【Short Paper】

Alleviation of Low Frequency Noise from a Soundproof House by Standing Wave Control*

Toshiyuki AOKI**, Masanori TANAKA*** and Yutaro SUGIURA***

**Kyushu University, 6-1 Kasuga Kouen, Kasuga, Fukuoka, 816-8580, Japan

E-mail: aoki.toshiyuki.418@m.kyushu-u.ac.jp

***Daimaru bouon Co., Ltd, 2-10-15 Higashi Kanda, Chiyoda-ku, Tokyo, 101-0031, Japan

Abstract

Low frequency noise is not clearly defined but is generally taken to mean noise below a frequency of about 100 Hz. Noise occurring at frequencies below 20Hz is often referred to as infrasound and this type of noise presents even greater difficulties in its countermeasure and assessment. The objective of our study is to suggest practical means of reducing the low frequency noise emanating from the opening of soundproof houses. This paper describes an experimental study on the alleviation of low frequency noise by the standing wave control in a soundproof house. As a result, about 3dB of low frequency noise reduction has been achieved at the reference point over a 1/3 octave band range of 200 Hz, which is the conversion frequency of 16 Hz for a real soundproof house. In the case of combination, the standing wave control and expansion type silencer, maximum noise reduction has been reduced by about 12 dB.

Key words: Low Frequency Noise, Alleviation Method, Standing Wave, Soundproof House, Infrasound

1. Introduction

Low frequency noise is not clearly defined but is generally taken to mean noise below a frequency of about 100 Hz. Noise occurring at frequencies below about 20 Hz are sometimes referred to as infrasound. Hearing becomes gradually less sensitive as frequency decreases, so for humans to perceive infrasound, the sound pressure must be sufficiently high. Infrasound is characterized by an ability to cover long distances and get around obstacles with little dissipation because of a very long wavelength. This type of noise presents even greater difficulties in its countermeasure and assessment⁽¹⁾.

Using soundproofing panels by leading manufacturers and ensuring optimum engineering for the intended purpose as well as safe and prompt installation, we have successfully conducted soundproofing works in various areas including soundproof houses for use during subway tunnel shield boring and road construction. Unfortunately, however, there are some problems, which have not yet been sufficiently reduced in regard to the leakage noise from the openings of soundproof houses as shown in Fig.1.

The objective of our study is to suggest practical means of reducing the low frequency noise of a vibration sieve emanating from the opening of soundproof houses. The experiments were carried out on a model soundproof house with a scale of 1 to 12 with a rectangular opening. Two of the loudspeakers were set inside of the model soundproof house as vibration sieves for earth and sand. The alleviation of low frequency noise by the standing wave control in a house has been experimentally investigated from the viewpoint of the infrasound characteristics.

*Received 28 Dec., 2009 (No. S-09-0760)
presented on IWEE 2009.
[DOI: 10.1299/je.5.226]

Fig.1 Detail of real soundproof house with the opening

2. Experimental apparatus

The model soundproof house (1000mm depth x 670mm width x 830mm height) with a scale of 1 to 12, shown in Fig.2, has acrylic plates of 10mm thickness and a rectangular opening of 166 x 83mm. The frequency of noise from the real vibration sieve was converted to $16 \times 12 = 192$ Hz for this model soundproof house. The frequencies of standing waves in the model soundproof house, namely rectangular cuboid were 172 Hz in depth mode (100), 257 Hz in width mode (010) and 207 Hz in height mode (001) close to our target frequency 192 Hz. This paper addresses an alleviative method by means of standing wave control using an inclined plate in a house. Present alleviative models have three types of inclined plates, namely the depth plates that have the inclined angle of $\theta=6.15, 7.45, 8.75$ degrees as shown in Fig.2, the side plates of $\phi=1.91, 3.81, 5.73$ degrees and the top plates of $\gamma=1.91, 3.81, 5.73$ degrees. Two small loudspeakers simulating vibration sieves were set in the model soundproof house. Two microphones were set at an inside point of P1 on centerline in a house at 50mm from the acrylic wall, and at an outside reference point of P2 on centerline at 166mm from the rectangular opening. The pink noise source was used by a sound source from two loudspeakers on the floor in the model house. When two loudspeakers were driven by the same phase or an opposite phase, an acoustic pressure spectrum inside the soundproof house almost became the same according to the experiment for the preparation. Therefore, two loudspeakers were driven by the same phase in the present experiment. Closed enclosures were used with a unit of 8cm in diameter with a high rigidity for two loudspeakers used. In addition, it was driven strongly by a power amplifier with a dumping factor of 260, an output power of 300W. The influence of the speaker's amplitude by the standing wave was reduced as much as possible.

Fig.2 Detail of model soundproof house (1/12 scale)

3. Results and discussion

Typical frequency responses at measuring point P1 in the model soundproof house with and without inclined plate are shown in Fig.3(a)~(c). The dotted lines in Fig.3 indicate the cases without inclined plates in model house and the solid lines indicate the cases with inclined plates. Figure 3(a) shows the case with a depth plate of $\theta=6.15$ degree as standing wave control. Figure.3 (b) and (c) show the cases with the side and top plates of $\phi=\gamma=3.81$ degrees. It is evident from Fig.3 (a) that the case with the depth plate that the peak of sound pressure at a standing wave of about 180 Hz is attenuated and split into two peaks. Attenuation level of the peak frequency is about 10dB. On the other hand, the differences between the solid and dotted lines at a target frequency of 192 Hz with side and top plates are comparatively small.

Fig.3 Frequency response with and without standing wave control in model soundproof house

In order to examine the attenuation of sound pressure levels in a model soundproof house, look at the 1/3 octave band sound pressure level calculated by frequency response of Fig.3. The attenuation rate RSPL in 1/3 octave bands between the inclined plates as standing wave controls are plotted against the inclined angle of plates in a house in Fig. 4(a)~(c). These points represent the results for 1/3 octave band frequencies, 160, 200, 250, 315 Hz. It is evident from the figure that the attenuation of 1/3 octave level of 200 Hz including the target frequency 192 Hz is large in the case with the depth plate of $\theta=6.15$ degree and the side plate of $\phi=3.81$ degree. The case with the top plate has a small effect on the 1/3 octave band results of 200 Hz because of the disappearance of a dip as shown in Fig.3(c). In general, when the size of the soundproofing house is different from this case it is better that the inclined plate is set up in a direction on the mode of a standing wave near the noise frequency of the vibration sieve.

Fig.4 1/3 octave band attenuation rate of inside sound for model soundproof house

The primary factors of present alleviative methods are the attenuation of standing waves in a soundproof house, Figs.3 and 4 show that the attenuation rate for target frequency 192 Hz is large in the case with the depth plate as the standing wave control. In order to examine the attenuation of sound pressure on the outside of the model soundproof house, the typical frequency response at measuring points P1 and P2 are shown in Fig.5(a) and (b). Figure 5(a) and (b) shows the results of the case with and without the depth plate in a soundproof house, respectively. Figure 5(a) shows that the attenuation rate between the inside and outside of a soundproof house is not so small, and the absolute sound pressure level of target frequency at point P2 is large because of the effect of a standing wave in depth mode. In the case with the depth plate as the standing wave control, the attenuation rates between the inside and outside is almost the same, but the absolute sound pressure level of the target frequency outside of point P2 has decreased 20 dB more than the results without the depth plate.

Fig.5 Frequency response at inside point P1 and outside point P2 of model soundproof house

Finally, the various combinations of conventional expansion type silencer and present alleviative methods using a depth plate are examined. The 1/3 octave band sound pressure levels at point P2 outside the opening of the model soundproof house are shown in Fig.6. It is evident from the figure that about 3dB of low frequency noise reduction has been achieved at the reference point P2 over a 1/3 octave band range of 200 Hz, which is including the target frequency of 192 Hz. In the case of combination the standing wave controls using a depth plate and expansion type silencer, maximum noise reduction has been reduced by about 12 dB.

Fig.6 1/3 octave band sound pressure level from the opening of the model soundproof house

4. Conclusions

An experimental investigation was carried out to examine the alleviative methods of low frequency noise from the soundproof house using a standing wave control with an inclined plate. As for the suppression of the standing wave, a depth plate in the direction of the depth was effective in the case of a soundproof house with an opening. As for the results, about 3dB of low frequency noise reduction was achieved at the reference point over a 1/3 octave band range of 200 Hz which is the conversion frequency of 16 Hz for a true soundproof house. In the case of the combination of both the standing wave control with a depth plate and an expansion type silencer, maximum noise reduction was reduced by about 12 dB.

Acknowledgement

This paper was presented in the “International Workshop on Environment & Engineering 2009” and could receive many useful discussions.

References

- (1) Inoue, Y., Actual State and Control of Low Frequency Noise, *Journal of INCE/J*, Vol.23, No.5, (1999), pp.311-318.