Acoustic Wave Crack Detection: A First Principles Approach

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Abstract

INTRODUCTION: A sound, stable infrastructure is vital for the safety and contentment of the earth's population worldwide. Mechanical segments of the many different infrastructures, such as roadways, bridges, cell-towers, pipelines, building materials (rock, concrete, brick, steel, etc.), are susceptible to cracking failures when exposed to differing environmental conditions that arise in normal usage. Examples of such conditions are: thermal cycling, corrosion, load cycling, and weather, to name a few. Since many cracks occur in locations that are not readily accessible or observable, it is necessary to develop methodologies that can determine the existence and/or location of a crack or cracks indirectly, as shown in Figure 1.

USE OF THE COMSOL MULTIPHYSICS® SOFTWARE: This model employs the Structural Mechanics Module of the COMSOL Multiphysics® software, a transient solver, and an impulse load located at one position of a rock mass. This model is derived from an earlier COMSOL® Model {1}. The impulse load generates a wavefront comprising both shear and compression waves propagating through the body of the rock mass. A characteristic 1D response curve (Figure 2) is generated at a measurement point on the surface of the un-cracked rock mass. When the rock mass is modified, through the incorporation of a crack, the characteristic curve 1D response curve changes and reflects the presence of the crack (Figure 3). Fourier Analysis of the transient response data is easily accomplished by postprocessing the 1D response curve. The Fourier Analysis displays the shift in the composite frequency distribution.

RESULTS: A comparison of the curves in Figure 2 and Figure 3 clearly demonstrates that the presence of a crack shifts the frequency distribution of the transient response of the rock mass.

CONCLUSION: Using COMSOL Multiphysics® software and a First Principles Approach is a powerful tool that allows the modeler to easily evaluate the concepts proposed for a new experiment. In this case, this model easily demonstrates the detectability of a crack or cracks by using acoustic waves passing through the rock mass.

Reference

1. COMSOL Multiphysics Model, 12811, Wave Propagation in Rock Under Blast Loads.

Figures used in the abstract

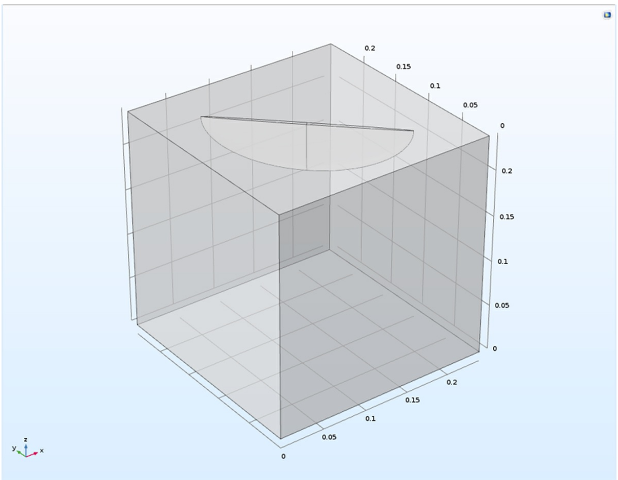

Figure 1: Rock Mass with Crack

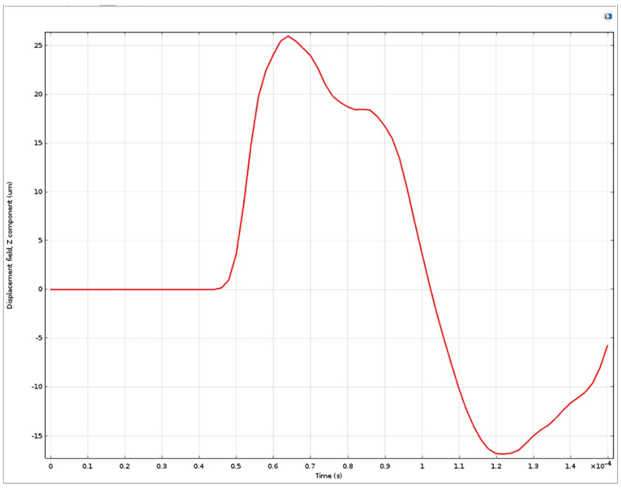

Figure 2: 1D Response Curve without Crack

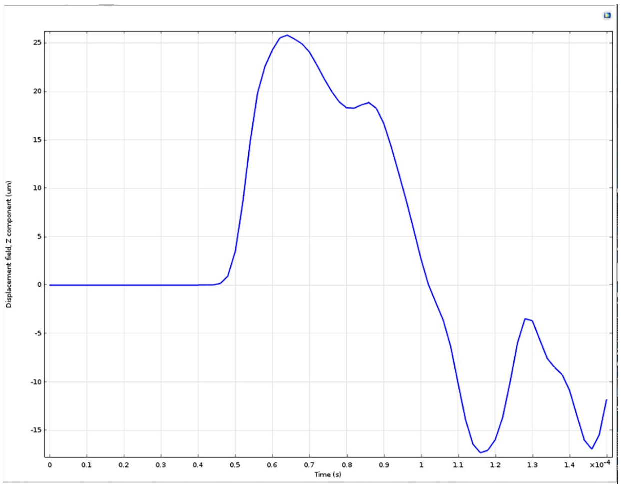

Figure 3: 1D Response Curve with Crack