二つの穴を持つヘルムホルツ共振器を用いた音響メタマテリアルによる通気性のある防音壁の解析

Ventilated metamaterial-based soundproof wall based on a double-hole Helmholtz resonator

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Soundproofing technology has been extensively studied for reducing urban noise, such as from cars or trains. In developing high-performance soundproof walls, the durability for wind load is as important as sound insulation. Resistance to wind load involves extra expense [1]. Here as a starting point we consider a design for a lightweight soundproof wall in the form of double-hole Helmholtz resonator [2]. The wall consists of a two-dimensional arrangement of unit-cells as represented in Fig. 1, each containing a Helmholtz-resonator cavity with holes in the front and back walls. The interaction between the cavity and the incident acoustic wave can produce efficient sound reflection, whereas air may pass freely through the wall via the holes. This structure was first introduced as an acoustic metamaterial with a negative bulk modulus [2]. Here we reanalyze the unit-cell sound-insulating mechanism by means of a simplified lumped-element acoustic model and by use of finite-element simulations. We also realize a well-ventilated soundproof box of 415 mm x 415 mm x 415 mm (see Fig. 2) and evaluate its sound-insulation performance in 0~2000 Hz. We identify the sound frequencies at which soundproofing is efficient. Our analytical model gives good agreement with the finite-element simulations.

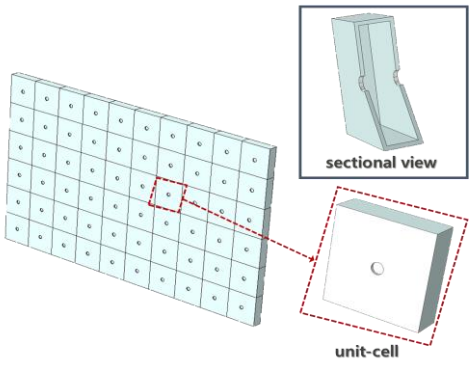

Fig. 1. Image of a ventilated soundproof wall. Inset: Enlarged image of a unit-cell and cross-sectional view. The unit-cell lateral size is 150 mm and thickness 50 mm, including the 5 mm acrylic thickness

Fig. 2. Photograph of the realized well-ventilated soundproof box.

1. D. Sato et al., “Development of a wind load reduction soundproof system”, Quarterly Report of RTRI (Railway Technical Research Institute) (Japan), **53** (3), 180, Aug. 2012

2. S. H. Kim and S. H. Lee, “ Air transparent soundproof window”, AIP Advances. **4**, 117123 (2014)