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Detection of Internal Peeling in Building Materials by Using High-Intensity Aerial Ultrasonic Waves
強力空中超音波を用いた建築資材の剥離検出

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1. Introduction

The impact acoustic method and the infrared method are often used to analyze building materials such as mortar and tile. However, both of these methods are susceptible to human error. In this study, we examine a new method that uses high-intensity ultrasonic waves to detect peeling. Specifically, we have developed a non-contact method for detecting defects in building materials by analyzing the vibration of objects excited with high-intensity ultrasonic waves of finite amplitude.

2. Experimental setup and method

Figure 1 shows a schematic diagram of the experimental setup. A stripe-mode vibrating plate (frequency: 26.8 kHz) was used as a point-converging acoustic source to generate high-intensity aerial ultrasonic waves.[1] The ultrasonic waves radiated from this acoustic source are focused onto a circular area of 10 mm in diameter at a distance of 140 mm from the opening of the acoustic source.

Figure 2 shows the relationship between the sound pressure at the focal point O and the power supplied to the sound source. This ultrasonic wave has finite amplitude and contains harmonic components that are integral multiples of the fundamental frequency.[2] In the experiment, the center of the sample was set at the focal point O of the radiated ultrasonic waves, as shown in Fig. 1. The sample was continuously irradiated with ultrasonic waves, and the vibration velocity on the surface of the irradiated sample was measured with a laser Doppler displacement meter located behind the acoustic source. The frequency of the measured vibration velocity was analyzed with a fast Fourier transform spectrum analyzer.

3. Experimental samples

The samples in this experiment consisted of tile and concrete plates, which were bonded together. The 5-mm-thick tile plate had dimensions of 100 mm × 100 mm, and the 50-mm-thick concrete plate had dimensions of 250 mm × 250 mm.

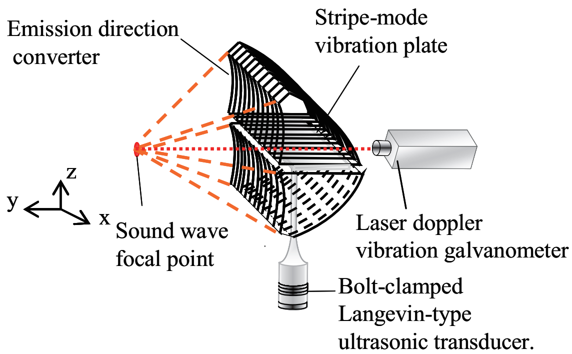

Fig. 1 Ultrasonic source and experimental setup.

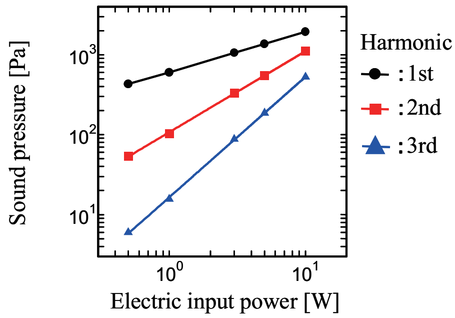

Fig. 2 Characteristics of ultrasonic waves at focal point.

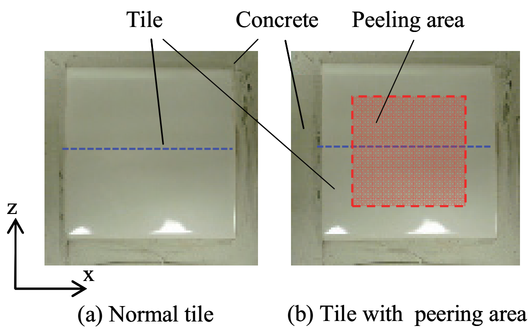

Fig. 3 Samples used in experiment.

Figure 3 shows two sample configurations used in this experiment. The sample shown in **Fig. 3(a)** consists of a tile plate that is bonded to the concrete plate with adhesive spread over the entire underside of the tile. For the sample shown in **Fig. 3(b)**, a thin film is inserted between the tile and

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concrete plates. Outside the area of the thin film, the tile and concrete are bonded together normally, while the thin film creates an artificial peeling area.

4. Experimental results

Figure 4 shows representative examples of the vibration characteristics of samples with and without the artificial peeling area. Each sample vibrates with finite amplitude at the fundamental frequency and harmonics corresponding to the ultrasonic wave. In addition, each sample vibrates in accordance with the supplied power to the sound source.

Figure 5 shows the vibration velocity distribution for each sample. Measurements were taken along the dashed blue line shown in Fig. 3, and the supplied power was held constant at 5 W. The colored area in Fig. 5 represents the artificial peeling area. As shown Fig. 5, the each sample's vibration characteristics at the harmonics do not differ between the artificial peeling area and the non-peeling area.

In contrast, the distribution of vibration velocity for each sample at the fundamental frequency clearly differs between the artificial peeling area and the non-peeling area.

Figure 6 shows the vertical axis of Fig. 5 converted to the distortion rate (the ratio of the total vibration velocity at the second to third harmonics to the vibration velocity at the fundamental frequency). As shown in Fig. 6, a clear difference in the distortion rate can be seen between the artificial peeling area and the non-peeling area.

Figure 7 shows results measured for the whole area of the tile shown in Fig. 3(a) as an example. The measured area is about 80 mm × 80 mm. The supplied power is constant at 5 W. Here, it can be seen that the distribution of the distortion rate clearly differs between the artificial peeling area and the non-peeling area.

In addition, it was found that the distribution of the distortion rate approximately corresponded to the artificial peeling area.

5. Conclusions

We have developed a method that uses high-intensity ultrasonic waves at 26.8 kHz with finite amplitude to detect the peeling of building materials. It was found that there is clearly a large difference in the distortion rate between the artificial peeling area and the non-peeling area. Therefore, it is possible to detect the peeling of building materials by using this method.

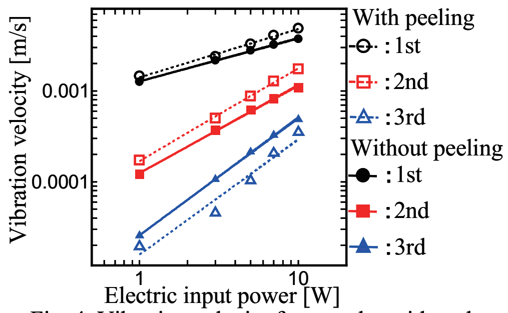

Fig. 4 Vibration velocity for samples with and without peeling.

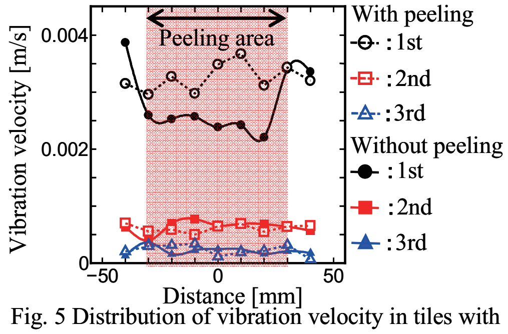

Fig. 5 Distribution of vibration velocity in tiles with and without peeling. (measured along dashed blue lines in Fig.3a and 3b)

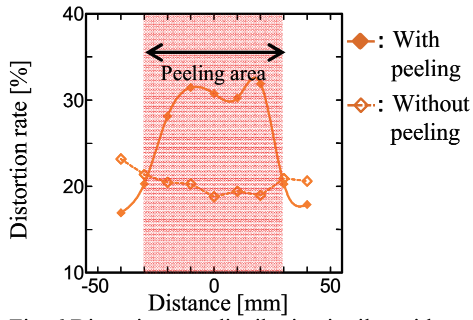

Fig. 6 Distortion rate distribution in tiles with and without peeling. (measured along dashed blue lines in Fig.3a and 3b)

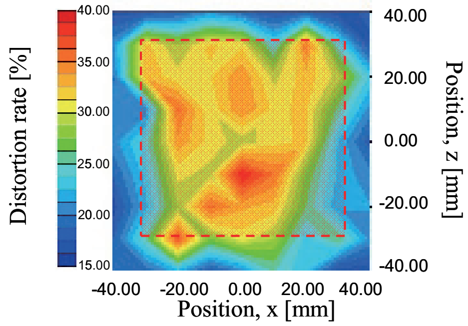

Fig.7 Distortion rate distribution in tiles with peeling. (measured over whole area). Red dashed square shows area of artificial peeling.

Refernce

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