Estimation of Porous Media Using Ultrasound

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Keywords	ultrasound instrument, ultrasound sensor, porous medium, bone, numerical simulation
Technical Support Skills	· General ultrasound measurements · Development of ultrasound sensors · Analysis of ultrasound propagation phenomena using numerical simulations

Research Contents — Investigations of ultrasound techniques for estimation of porous media

Background

In diagnostic apparatus for osteoporosis using ultrasound techniques, sufficiently high reliability is not obtained. This is because the behavior of ultrasound waves in cancellous bone (Fig. 1) is not yet clearly understood.

Purpose

The purpose of this study is to elucidate the ultrasound propagation phenomena in cancellous bone.

Detailed contents

Measurements of ultrasound properties in cancellous bone phantoms

Cancellous bone has a complicated trabecular structure, but the effect of the structure on the ultrasound propagation is not sufficiently clarified. The ultrasound measurements for cancellous bone phantoms in which the structure is simplified are performed to investigate the structural effect.

Investigation of a new measurement method using a membrane hydrophone

A membrane-type hydrophone (Fig. 2) with no backing material has high acoustic permeability. New ultrasound reflection and backscatter measurements using the membrane hydrophone, which cannot disturb the ultrasound field, are investigated.

Numerical simulations using an FDTD (finite-difference time-domain) method

The ultrasound propagation, reflection, scattering, etc. in cancellous bone are numerically simulated by an FDTD method (examples of the simulated results are shown in Fig. 3). The development of the simulation software (with parallel and GPU processing facilities) is also performed. Moreover, numerical simulations of bone remodeling, namely bone formation and resorption, are performed to develop the osteoporotic cancellous bone models.

Various analyses of ultrasound signals

The ultrasound signals in bone can include the mixed information of the density, elasticity, and structure. In order to estimate the bone strength and predict the fracture risk, the respective informations must be extracted. For example, two waves called as fast and slow waves can appear in the signals propagating through cancellous bone, and the separation of the two waves is attempted using time-frequency analyses, such as short-time Fourier transform, Wavelet transform, etc.

Developments

This study is applicable to the ultrasound measurements in geophysical materials (soils, rocks, and sea sediments) and industrial materials (honeycomb ceramics), which can be regarded as porous media like cancellous bone.

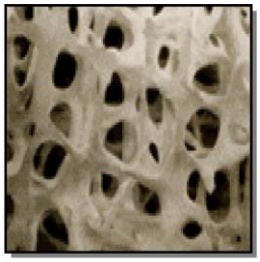

Fig. 1 Cancellous bone.

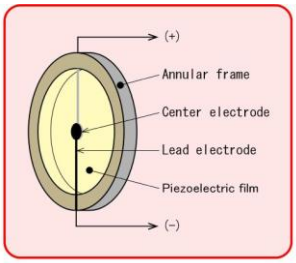

Fig. 2 Membrane hydrophone.

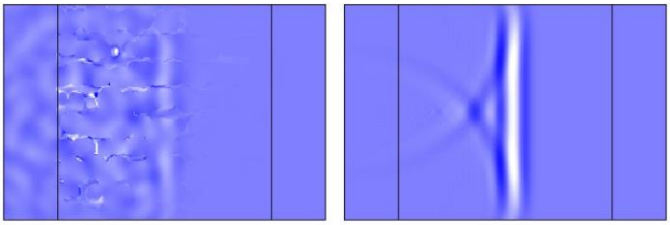

Fig. 3 Simulated results for ultrasound propagation.

Available Facilities and Equipment

Measurement system for ultrasound propagation in water (self-made)	
Ultrasound sensor (self-made)	
High-performance parallel computing system (HPC SYSTEMS)	
FDTD simulation software (self-made)	