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Basic study of an estimation method for fire damage within concrete using high-intensity ultrasonic waves and optical equipment

強力空中超音波と光学機器を用いた
コンクリート内部の火害影響推定の基礎検討

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1. Introduction

At fire sites, the location and of concrete walls in particular provide important information about the cause of fire outbreak. A distribution of fire damage of the surface on the concrete wall is one of them. On the other hand, it is very important to comprehend the fire damage level of inside the concrete wall because it needs to decide the restoration scale of the building caught fire.

In previous study[1)], we propose a new method by high-intensity aerial ultrasonic wave and contempt to estimate the fire damage level on the concrete.

In this report, we examined a new method in slight destructive and non-contact way to estimation fire damage level in concrete.

2. Experimental set up and method

Figure 1 shows a schematic view of experimental device. The experimental device consist of a sound source to generate high-intensity ultrasonic wave and a optical equipment (LDV: Laser Doppler velocimeter). A point-converging acoustic source with a stripe-mode vibration plate (frequency:26.8kHz) was used to generate high-intensity aerial ultrasonic waves[2)]. The convergence point O is on the x-axis, which passes through the center of the vibration plate 140 mm from its edge.

Figure 2 shows, for a free field, the relationship between the sound pressure and the power supplied to the sound source, as measured at the convergence point O of the ultrasonic waves as shown in Fig. 1. In this convergence point, a very high-intensity ultrasonic wave of 5000 Pa is created when the electric input power to the sound source is 15 W and generated the fundamental frequency and the harmonic frequencies. Under this high-intensity ultrasonic irradiation, the surface on the concrete wall is vibrated at the fundamental frequency and the harmonic frequencies[3)].

In this experiment, we dig a small pore (diameter : 10 mm) in the concrete sample because we measure the fire damage of concrete in the depth direction. We estimate the fire damage level in concrete to measure the vibration velocity at an excavation surface of the small pore in concrete. The excavation surface is dag to become the flat plane by square drill. In the measurement, it measured the vibration velocity at the concrete excavation surface of each required depth by using LDV. The measurement value by using LDV is subjected to frequency analysis by using FFT analyzer. However, the sound pressure is different at the excavation surface of concrete pore depending on the depth of pore when the sound waves incident the pore. Therefore, as shown

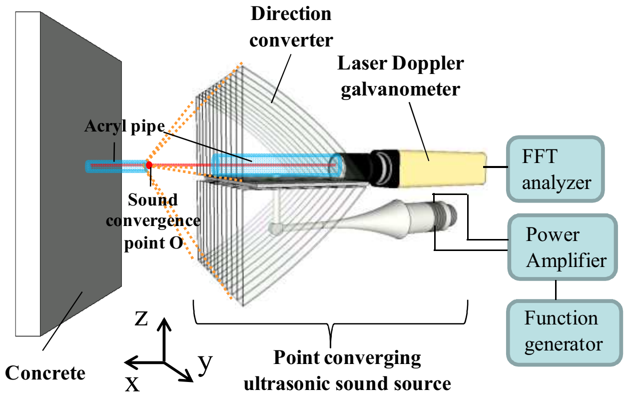

Fig.1 Schematic view of experimental system used.

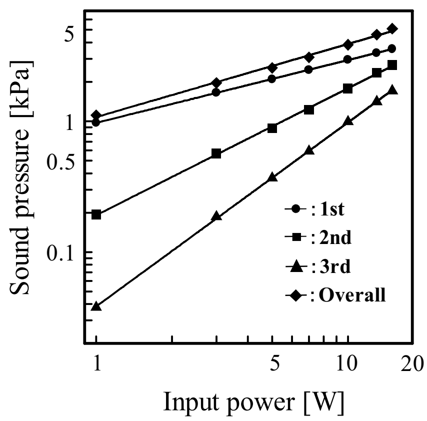

Fig.2 Relationship between electric input power supplied to sound source and sound pressure at each frequency.

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Figure 3, it keeps the sound pressure constant at the excavation surface to insert a transmission pipe (length: 41mm, diameter: 6mm) of sound wave into the concrete pore. In addition, the transmission pipe is displaced at the converged point.

3. Sample detail

We prepared a normal concrete sample without burning (NCS) and a burning concrete sample (BCS) by using an electric furnace. BCS was exposed to the temperature of about 800 ºC for 30 min, after which they were suddenly cooled for 5 min in water and then naturally dried in air for 120 min, as in an actual fire site.

In experiment, we measure vibration velocity at the five points around center of surface on the sample and averaged the measurement values. For this measurement, input power is 10 W constant.

4. Result

Figure 4 shows the vibration velocity of NCS surface. In the figure, the vertical axis is the vibration velocity and the horizontal axis is the distance from surface of concrete sample. As a result, the vibration velocity at each frequency is almost no change in depth direction.

Figure 5 shows the vibration velocity of surface on the concrete sample with burning. As a result, the vibration velocity of BCS at the each frequency is approximately twice as large as that of NCS around the surface of sample. As this reason, we consider the vibration velocity of BCS become large because the compressive strength and the Young's modulus of concrete decrease by heating. In addition, the vibration velocity of BCS approaches that of NCS as the measurement position became deeper. Therefore, we consider these result shows the characteristics of fire damage level in the direction to the depth in concrete.

5. Conclusion

We examined the new method in slight destructive and non-contact way to estimation the fire damage level in the concrete. As a result, it is found to be possible to estimate the fire damage level in concrete to measure the vibration velocity at the excavation surface of the each required depth in the concrete pore by using LDV.

References

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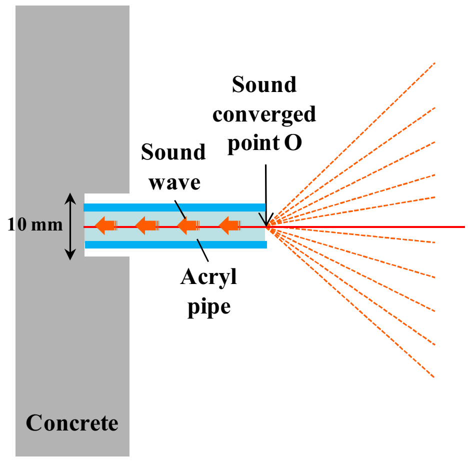

Fig. 3 Schematic view of ultrasonic irradiation with transmission pipe.

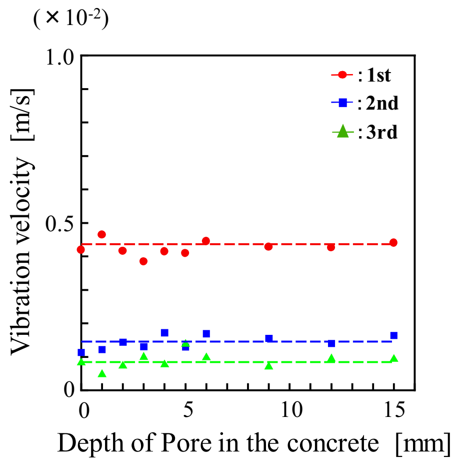

Fig.4 Relationship between vibration velocity at each frequency and depth of pore in the concrete (normal concrete sample).

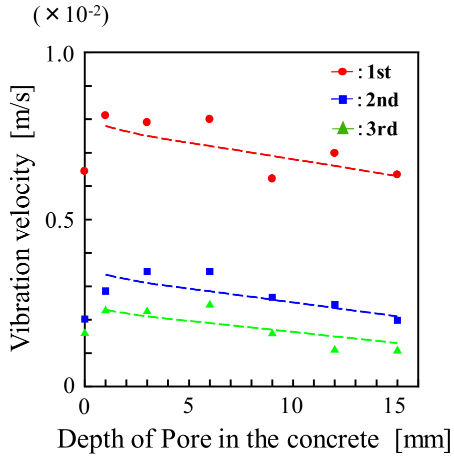

Fig.5 Relationship between vibration velocity at each frequency and depth of pore in concrete (burning concrete sample).