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論　文（Original article）

Sound insulation performance of wood (*Larix kaempferi*) sound barriers constructed along an expressway twenty years ago

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Abstract

The sound transmission loss of Japanese larch sound barriers, which were constructed along an expressway twenty years ago, was measured to investigate their acoustic durability. When large gaps at the joints of the wood sound barriers were filled with oil clay, their sound transmission loss increased and complied with the sound barrier regulation for Japanese expressways. Moreover, filling all the joints with oil clay further improved the sound transmission loss. These results indicated that the solid part of the wood sound barriers showed sufficient sound insulation performance. Therefore, wood sound barriers, which are well-designed and maintained to ensure no gaps emerge at the joints, will perform adequately as expressway sound barriers for at least twenty years.

Key words : Wood sound barrier, Japanese larch, Sound transmission loss

1.Introduction

Installing barriers is one of the most efficient and frequently used methods to control road traffic noises (Ekici et al., 2003). The theoretical concepts of noise attenuation by barriers have also been investigated. Though field tests involving sound barriers are expensive and require careful monitoring of many variables, they have been conducted to determine the actual sound barrier performance. Various kinds of sound barriers have been developed and many standards have either already been implemented or are being drafted in Europe. Such concrete and metal sound barriers have been developed as permanent structures.

As for wood sound barriers, wood is a basic building material which can be used as an acoustical insulator (Bucur, 2006), but we should always consider its durability, which is affected by weathering and decay. The properties of wood sound barriers were reported as follows: Weathering causes gaps to develop in the barriers due to dimensional changes in the wood, while decay causes the wood to decompose. Preservative treatments are commonly used to resist weathering and decay, both of which affect sound transmission loss. Wood sound barriers have an expected service life of 15 to 25 years when treated with preservative (Boothby et al., 2001).

In Japan, most expressway sound barriers are constructed using concrete, metal and/or combinations of the two as permanent structures. Wood sound barriers along the expressway have been constructed in certain locations on a small scale and trial basis. Although the initial sound insulation performance of wood sound barriers has already been confirmed as meeting the sound barrier regulation for Japanese expressways (hereinafter referred to as the sound barrier regulation, stipulating sound transmission loss of 25 dB and over at 400 Hz, and 30 dB and over at 1000 Hz respectively.), few experimental results exist showing their durability as stable structures (Machida et al., 2007; Sueyoshi et al., 2007; Shibata et al., 2008; Sueyoshi et al., 2008; Machida et al., 2009; Shibata et al., 2009 and Sueyoshi et al., 2011).

In this research, we had the opportunity to measure the sound insulation performance of sound barriers made from Japanese larch (*Larix kaempferi*) twenty years after their installation. Measuring the sound transmission loss of these old sound barriers based on Japanese Industrial Standards, data to facilitate the maintenance control of wood sound barriers were obtained.

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Experimental

Some of the Japanese larch sound barriers (hereinafter referred to as the wood sound barriers), which were installed south of the Iida Interchange of the Chuo Expressway in the early spring of 1986, were replaced with new sound barriers of equivalent specification and used for this experiment. Each sound barrier unit consisted of five components of Japanese larch timber, which were sawn and fastened with bolts and nuts as shown in Fig. 1. Wood components were treated with preservative (PF3, Phosphorus trifluoride).

Fig. 2 shows a schematic diagram measuring sound transmission loss as an index of the sound insulation performance of the wood sound barriers. Acoustic tests were performed in the experimental facility, where two reverberation chambers specified as type I in JIS A 1416 (JIS Committee, 2000) were connected. As shown in Photo 1, this involved installing H-shaped steel frames, with openings 1990 and 720mm wide to the space (2710mm wide, and 3600mm high) of the portion connecting the two reverberation chambers. The test specimen consisting of wood sound barriers 1960 and 680mm wide were set in the space of the connection portion. One reverberation chamber was used as a sound source room, in which 1/3 octave-band noises were generated using equipment consisting of a noise generator (RION, SA-28), amplifier (ONKYO, A-977) and speaker (ONKYO, D-77MRX). The other reverberation chamber was used as a sound receiving room. The sound pressure levels were simultaneously measured using five sound level meters (RION, NA-20) and sound level recorders (RION, LR-07) in each chamber. The sound transmission loss, R was calculated by the following equation:

$$R=(L_1-L_2)+10\log(S/A)$$
$$A=0.16V/T$$

where L_1 was the average sound pressure level in the sound source room (dB), L_2 the average sound pressure level in the sound receiving room (dB), S the area of the specimen (m^2), A the equivalent absorption area of the sound receiving room (m^2), V the volume of the sound receiving room(m^3) and T the reverberation time in the sound receiving room(s).

Filling the gaps at the joints of the wood sound barriers with oil clay step by step, the sound transmission loss was measured to investigate the influence of the gaps on sound transmission and determine the sound insulation performance of the solid part of the wood sound barrier. The oil clay was temporarily used to fill gaps during experiment.

Results and discussion

The sound transmission loss of the wood sound barriers is shown in Fig. 3. As a reference, the sound transmission loss of the initial wood sound barrier measured twenty years ago via a procedure equivalent to that of this experiment, described in JIS A 1416 (Takei et al., 1991), was plotted. The initial wood sound barrier was offered for an experiment to determine the specification of the wood sound barrier before the on-site construction and had the same structure as the wood sound barrier in this study. However, the units of the initial wood sound barrier differed from those of the wood sound barrier used in this experiment. The initial sound insulation performance was close to the theoretical line of a mass law (TL = 18log(fm) - 44, TL: sound transmission loss, f: frequency (Hz), m: surface density (kg/m^2)) and satisfied the sound barrier regulation.

When the gaps at the joints of the wood sound barriers were not filled with any oil clay, as shown in Photo 1, the sound transmission loss was lower than that prescribed by

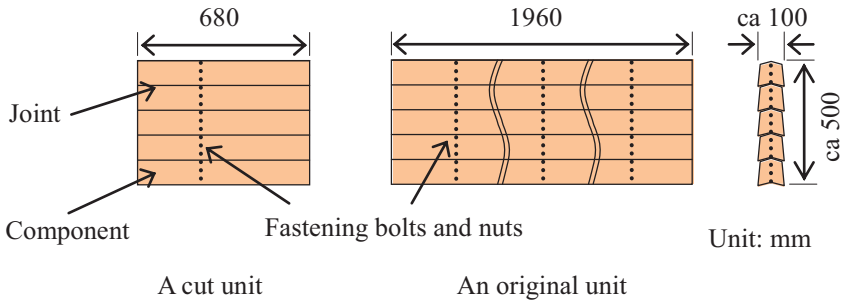

Fig. 1 Schematic diagram of units of Japanese larch sound barriers.

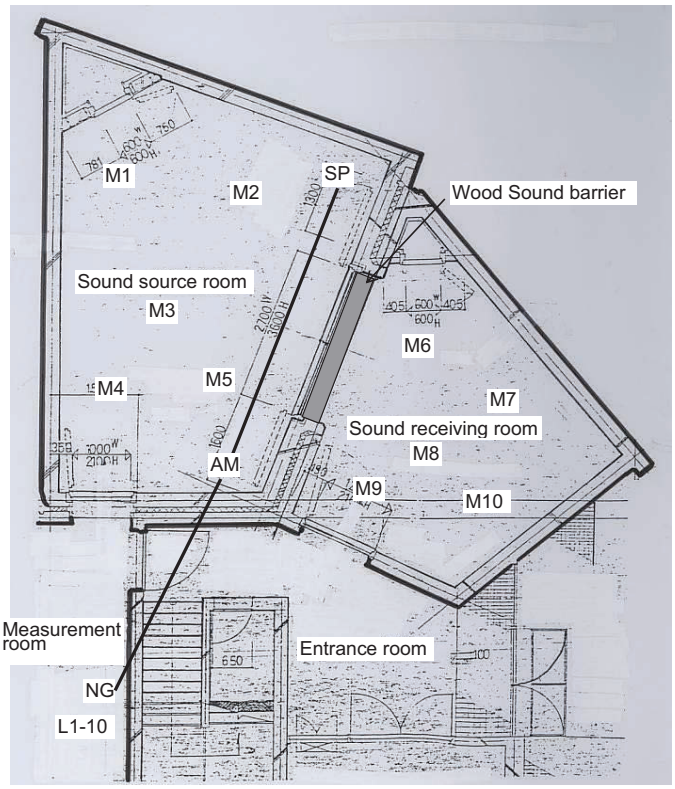

Fig. 2 Schematic diagram showing measurement of sound transmission loss.
M1-10: Sound level meter, L1-10: Sound level recorder, SP: Speaker,
AM: Amplifier, NG: Noise generator.
The sound level meters are connected to the sound level recorders, respectively.

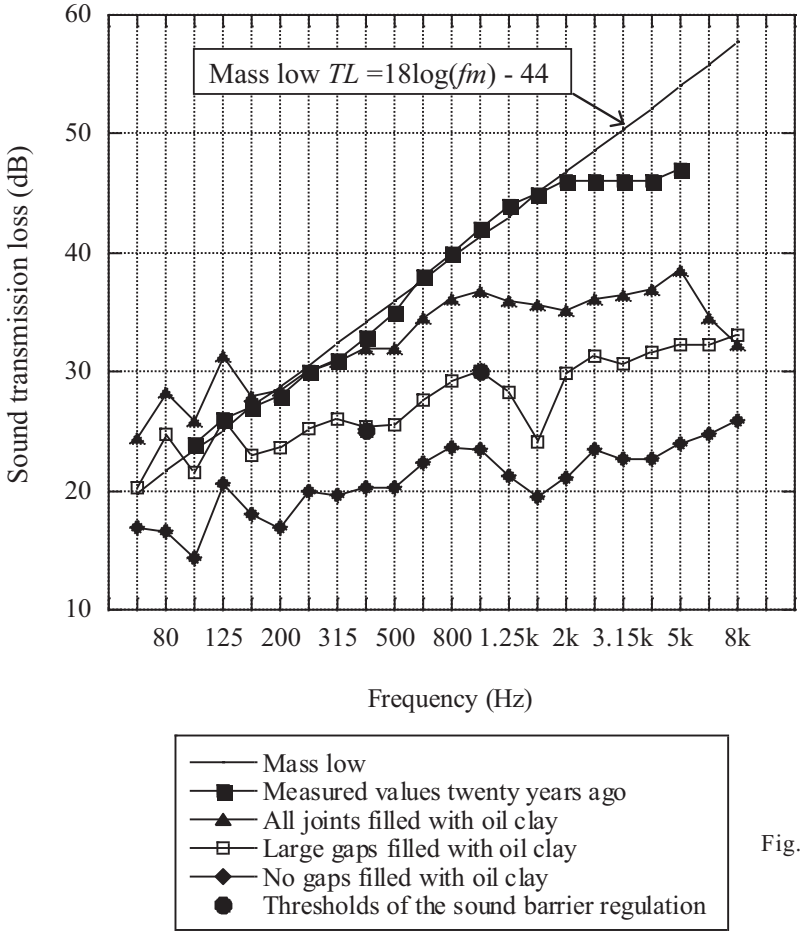

Fig. 3 Sound transmission loss of Japanese larch sound barriers
R: Sound transmission loss (dB), *f*: frequency (Hz), *m*: surface density (kg/m^2)

Photo 1 Japanese larch sound barrier without oil clay at the joints.

Photo 2 Japanese larch sound barrier of which the gaps allowing light through were filled with oil clay.

Photo 3 Japanese larch sound barrier, the joints of which were entirely filled with oil clay.

the sound barrier regulation. Where the gaps allowing light through were filled with oil clay as shown in Photo 2, the sound transmission loss exceeded the level specified in the sound barrier regulation. Furthermore, when all the joints were filled with oil clay, as shown in Photo 3, the sound transmission loss was further improved and attained the level of 20 years ago up to 400Hz. These results indicated that the solid part of the wood sound barriers satisfied the sound insulation performance provided by the sound barrier regulation.

Conclusion

The results obtained suggest that the sound insulation performance of the wood sound barriers, which were properly maintained to suppress the gaps at the joints, would satisfy the sound barrier regulation. Therefore, if Japanese larch sound barriers are adequately designed and maintained to eliminate any gap at their joints, they can be used as expressway sound barriers for at least twenty years.

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20 年前に高速道路沿いに建設されたカラマツ製遮音壁の防音性能

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要 旨

20 年前に高速道路沿いに設置された木製遮音壁の音響的耐久性を調べるため、音響透過損失を測定した。木製遮音壁の構成要素の接続部分の大きな隙間を油粘土で埋めると、音響透過損失は改善され、日本の高速道路の遮音壁設置基準を満たした。さらに、すべての接続部分を油粘土で埋めると、音響透過損失は一段と改善された。これらの結果は、木製遮音壁の木材部分には十分な遮音性能があることを示している。したがって、隙間ができにくいデザインで、しかも隙間ができにくいように適切に維持管理されれば、木製遮音壁の遮音性能は少なくとも 20 年間は保たれるであろう。

キーワード：木製遮音壁、カラマツ、音響透過損失

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