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Numerical study and analytical solution of P-wave attenuation insensitive underground structure

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Abstract

stability the underground sensitive structures in order to reduce the damage of explosion on these structure including nuclear and military installations as well as energy site is an issue of great importance which cavers all the substructures and vital centers. The focus of this study is on the energy attenuation of one-dimensional p-wave in rock mass.
As a proposal to strengthen the structures applying virtual space in rock mass, analytical (based on wave reflection and transmission) and numerical study on P-wave attenuation are used.
Analytical and numerical results have shown that any vacuum or cavity in rock mass greatly increases P-wave attenuation, and that any rock material with strength mechanical properties in virtual space decreases attenuation and raises P-wave energy transmission. Moreover, this results can be a good source for intelligent designing of this structures.
Key words : Wave attenuation, Analytical solution, Numerical analysis, virtual space

1. Introduction

The first investigation regarding rock dynamic properties might be those laboratory studies which Barton said that in his book on the early researchers of this field.
The potential effect on density on P-wave velocity and attenuation was the issue which investigated using blast hole (e.g. Aikada 1993).
His studies showed that the main reason for an increase in P.wave velocity and a decrease in P-wave attenuation as the depth of the ground increases is due to an increase in rock mass density and a decrease in an isotropic rock mass. In addition, many researchers have investigated the effect of density on P-wave velocity using laboratory studies and insitu tests(Emalive1993; Yammoto *et al* 1995; Ishikawa et al 1995) .
We can also refer to Grogik & Koda (1994) studies on two types of rock, Marl & Predotit (1996), which led them to linear equation of $V_P = 4/75y - 7/3$, of great important result in all the studies conducted is that as rock density increases and rock mass properties get close to isotropic rock, the velocity of P-wave increases.
Considering dynamic from a different perspective, we can refer to the effect of porosity and uniaxial strength of rock on P-wave transmission.
The results clearly illustrate that an increase in porosity and a decrease in uniaxial strength which are in some way related to each other, make P-wave velocity greatly decrease while P-wave attenuation increase. For further studies refer to (Won & Raper 1997; Johnston 1995).
Most of these studies have been concerned with cracks (i.e., micro-cracks and micro-voids) of a small size relative to the seismic wavelength, based on the wave scattering models (Hudson 1990; Achenbach 1990 ; Odherty RF 1997 ; Bedford 1994).
In most modeling using numerical methods, it was assumed that fracture or joint be very small in relation to dynamic wave length. The latest studies made in this regard have been mostly conducted by Zhao &et al as well as Wang's & et al (Zhao & *et al* 2008,2009,2010 ; Zhang 2005 ; Wang Zl *et al* 2010 ; J.Dean 2009 ; Zhao Gf 2010).
Applying a coefficient called wave transmission coefficient, Zhao investigated the effect of fracture spacing on wave propagation.
Comprehensive scientific research which have been published in a number of papers.
It should be stated that in recent year's Z.L. Wang's et al has attained remarkable results using analytical and numerical methods. Their latest studies are also concerned with the enhancement of underground structures