INJECTION OF REPAIRING MATERIALS TO CRACKS USING ULTRASONIC RECTANGULAR DIFFRACTION METHOD

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The following are measured by various non-destructive testings : crack and peeling which arose in concrete structures used as basic bedsill of machine tools and pressure vessels. Repairing materials are injected in measured the crack department and peeling division, and repair and reinforcement of the structure are carried out. The prolonging life of the structure will be conducted.

However, the report of whether it injects repairing materials is not found. Here, concrete repairing materials were injected to the crack department, and the filling behavior was examined by rectangular diffraction method of ultrasonic wave. The filling of repairing materials in the cracks can be evaluated by the direction and amplitude of the first wave of receiving wave. This waveforms from the crack divisions equal to the waveform of the soundness, when repairing materials were filled at the cracks.

Key words: Repairing material, injection behavior, Crack, Peeling division, Rectangular diffraction method

1. Introduction:

Maintenance management, repairs, reinforcement, estimation in remaining life, etc. are carried out in concrete, when concrete structures such as tunnel and dam were used for a long time. For example, in the measurement of crack depth and peeling dimension that arose in the inside of the concrete structures, radiographic examination, radar methods, and ultrasonic testing, etc. are mainly utilized, and various measuring methods are proposed. The prolonging life of the structures will be conducted by the injection of concrete repairing materials variously.

Here, concrete repairing materials were injected to the crack department, and the filling behavior was examined by rectangular diffraction method of ultrasonic wave. The measurement principle and experimental results are described at the following.

2. Test-piece and measurement principle:

Dimensions of the test piece which made water-cement ratio w/c to be 55% were length of 400mm, width of 100mm, height of 200mm, and it respectively put the crack depth of 50mm, 100mm and 150mm in the central of the test pieces in respect of the crack width of 1mm. And, the test-piece which replaced the crack angle with 0°, 30°, 45° and 60° was produced. The measurement principle used the diffracted ray system (Lamp method). This measuring method requires right-angled diffracted ray from the crack tip division.

Transmit and receive probes hold on the crack as shown in Fig.1. The length 2a of these probes are kept away from the position. The receiving wave is inverted in before and behind of y = a, when the depth of the crack is made to be y, and the depth of the crack is obtained.

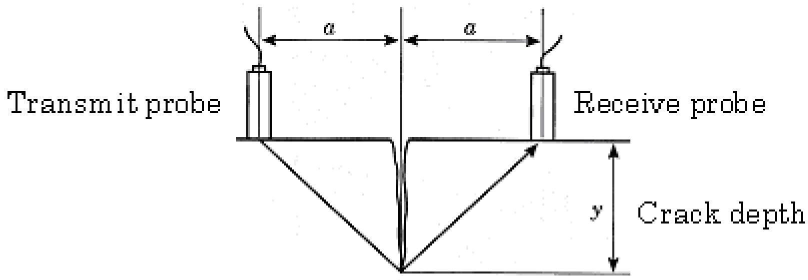


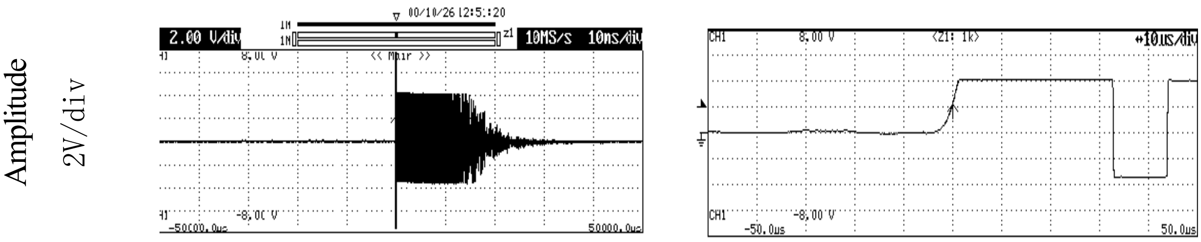
Fig.1 Measuring method by right-angled diffracted ray

The waveform from the ultrasonic testing instrument made by Toyoko-elmes was output in the digital scope. Used test frequency is 28 kHz. In this experiment, cement system impregnate agent (ultra-fine particle cement grouting material) was used. The receiving wave type obtained by ultrasonic testing is dependent on the existence of the filling of repair medicine. First, the crack depth was measured by the diffracted ray system. Afterwards, repairing material was injected into the crack department in the condition that the ultrasonic probe was fixed. The relationship between filling situation and signal waveform of that time repairing materials was examined.

3. Experimental result and consideration

3.1 The waveform in the soundness division.

Fig.2 shows sound receiving wave type of the test-piece without cracks and cavities. Fig.2(a) shows the wave from the soundness division. It is Fig.2(b) to expand the time base by the attention to the undulate first wave. It is a signal waveform near the first wave that expanded time base at 1000 times, and first wave from the soundness division looks up.



(a) Receiving waveform (b) First wave of receiving wave (×1000) .

Fig.2 Waveform of soundness divisions in the concrete.

3.2 Measurement of crack depth by probe interval change.

The result that measured by distance changes of the two probes which held the crack depth of 100mm and tilting angle of 0 degree is shown in fig. 3. The wave shape of the reception first wave is different by the interval 2a, when two transmit and receives probe interval 2a were gradually extended. In a = 30mm in which distance between crack and probe changes, it becomes waveform downward. That is to say, it is different from the upward waveform of first wave in the soundness division. The downward waveform is a longitudinal wave by shear force that arises from direct wave in crack tip, and the upward waveform is a longitudinal wave that is right-angled for direct wave according to a movement Poisson ratio effect. In a = 95mm, the small wave appears (b). This small wave is based on receiving the wave in which the signal from the transmission probe was diffracted in the tip of the crack. In a = 96mm, the small wave begins to collapse(c). In a = 100mm, the small wave becomes upward waveform which is disappearing(d). It becomes the same almost shape in the soundness division(e).

3.3 Filling of repairing materials to the cracks

After the crack detection, the position of the probe in examining filling situation of repairing materials is shown in Fig. 4. The position of the probe in measuring the crack depth is shown in the dotted line in the figure. Here, the test - pieces of crack depth 100mm and 0 degree were used.

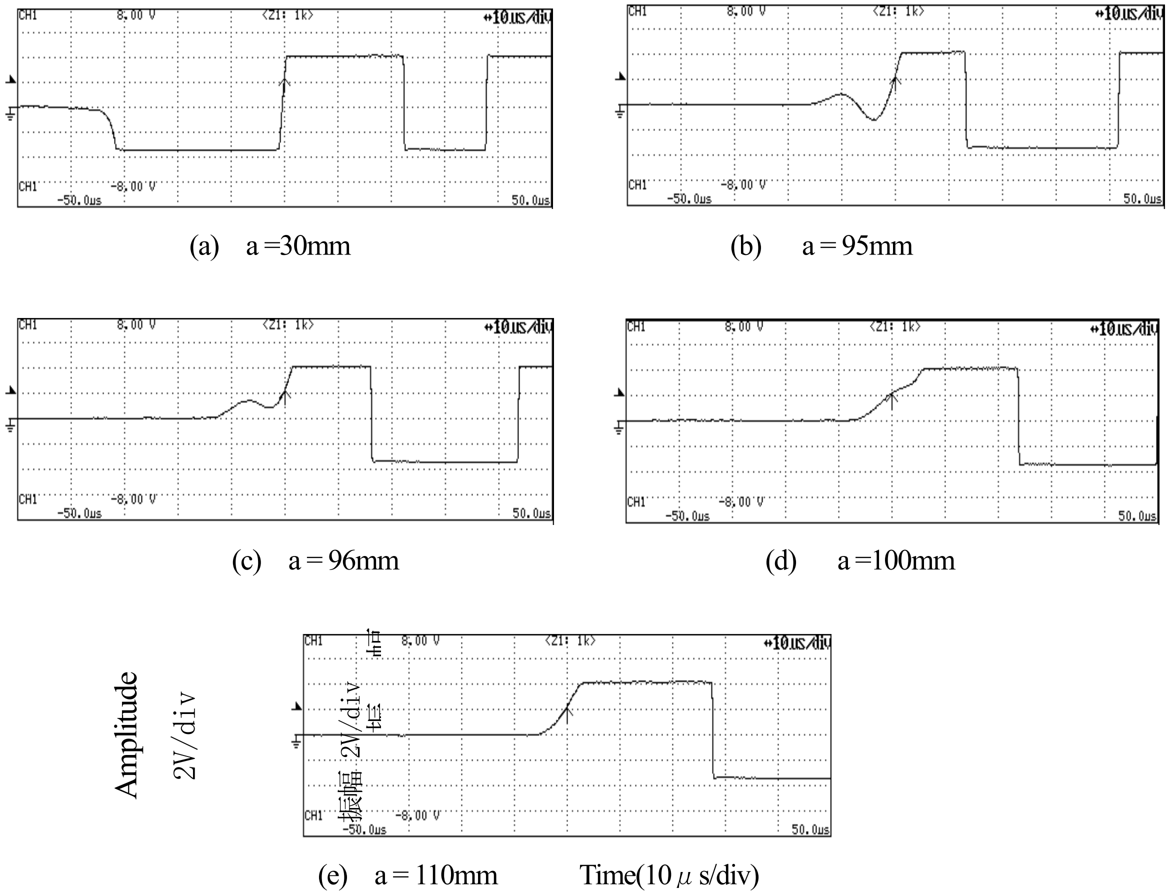


Fig.3 First wave from the crack department (Crack depth 100mm, 0 angle).

First waveform obtained by injection depth variation of repairing materials was noticed. The result of measuring is shown in Fig.5. The first wave is downward waveform, when repairing materials of in Fig.5(a) were injected to 30mm depth. This is different from the upward waveform of first waveform in the soundness division as well as the waveform of the crack without repairing materials. The amplitude of vertical line are 2V/div.in Fig.5.

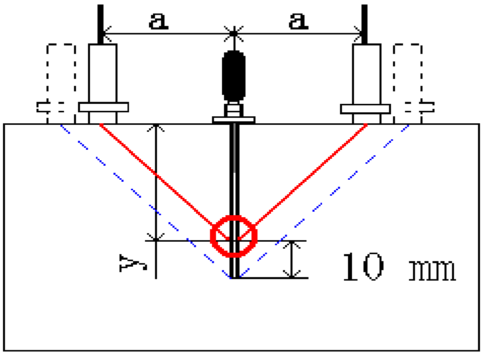
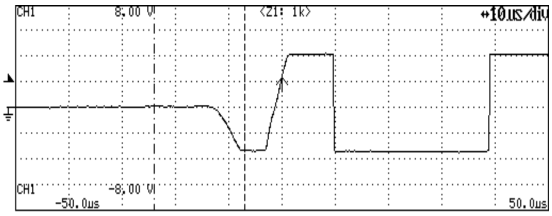
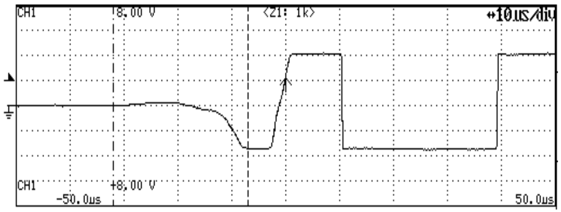


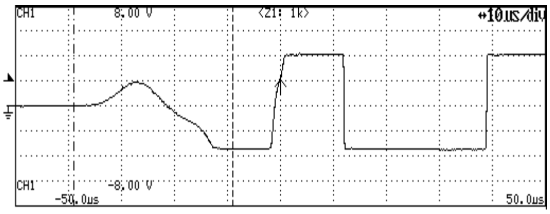
Fig.4　Measuring location of the probe.



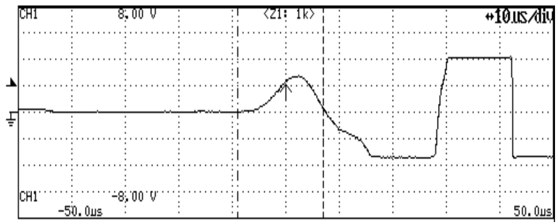
(a)　30mm



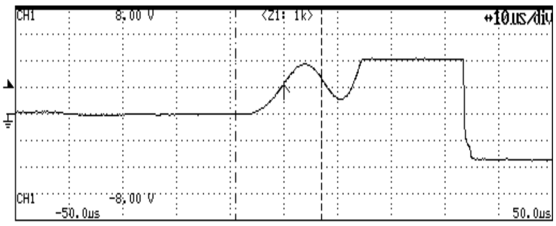
(b)　50 mm



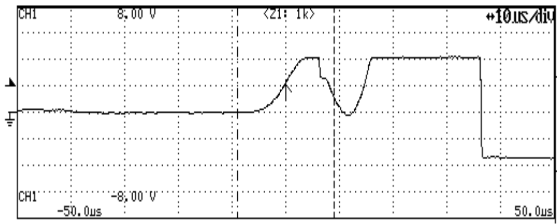
(c)　60 mm



(d)　70 mm



(e)　90 mm

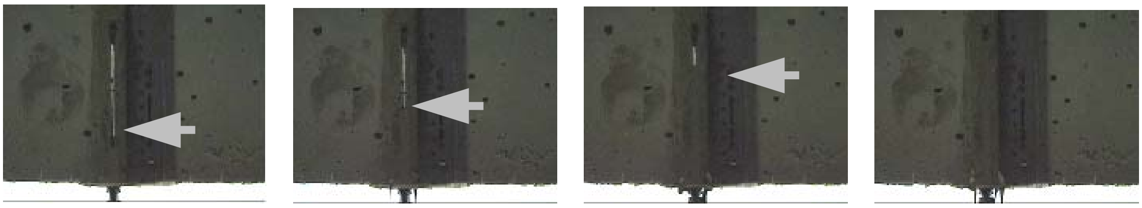


(f)　100 mm　　Time　(10 μ s/div)

Fig.5　Waveform changed by the injection depth

When the depth of repairing materials is 50 mm, the clear waveform change is not observed Fig.5 (b). With becoming 60mm and 70mm at the injection depth, the small wave which is clearly upward appears, and height of thread (Amplitude) also rises (c and d). In addition, the waveform rose in 90mm(e), the small wave perfectly faded away in 100mm, and it became an upward waveform (f). Though small valley has upward waveform appeared. And the valley disappears in Fig.5(f), when repairing materials were perfectly filled in the cracks. It is equalized with the waveform of the sound department.

Fig. 6 was shown the photograph in filling at 30, 50, 90 and 100 mm at injection depth of repairing materials. Injection tip of repairing materials becomes the almost uniform depth. Fig.7 shows the measurement result that variously changed tilting angle of the crack in the case of the cross section depth of 100 mm. The amplitude of the reception first wave is the degree that slightly changes, when repairing materials were slightly injected. The result has remarkably appeared, as the degree of tilting angle increases. Fracture surface photograph that repairing materials were perfectly injected to the crack department is shown in fig.8.



(a) 30mm (b) 50mm (c) 90mm (d) 100mm

Fig.6 Injection situation of repairing materials

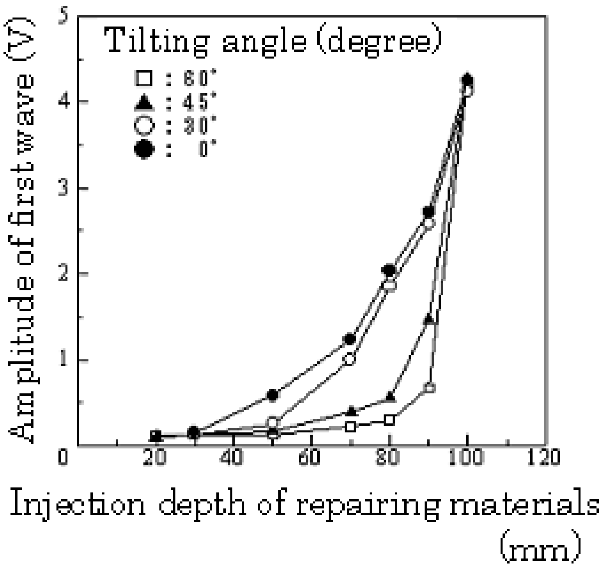


Fig.7 Changes of the amplitude for the injection depth of the gradient cracks.

Fig.8 Fracture surface in the crack repair division.

4. Conclusion:

As repairing materials were injected to the cracks, the filling situation measured by rectangular diffraction method of the ultrasonic wave, the results were obtained as follows.

(1) In the case which distance between crack and the probe is smaller than crack depth y, first wave becomes downward.

(2) The evaluation is possible at direction and amplitude of the reception first wave when cracks repairing materials filling situation. (

(3) The first wave in the part in which the filling of repairing materials finished becomes it in the soundness division.

From the above result, the decision is possible for the quality of filling situation of repairing materials, if the crack depth is beforehand measured.

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