Laboratory Test Measurement of Material Attenuation of Shear Waves Propagating in Sand

砂中でのせん断波伝播における内部減衰の室内試験測定

Abstract

The material attenuation characteristics of the ground are necessary for predicting the propagation of vibrations in the ground. This research focused on evaluating material damping of soil through laboratory tests using cylindrical specimens. Shear wave vibrations were measured on a cylindrical specimen. The validity of the method was examined by comparing the results of vibration tests conducted at a test field in Abira, Hokkaido, Japan, with the results of laboratory tests.

地盤内の振動伝播予測には、地盤の内部減衰特性の評価が必要である。本研究では、円柱供試体を用いた室内試験により地盤のせん断波の内部減衰特性を評価する手法を検討した。北海道安平町の試験場で採取したサンプル試料に対し室内試験によって内部減衰を評価し、同試験場で実施した振動試験の結果と比較した。伝播速度200m/sのせん断波において、室内試験と実地盤試験の内部減衰定数は概ね一致した。

Damping Formula

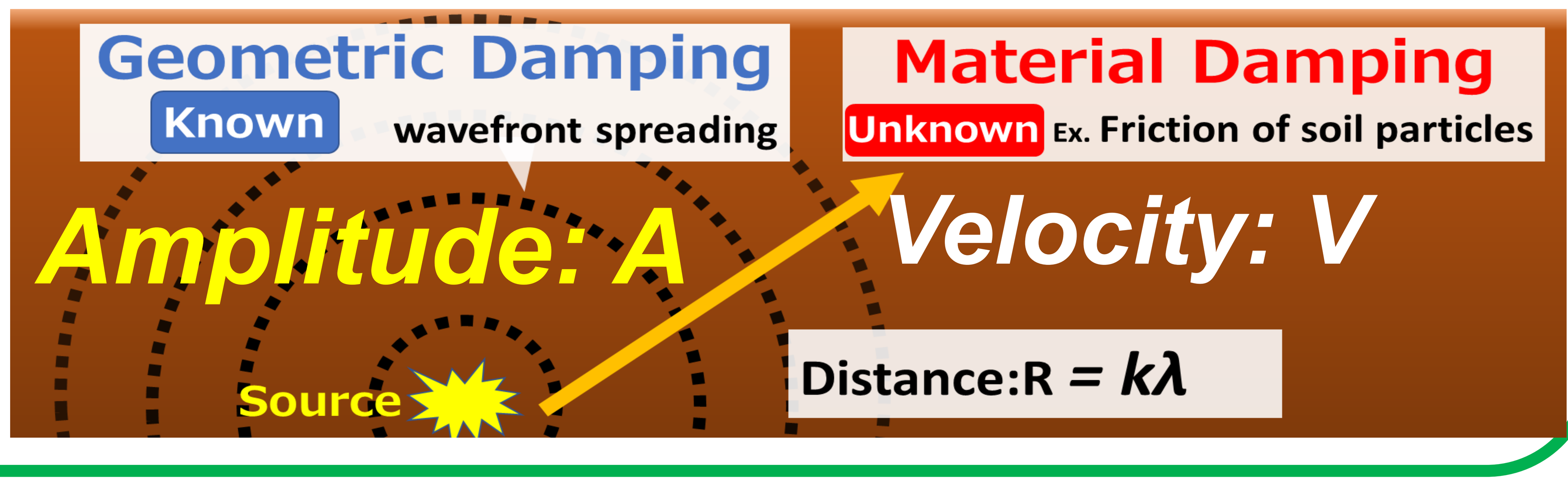
1.Each wavelength of vibration has a specific amount of attenuation. [G. Bornitz , *J. Springer,* 1931]

Geometric damping is theoretically determined by the type of elastic wave and location of the source.

[*Geotechnical earthquake engineering and soil dynamics III*. No. 75, vol. 2, 1998. p. 1507-17.1]

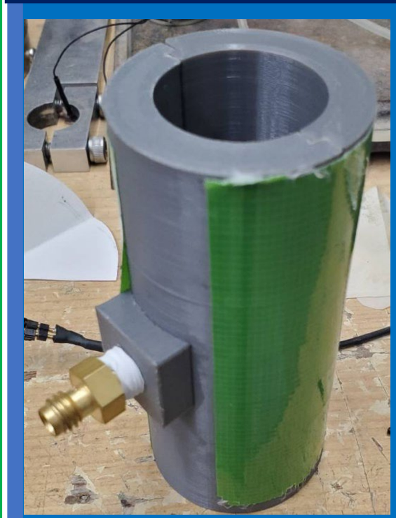
1.**Material Damping is unknown factor** which depends on various factors such as friction of soil particles

$$A = R^{-n} \times exp[-V \times \alpha_0 k]$$

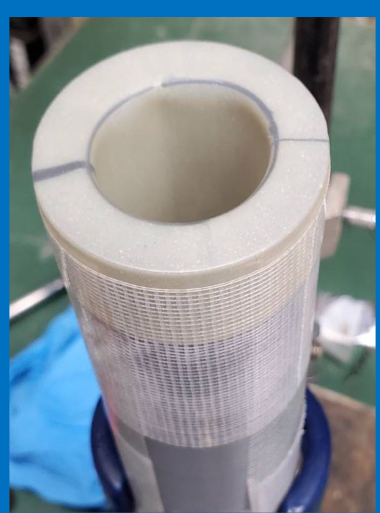


Laboratory test

How to make Specimens

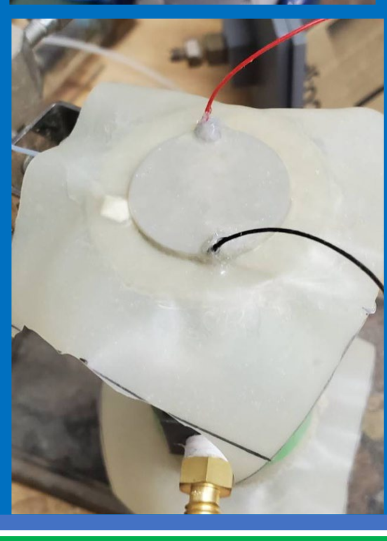


1. The membrane is attached to the inside of the mold with an inner diameter of 30 mm.

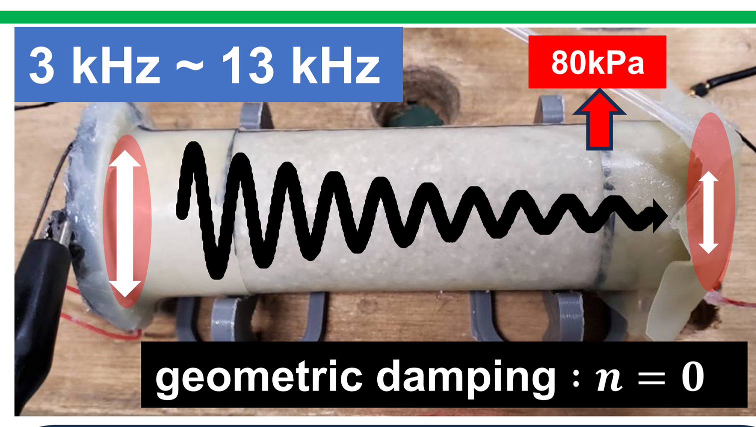


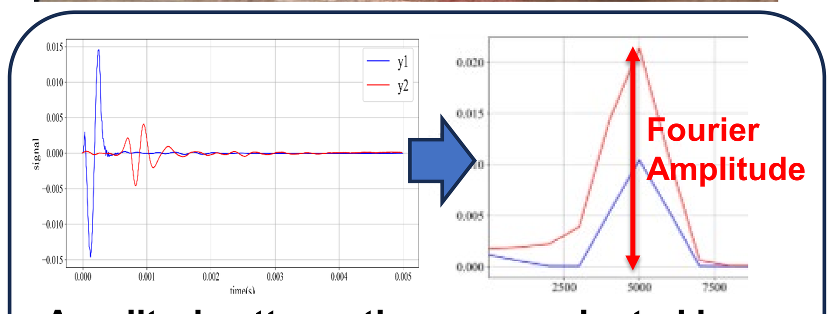
2. Piezoelectric receiver is attached to the end of the membrane and attached with silicone glue

3. fill with material, tapping the side of the mold 30 times every 2cm

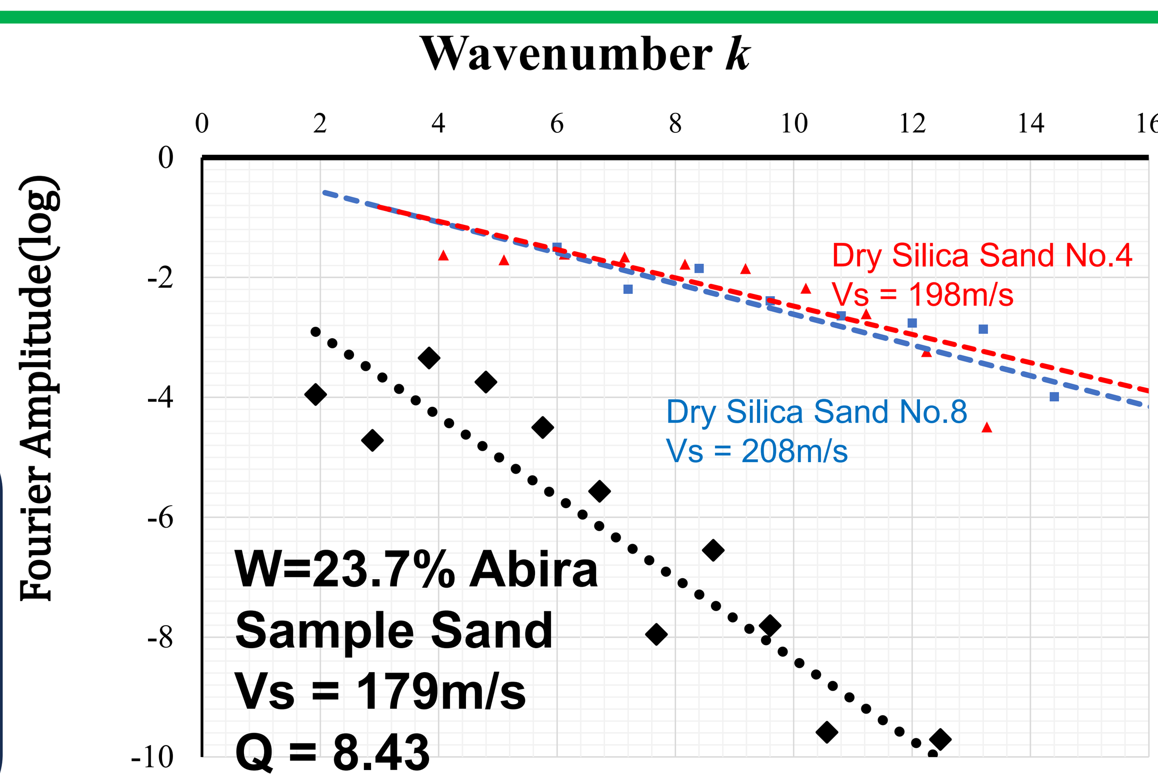


4. membrane-covered PE on the receiver side was attached to cover the top surface.



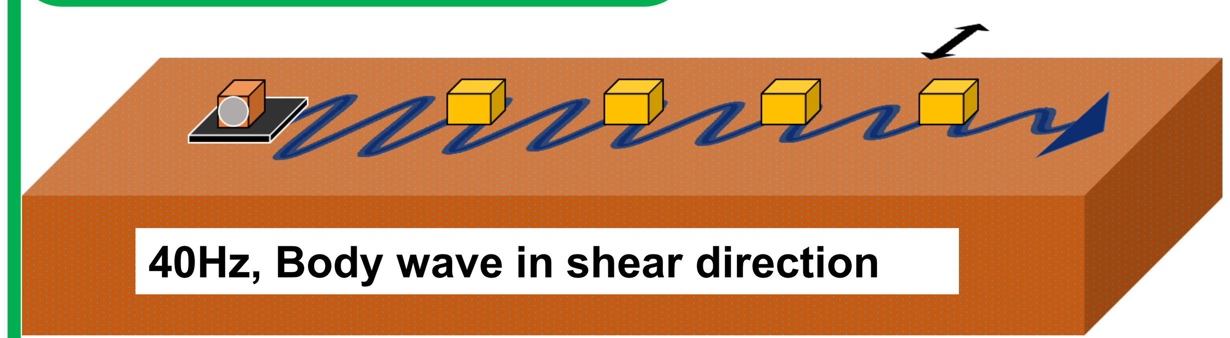


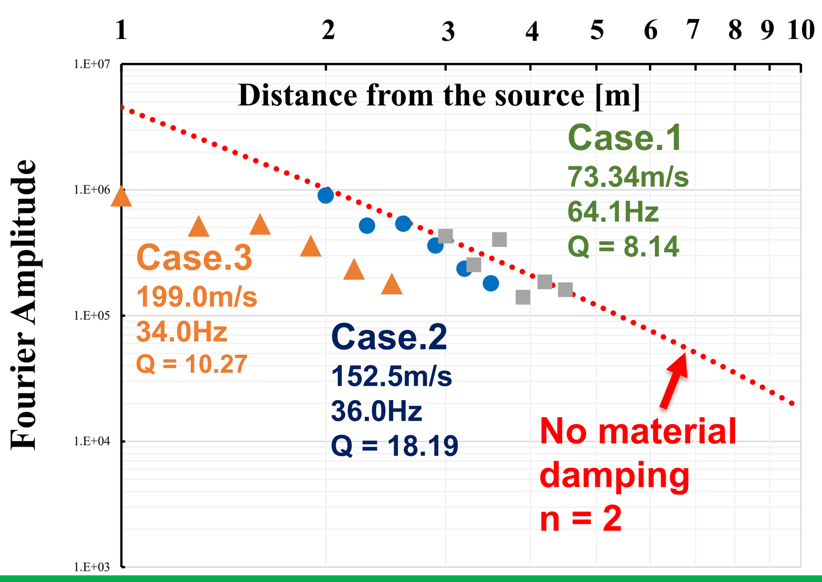
Amplitude attenuation was evaluated by discrete Fourier transform of the vibration



- **Excitation over the entire cross-section** results in excitation with **no wavefront extension (n=0)**
- The relationship between **the Fourier amp ratio** and frequency at the ends of the specimen and the **wavenumber conversion of the distance *k***
- The Fourier amplitude ratio of vibration at the end face decreased as the excitation frequency increased.
- The sample sand from Abira town showed **about 49% of the amplitude was damped for every wavelength** advanced

Field test





- Calculate the energy decay constant α_0 by comparing the Fourier amplitude near the peak frequency with the propagating distance, then wavenumber conversion k
- The range of shear **wave velocity was 73.3~199 m/s**
- The calculated energy attenuation constant α_0 was $1.39 \times 10^{-3} \sim 10.1 \times 10^{-3}$, **about 20~50% of the amplitude was damped for every wavelength** advanced

Results

	Field test (n = 2)			Lab test (n = 0)
	Case 1	Case 2	Case 3	
Velocity [m/s]	73.34	152.53	199.0	204.5
Frequency [Hz]	64.1	36.0	34.0	3000~13000
$\alpha_0 \times 10^{-3}$ [s/m]	**10.1**	**1.39**	**2.38**	**3.78**
Q value	8.14	18.19	10.27	8.43

- Comparing the field tests and the laboratory tests on the Abira sand, the results were **consistent when propagation velocities were close to 200 m/s.**
- The calculated energy attenuation constants α_0 were $1.39 \times 10^{-3} \sim 10.1 \times 10^{-3}$, which were **close to those of the coarse-grained and loosely packed sand**($\alpha_0 = 1.800 \sim 2.050 \times 10^{-3}$),
- About **20~50% of the amplitude was damped for every wavelength** advanced [XJ. Yang ,1995, Evaluation of man-made ground vibration]

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