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# THE EFFECTS OF WIND AND TEMPERATURE CONDITIONS ON OUTDOOR SOUND PROPAGATION (SCALE MODEL EXPERIMENT)

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## INTRODUCTION

The authors have been investigated the methods of simulating the effects of wind and temperature conditions in the atmosphere on the sound propagation by acoustic scale model experiment using wind tunnels. In this paper, some examples of them are presented.

## SIMULATION

The atmosphere near the ground is turbulent because of the presence of wind and temperature variation, and so the sound propagation in it is markedly complicated. However, as a rough estimate according to the sound ray theory, it is considered that the sound propagation can be approximately simulated by simulating the sound velocity variation in space due to wind and temperature gradients. In order to realize these conditions, the vertical mean wind velocity or temperature gradients in the real atmosphere should be compressed in the model atmosphere according to the geometrical modelling scale.

## EXPERIMENTAL METHODS

In this study, two wind tunnels of boundary layer type were used: one is a small-sized wind tunnel of 0.8m×0.8m in section and 4m long, and the other is a large-sized one (atmospheric simulation facility) of 3m×2m in section and 24m long. The interior walls and ceilings of the wind tunnels were finished absorptive with glass fiber boards.
As the modelling scale, 1/100 scale was adopted, and the vertical wind gradient or temperature gradient was controlled so as to approximately correspond to 1/100 scale of the real ones.
As the sound source, a semicylindrical loud speaker system shown in Fig.-1 which had approximately omnidirectional characteristics around the axis as shown in Fig.-2 was used, and octave band noises of 12.5kHz to 100kHz were radiated from it. The propagated sounds were received by a 1/4 inch condenser microphone.

EXPERIMENTS

[Exp.-1] ON WIND EFFECT (1)

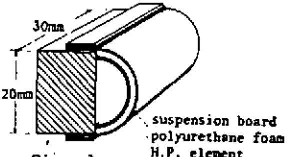


Fig.-1

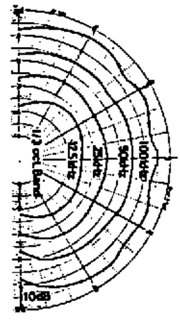


Fig.-2

In order to investigate how the effect of wind on sound propagation changes with the height of the sound source ($H_S$) and that of the receiving point ($H_T$), a simple experiment was carried out, by using the small-sized wind tunnel. As the experimental condition, Fig.-3 shows the vertical wind gradient (approximately 1/6-power profile). The distributions of mean sound pressure level in distance on the absorptive model ground (glass fiber board was used) were measured by changing $H_S$ and $H_T$, with and without wind.
The experimental results measured under the condition of $H_S$=$H_T$=1.5cm and $H_S$=$H_T$=10cm are shown in Fig.-4 (A) and (B). In Fig.(A), it can be seen that, when the source and receiver are close to the ground, the received sound pressure level increases in downwind condition and decreases in upwind condition, and the extent of sound pressure level change increses with incresing the distance, as is well known by some field examinations. In Fig.(B), on the other hand, it can be seen that, when the source and receiver are relatively high above the ground, the effect of wind becomes slight.

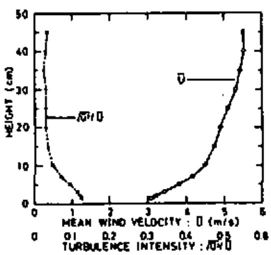


Fig.-3 Wind profile

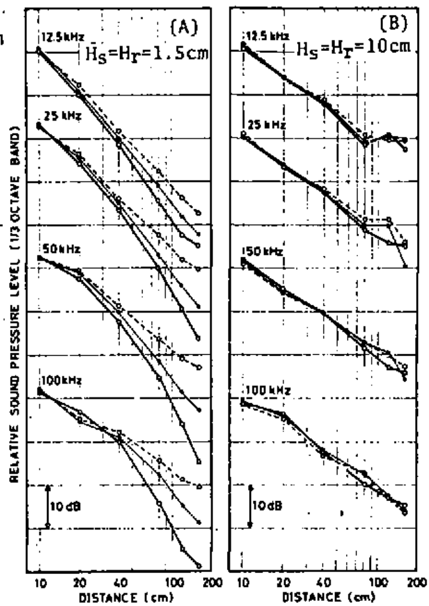


Fig.-4 Measured results

no wind  downwind  upwind

[Exp.-2] ON WIND EFFECT (2)

In order to investigate the change of the effect of wind on sound propagation with wind direction, a basic experiment was carried out by using the large-sized wind tunnel. The air flow in it was set in two conditions (W-3, W-6) as shown in Fig.-5. The sound source and the receiver were located at 1.5cm above the model ground (absorptive with flannel cloth, and reflective with iron board), being faced each other at a distance of 160cm, and, as shown in Fig.-6, the relative position between them was changed in steps every 30 degrees in order to change the angle (Θ) between the sound direction and the wind direction. The measurements were made under the two wind conditions mentioned above and without wind. As the experimental results, Fig.-7 shows the plots of the rise and fall of the mean sound pressure level caused by wind against the vector wind. (All data were refered to the level under the no wind condition.) From these results, it can be said that, as a rough approximation, there is a linear relation between the rise and fall of mean sound pressure level and vector wind, but the extent of the sound pressure level variation depends on the acoustic nature of the ground.

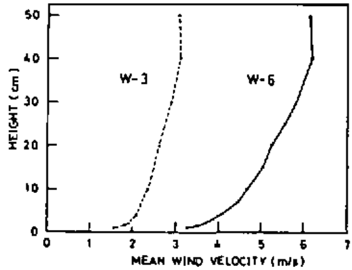

Fig.-5 Wind profiles

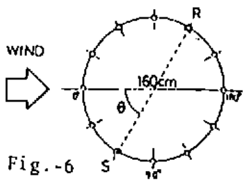

Fig.-6

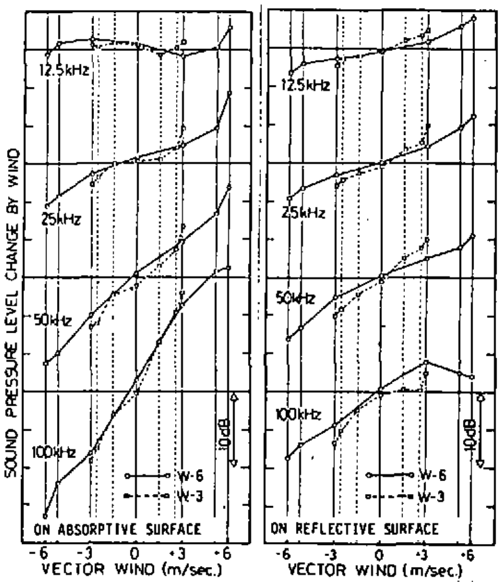

Fig.-7 Experimental results

[Exp.-3]
ON TEMPERATURE EFFECT

It is well known that the vertical temperature gradient affects the sound propagation as well as the wind gradient. Then, the simulation of the effect of vertical temperature inversion on horizontal sound propagation was

examined as follows. In this experiment, the large-sized wind tunnel which can make temperature gradient in it by heating (or cooling) the floor panels and the air flow was used, and the vertical temperature inversion condition shown in Fig.-8 was set. The velocity of the air flow was kept as low as possible in the extent that convection did not take place and the temperature gradient was kept stable.
The sound source was located at 1.5cm above the model ground (absorptive with glass fiber board, and reflective with iron board), and the sound pressure level distributions in distance from the source were measured at the same height, under the temperature inversion condition (with weak wind) and neutral condition (without wind).

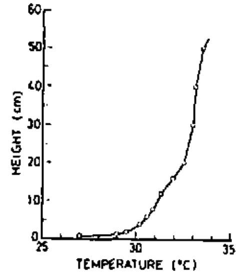


Fig.-8
Temperature profile (Inversion)

Fig.-9 shows the relative received sound pressure level distributions in distance in 1/3 octave bands of 12.5kHz to 100kHz. On the absorptive ground, sound pressure level increases caused by the temperature inversion are clearly seen in the frequencies above 25kHz. Wherease, on the reflective ground, sound pressure level variation due to the temperature inversion is much more complicated. This phenomenon is probably due to the interference between the sound propagated along the ground and that refracted from the upper regions.

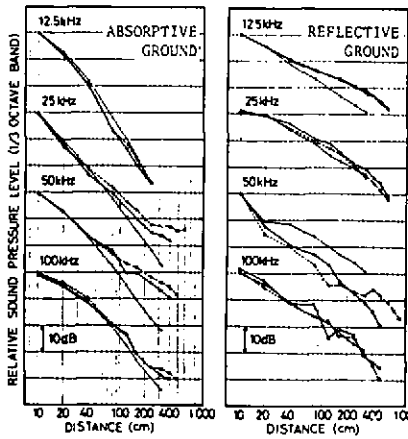


Fig.-9 Experimental results

neutral; downwind, upwind } inversion

## CONCLUSION

The results obtained in this study are quantitatively consistent with the results of field examinations. So the experimental method mentioned here seems to be effective to study the effects of meteorological conditions on sound propagation.

## REFERENCE


1) H.Tachibana and K. Ishii, "Scale model experiment of the effect of wind on sound propagation", Inter-Noise 75 (Sendai, 1975)
2) H.Tachibana and K.Ishii, "An experimental study on noise propagation outdoors" 9th I.C.A. (Madrid, 1977)
3) K.Yoshihisa, H.Tachibana and K. Ishii, "An experimental study on the effect of temperature gradient on outdoor sound propagation", 1st Acoustic Conference of the West Pacific Region (Singapore, 1982)