EFFECT OF VOID RATIO OF HORIZONTAL CRACK LAYER ON MULTIPLE REFLECTION BEHAVIOR OF ELASTIC-WAVE

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1. INTRODUCTION

While concrete structures are aging in Japan, the establishment of a nondestructive evaluation method for detecting the deterioration of concrete structures, which is difficult to visually inspect, has become an urgent issue in order to lengthen the life of concrete structures. For this purpose, the impact elastic wave method[1)] has been studied as a nondestructive evaluation method for horizontal cracks caused by fatigue in RC slab of highway bridges. However, it is often the case horizontal cracks may not be detected when the impact elastic wave method is applied to an actual RC slab. One of the reasons is considered that the concrete on the upper side and the lower side of the horizontal cracks partially contacts with each other in the actual structures.

In this study, the effect of void ratio of horizontal crack layer on the multiple reflection behavior of elastic-wave was investigated analytically.

2. OUTLINE OF ANALYSIS

2.1 Model Overview

In this study, three-dimensional impact response analysis was carried out. The analytical model is shown in Fig. 1 and the physical properties in Table. 1.The model dimensions were 1000mm (x-Axis Direction) × 1000 mm (y-Axis Direction) × 200 mm (z-Axis Direction), respectively, and horizontal crack layer were formed in the range of 800 mm (x-Axis Direction) × 800 mm (y-Axis Direction) × 1 mm (z-Axis Direction) at the position of 100 mm depth.

2.2 Input and Output Conditions

Fig. 2 shows the input wave form. There were 2 patterns of load duration: contact time [2)] Tc = 25.8 and 81.7 μs, which were presumed by impact with steel balls of 6 and 19 mm in diameter. The input point is at the center of the model top and the output point is 50 mm away from the input point. The output interval of in the acceleration waveform was 1 μs and total output points were 10,000 points, and FFT was carried out after the initial 90 μs of the wave front was cut.

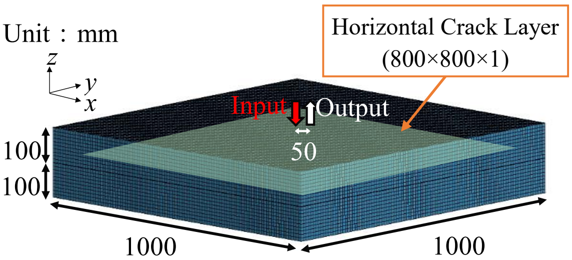

Fig. 1 Analytical Model

Table. 1 Physical Properties

Density (kg/m^3)	2.30×10^3
Elastic Coefficient (N/mm^2)	3.00×10^4
Poisson's Ratio	0.20

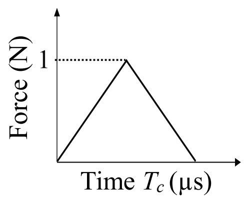

Fig. 2 Input Wave Form

2.3 PATTERN OF VOIDS ON HORIZONTAL CRACK LAYER

(a) Effect of differences in void ratio

As shown in Fig. 3, a total of 5 patterns of horizontal crack layer were prepared with void ratio of 0, 25, 50, 75, and 100%.The voids were arranged with symmetry as much as possible, and a size (= Size of the air gap unit) of the voids was 100 mm × 100 mm.

(b) Effects of differences in the arrangement of voids

As shown in Fig. 4, when the void ratio was 25 or 75%, 2 patterns were added to the examination of (a).

3. ANALYSIS RESULTS AND DISCUSSION

(a) Result of the effect of differences in void ratio

Fig. 5 shows an example of the frequency spectrum of each void ratio. In the case of Tc = 25.8 μs, the peak was found at

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the longitudinal wave resonance frequency corresponding to the slab thickness when the void ratio was 0%, but as the void ratio increased, the peak was found at the longitudinal wave resonance frequency corresponding to the depth to the horizontal crack layer. And, in the case of *Tc* = 81.7 μs, the peak was obtained at the longitudinal wave resonance frequency corresponding to the slab thickness at the void ratio of 75% or less. However, as the void ratio increased, the longitudinal wave resonance frequency corresponding to the slab thickness tended to decrease.

(b) Result of the effects of differences in the arrangement of voids

Fig. 6 shows an example of the frequency spectrum of the arrangement of the voids. In the case of *Tc* = 25.8 μs and void ratio 25%, there was a slight difference in the frequency spectrum depending on the arrangement of the voids. This is considered to be due to the difference in the void ratio just below the input point. The similar tendency was also obtained in the arrangement of other void and *Tc*.

4. CONCLUSIONS

Under the analytical conditions of this study, the following conclusions were obtained.

1) As the void ratio increased, the peak was found at the longitudinal wave resonance frequency corresponding to the depth to the horizontal crack layer, but the longitudinal wave resonance frequency corresponding to the slab thickness tended to decrease.

2) It was found that the arrangement of the voids had some effects on the frequency spectrum.

REFERENCES

1) Kamada, T., Nakayama, K., Onishi, H., Uchida, S.: Fundamental study on evaluation method of horizontal cracks of RC slab by impact elastic wave method, Annual report on concrete engineering, Vol. 31, No. 1, pp. 2113-2118, 2009.

2) Sansalone, M. and Streett, W.B.: Impact Echo, Bullbrier Press, Ithaca, N.Y., pp. 29 -46, 1997

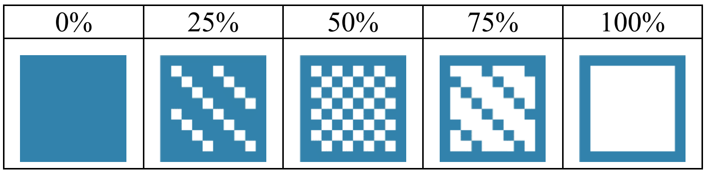

Fig. 3 Top View of Horizontal Crack Layer
(differences in void ratio)

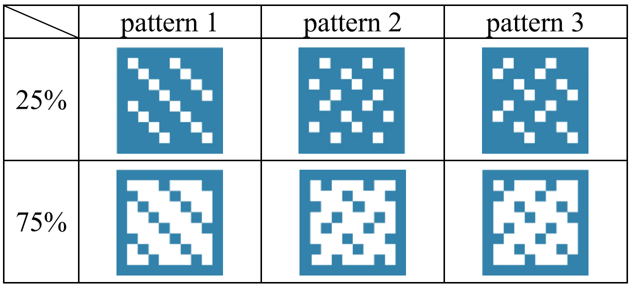

Fig. 4 Top View of Horizontal Crack Layer
(differences in the arrangement of voids)

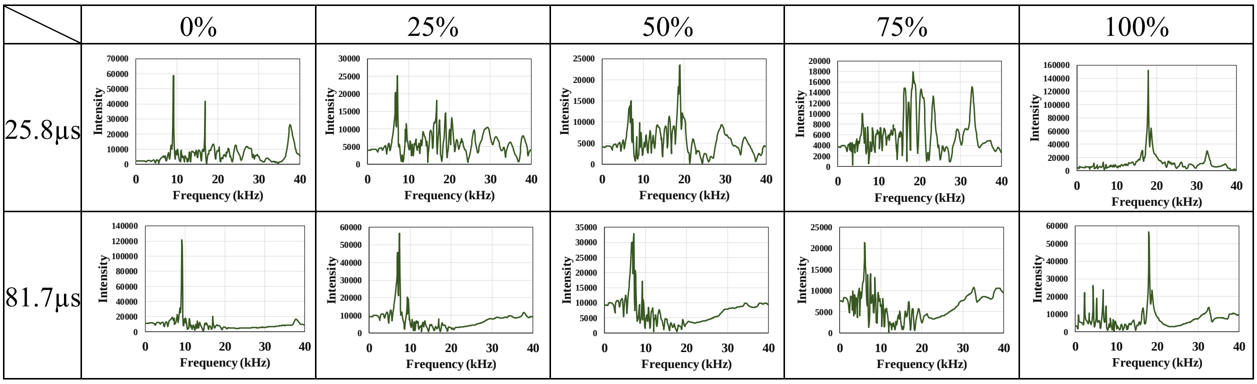

Fig. 5 Frequency Spectrum (differences in void ratio)

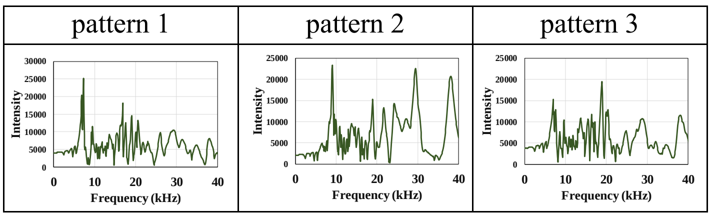

Fig. 6 Frequency Spectrum (differences in the arrangement of voids・*Tc*=25.8 μs, void ratio 25%)