressure level with the active system turned off decreases gradually as x increases. The same trend occurs in the plot corresponding to the active system turned on, but diminished by 5 to 6 dB in



(a) $z=0$, $x=20 \sim 80$ m
(b) $x=50$ m, $z=-15 \sim 50$ m

Fig. 5 Sound pressure level at the distant receiver locations.

the region of $x < 50$ m, and by 4 to 5 dB in the region $x > 50$ m. The decreased attenuation in the region of $x > 50$ m seems to be due to a smaller signal to back ground noise ratio. In Fig. 4 (b), an attenuation of 5 to 6 dB was attained at all the receiver points except near z = 50 m, where it was less. Ignoring the back ground noise, the attenuation was more than 6 dB in most cases.

CONCLUDING REMARKS

The current study provided experimental verification of our previously developed theory for the active suppression of sound diffracted by a barrier. Two independent controllers were used in the experiment, and the sound pressure at ten points on the diffraction edge were minimized by using adaptive signal processing. The results are summarized as follows : (i) the two adaptive systems worked stably, having no detrimental effects on each other, and (ii) the control provided more than 6 dB attenuation at receivers located about 50 m from the barrier.

The results suggest that more than two adaptive systems could be employed to provide more channels for active control. In addition, since 6 dB attenuation is equivalent to increasing the height of the barrier to 5 m, it is likely that the system has practical application.

ACKNOWLEDGMENT

The authors would like to thank Mr. F. Kishino, Mr. J. Sawada (NICHIAS Corp.), Mr. K. Abe, and Mr. M. Nakahara (Kyushu Inst. of Design) for their helpful assistance in this study.

REFERENCES

[1] A. Omoto and K. Fujiwara, Proc. Inter Noise 91, pp. 513-516 (1991).

[2] A. Omoto and K. Fujiwara, J. Acoust. Soc. Am., 94(4), pp. 2173-2180 (1993).

[3] H. Hamada, Proc. 1991 Acoust. Soc. Jpn. Int. Symp., Active Control of Sound and Vibration, pp. 33-44 (1991).

[4] S. J. Elliot, C. C. Boucher, and P. A. Nelson, Proc. Inter Noise 91, pp. 157-160 (1991).