Acoustic Wave Crack Detection: A First Principles Approach

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Introduction: Crack detection is an active field of exploration. The concepts presented herein explore an acoustic methodology for the modeling and detection of cracks and families of cracks in crystalline solids, polycrystalline solids and high viscosity amorphous materials (glasses).

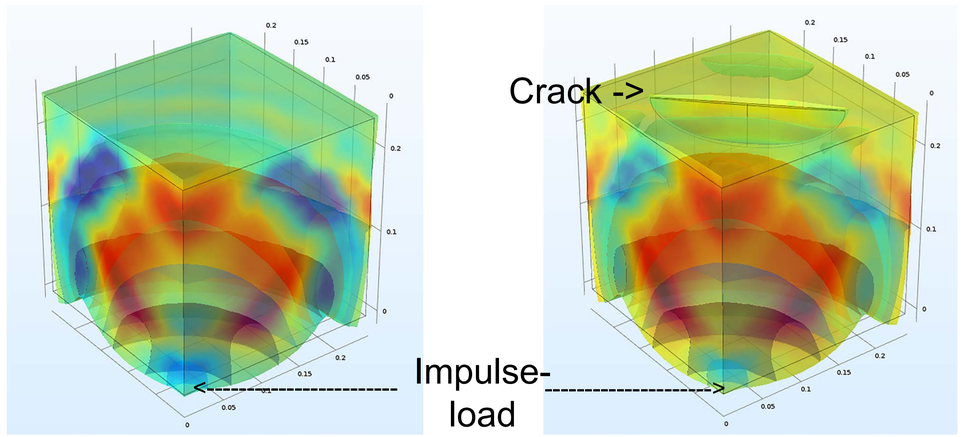

Figure 1. Acoustic wave patterns induced in a quarter-section of rock with (right) and without (left) cracks.

Computational Methods: The primary analytical consideration is the single-point transient displacement (shear wave) of a z-axis point on the upper surface of the model geometry. The upper z-axis point displacement (Figure 1) is calculated, both with and without cracks in the upper surface, after the impulse-load has been applied to a relatively small area on the lower surface, centered on the z-axis and located directly below the displaced measurement point (Figure 2). The single fundamental assumption made is that, as a result of wave-crack interaction, the acoustic wave frequency distribution profile changes.

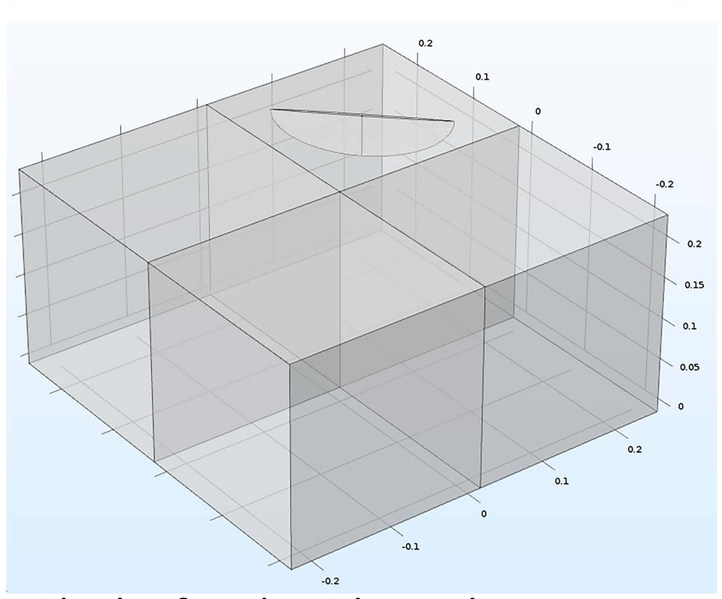

Figure 2. Block of rock with crack in upper surface and Impulse-load in the lower center.

Results: For the 0-, 1-, 2- and 3-crack structural mechanics models, the study calculates the displacement of the measurement point for a 400 microsecond response period. The difference between the cracked geometries and the un-cracked geometry response curve is determined by using differential analysis, after the submission of the displacement curves to Fourier analysis.

Figure 3 shows the collected results of all four models and the differential analysis. The upper four curves are the curves before differential Fourier analysis. The lower three curves show the 1-Crack, 2-Crack, and 3-Crack difference curves.

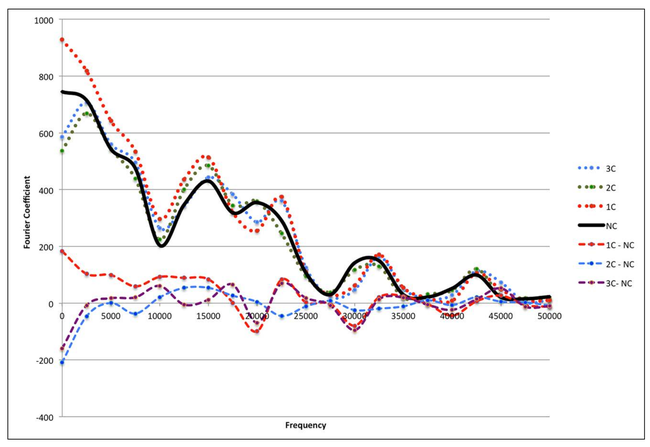

Figure 3. Differential Crack Detection

Conclusions: Figure 3 shows that the presence of 1 or more cracks in the geometry significantly alters the frequency spectrum of the displacement curve; therefore, the measurement of displacement curve changes could be used to detect cracks in these materials.

References:

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