Entertainment park noise control devices

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Abstract: A noise control system combining barrier effect and a wind-stream produced by fans has been analysed to reduce noise level due to attractions in a big entertainment park.

INTRODUCTION

Various attractions in a big entertainment park near the Garda lake in Italy produce annoyance in the surroundings, due especially to the shouts of people playing on high drops, roller coaster and so on. The noise generated by these high sources must be analysed and attenuated using noise barriers, as required by the actual regulations against noise in dwellings.

In this paper a noise control device is proposed, that combines the effects of an earth noise barrier and a vertical wind-stream produced by a ducted fans. A first theoretical approach is outlined and a case study is proposed.

THEORY

Outdoor sound propagation is influenced by different ambient factors, such as the wind and the air temperature. A geometrical direct approach (1) can be considered taking into account the distance between the source and the receiver. The air velocity $\vec{u}$ and the sound speed $c \cdot \hat{n}$ are combined using a vectorial sum ($\hat{n}$ is the unit vector normal to the wave-front), and the result is the ray velocity:

$$\vec{v} = \vec{u} + c \cdot \hat{n} \tag{1}$$

Sound speed is also related to the air temperature T by $c = \sqrt{\gamma \cdot R \cdot T}$ where γ and R are the density and the gas constant of the air.

Assuming that the ray path is horizontal and the air temperature is T_0, a vertical air-stream is produced toward the wave front at velocity w, temperature T_1 and width L. The resulting ray path is shown in figure 1, and the vertical deviation is:

$$\Delta z = L \cdot \tan\left(\frac{v_z}{v_x}\right) = L \cdot \tan\left(\frac{w + c_1 \cdot n_z}{c_1 \cdot n_x}\right) \tag{2}$$

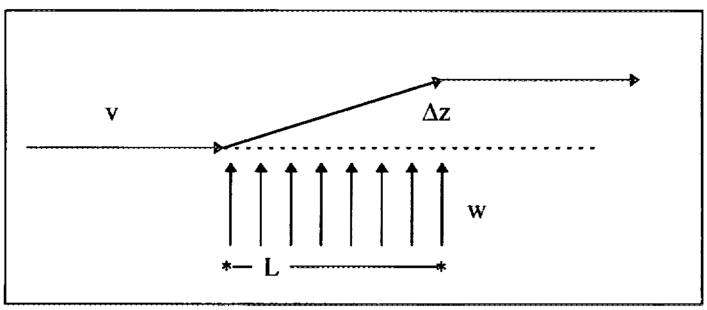

Figure 1

where subscripts x and z refer to horizontal and vertical components.
Noise barrier attenuation is usually given by the Maekawa formula (2); ray paths propagating from the upper edge of the noise barrier to the receiver have different intensity for each frequency.
The presence of a vertical air-stream modifies the direction of propagation of ray paths (figure 1) with a Δz vertical shifting. The effect of the vertical air-stream is that the horizontal ray (the lowest possible, due to the width of the barrier) diffracted by the first edge of the barrier cannot reach the second edge: so the second diffraction of the ray is cancelled and the receiver is now in a shadowed acoustical zone; some problems arise if the deviated ray can reach directly the receiver, as in the case of very high sources (figure 3, line c).

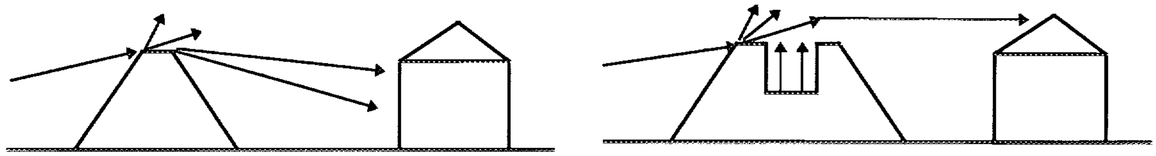

Figure 2 a) b)

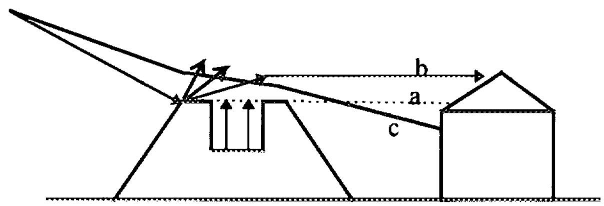

Figure 3

CASE STUDY

A practical application of this device is proposed to reduce the noise produced by a source 5 m high in a receiver position 50 m far and 3 m lower. Earth barrier and a fan producing 20 m/s speed air flow are considered. The fan is positioned on the straight line connecting noise source and receiver, and it is assumed that the self noise is completely attenuated by the barrier.
A numerical simulation of the global attenuation for each frequency, obtained with this combining device, is shown in figure 3; in this example, the presence of the airflow increases the efficiency of the barrier for all frequencies, reducing the noise levels of 2-3 dB.

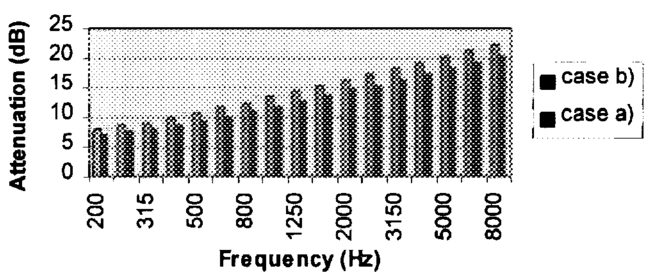

Figure 3

An improvement of the efficiency of the presented device can be achieved taking into account the influence of a difference between the atmospheric and the air-stream temperatures; this effect is now object of a further analysis.

REFERENCES

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