Estimating Arrival Time of Crack Wave by Using Moving Window

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1. Introduction

Acoustic emission (AE) is produced due to an elastic wave generated from the damage in solid materials. However, an accurate determination, by a non-destructive manner, of localization on where the damage happened in solids still remains challenging. Here, we report a novel crack wave arrival time determination algorithm of AE suitable to identify crack wave with low signal-to-noise ratios generated in rocks. Calculation of variances resulted from moving windows as a function of their size differentiates the signature from noise and from crack signal, which lead us to determine the crack wave arrival time. To validate our algorithm, we have performed the pencil lead break test using rock samples, which resulted in successful determination of the wave arrival time and crack localization.

2. Proposed Method

Fig. 1 shows a clear difference between the crack wave and the noise after the frequency analysis on crack wave as a function of time domain (see the inset). The crack wave signal has a narrower frequency range with higher amplitude, whereas the noise signal has the frequency distribution of a wide band with lower amplitude. The frequency analysis result from the crack wave possesses a specific frequency range, while that from the noise signal does a wide frequency distribution.

The main idea comes from the frequency characteristics. Fig. 2 (b) shows that the variance of a windowed noise signal in the time domain is not changed with varying length of window. This is because the noise has wide band frequency range. However, because the crack signal has narrow frequency range, the variance of a windowed crack signal is changed depending on the widow size as shown in Fig. 2 (a).

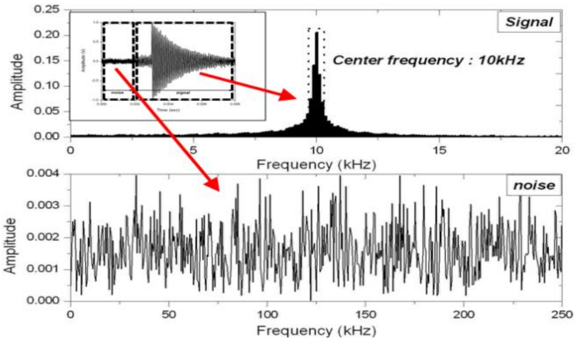
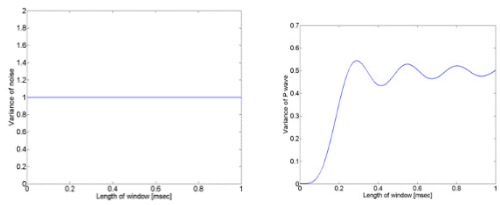


Fig. 1. Results of a crack wave generated from the rock and the frequency analysis of the noise signal.



(a) (b)

Fig. 2. Signal variance as the window size of (a) noise signal and (b) crack wave.

3. Validation using the experiment

In this paper, to verify the accuracy of the proposed algorithm for measuring the arrival time of the wave, the experiment was performed on the surface of the rock.

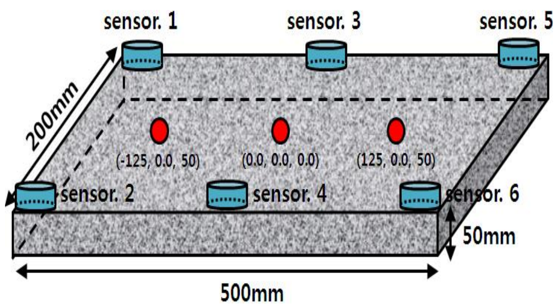


Fig. 3. Location of AE sensors on the granite rock and the schematic diagram of the pencil lead break for the accuracy of the source localization.

The AE signal is generated by using the pencil lead break. Fig. 3 shows the location of the three hit points and the coordinate information of the six sensors used in the experiment. The three red circles denote the pencil lead break points.

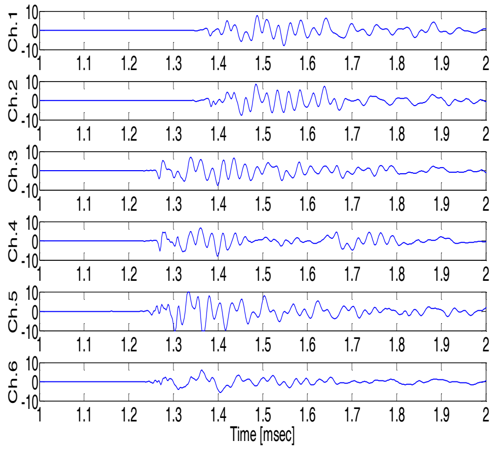


Fig. 4. Measured AE signals when the pencil lead break test was performed at (125 mm, 0.0 mm, 50 mm).

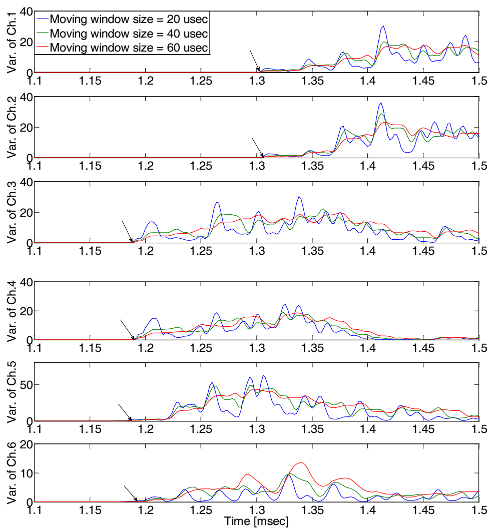


Fig. 5. Experimental results by using the proposed moving window method when the pencil lead break test was performed at (125 mm, 0.0 mm, 50 mm).

Fig. 4 shows the measured raw signal from each AE sensors. It is difficult to find the starting point of the each wave. However, we can detect the arrival time easily by using the proposed method as shown in Fig. 5.

To verify the result of the Fig. 5, we have performed source localization. In the Fig. 6, the estimated source location was (125.8 mm, 2.7 mm, 50 mm) when the true source location was (125 mm, 0 mm, 50 mm). Therefore, the result shows that the proposed method can estimate the arrival time of crack wave accurately.

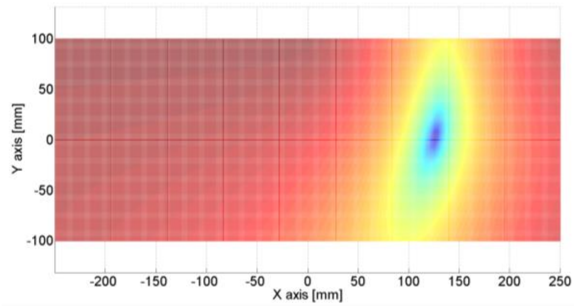


Fig. 6. Source location was estimated by calculating the variance of velocities, where the minimum value of variance indicated source location.

4. Conclusion

In this paper, we suggested how to predict the arrival time of the crack wave by using the moving window. To verity the method, the experiment for the rock specimen was performed. The result shows the method is quite powerful for estimating the arrival time of crack wave in nosy environment.

REFERENCES

[1] Tsang, C. F., Bernier, F. and Davies, C. (2005), “Geohydromechanical processes in the excavation damaged zone in crystalline rock, rock salt, and indurated and plastic calys-in the context of radioactive waste disposal”, Int. J. Rock Mech. Min. Sci., Vol.42, No.1, pp.109-125.

[2] IAEA, (2001), “Monitoring of geological repositories for high level radioactive waste:, IAEA-TECDOC-1208, IAEA, Vienna.

[3] EU (2004), “Thematic network on the role of monitoring in a phased approach to geological disposal of radioactive waste”, Final report to the European Commission Contract FIKW-CT-2001-20130, pp.1-16.

[4] hardy, H. R. (1994), “Geotechnical field applications of AE/MS techniques at the Pennsylvania state university: a historical review,” NDT&E International, Vol.27, No.4, pp.191-200.