博　士　論　文　の　内　容　の　要　旨
Abstract of Doctoral Dissertation

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The sound absorption technique is a method for noise control. In recent years, with the development of the social economy, there has been a demand for functional materials that are lighter in weight, have superior performance, and are environmentally friendly. Sound-absorbing materials are widely used as noise suppression measures in practice.

However, in the design and development of sound-absorbing materials, we are still far from elucidating the mechanisms of sound insulation and sound absorption and designing optimal structures. In response to the diversification of materials and structures, the demand for functional materials, including more efficient suppression effects, recycling, and other various performances, is increasing daily. This research aims to develop composite materials and structures with excellent sound absorption effects for humanly audible sounds and to establish a method for evaluating their performance. The establishment of an evaluation system for sound absorption performance of functional materials and elucidation of the mechanism were studied. In particular, we fabricated sound-absorbing materials using green composites containing waste wood and natural fibers and evaluated their performance. The obtained main results are as follows:

(1) In the first part of the work, we proposed a single cavity structure (SCRS) and a double cavity structure (DCRS) embedded with PMs and/or MPPs to enhance low-frequency absorption performance. A new sound absorption structure with two air cavities combined with a porous material or a microperforated board inside the Helmholtz resonator was designed and fabricated. Then, the absorption coefficients and peak frequencies are systematically discussed. The findings revealed that the DCRD's sound absorption performance is more than two times higher than that of the Helmholtz resonance structure.

The developed DCRD could absorb low-frequency sounds without sacrificing high-frequency performance by using the microperforated board of MPP 3. The optimization of absorption behaviour is obtained, especially in the low-frequency region, which may offer a flexible design approach without increasing the structure's size. In addition, it is clarified that the absorption effect of SCRD with wave foam is better than that of flat foam, and the continuous round hole shape is better than slit holes.

(2) In the second part of the work, a multi-band sound-absorbing device with two air cavities was proposed, of which a double resonant structure was constructed by embedding a sound-absorbing material in the Helmholtz resonator's neck and a microperforated board inside the Helmholtz resonator, respectively. In particular, we systematically discuss the sound absorption coefficient of each assembly unit and shed light on the mechanism and structure-activity relationship of the proposed double cavity resonant device (DCRD). The results show that the sound absorption performance of the

prepared DCRD is twice times higher than that of the Helmholtz resonance structure under the same content of the air cavity. Thus, it could greatly improve the absorption ratio of low-frequency sound without sacrificing high-frequency performance with the assistance of microperforated plates.

(3) In the third part of the work, the straw and rice husk are abundant and easily accessible biological resources, which are considered excellent candidates for sound absorption materials for their natural porous structure. The typical sound-absorbing materials were prepared from different kinds of rice straws (thickness) and rice husks. A systematic exploration was devoted to studying the effect of rice straw type and cavity thickness on sound-absorbing performance. The results showed that rice straws with a diameter of ≥3 mm exhibited an optimized sound absorption capacity, and the performance continued to be enhanced after mixing with rice husks. In addition, the sound absorption performance of the multilayer structure composed of porous medium-density fiberboard and thick straw and rice husk samples on the low-frequency side is better than that of the multilayer sound-absorbing structure using non-woven fabrics.

In summary, we believe this work provides a new toolbox for enriching the family of resonant sound absorption materials, especially realizing noise reduction optimization of low-frequency sounds through a flexible design approach without increasing the structure size.