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CONVENTIONAL METHODS TO EVALUATE SHEAR WAVE TRAVEL-TIME IN LABORATORY TESTS

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Abstract

The evaluation of shear wave velocity in soil is so much desirable in geotechnical engineering due to its application to estimate the soil moduli under small strain condition. Obtaining the best travel-time is a main concern in calculating shear wave velocity in laboratory tests. Correct travel-time might be masked by some unwanted phenomena such as near-effect. In present paper, basic parameters and specific application of different methods to examine shear wave travel-time i.e. temporal, mathematical, and frequency methods are explained and their exactitude are comprised. Based on authors' laboratory tests on granular soils, maximum difference between different temporal method results is reached up to 0.09 ms. Cross-correlation presents its best results when the first peak of the received signal is the greatest between all next peaks. The frequency method was completely explained since the results of different method results to evaluate the most correct travel-time is converged using this process.

Keywords: Granular soil; Shear Wave Velocity; Travel-time; Cross-correlation Function; Frequency Methods

1. INTRODUCTION

In the field of soil mechanics, wave propagation is a fundamental topic because soil elastic moduli can be evaluated by calculation of shear wave (S-wave) and compressional wave (P-wave) velocity propagating through soilunder small strain level,the area below the threshold of 10-5[1].In fact, main concern in analyses of wave velocities is obtaining the best travel-time, especially for S-wave, due to near-effects [2]. There are three conventional methods to evaluate travel-time of waves in literature; temporal, mathematical (cross-correlation), and frequency methods. Dyvik and Madhus[2] used temporal methods in their bender element tests to measure S-wave travel-time in different experimental conditions. Thereafter, Viggiani and Atkinson [3] experimentally evaluated S-wave travel-time in reconstituted samples of boulder clay with various methods such as peak points, cross-correlation function, and cross power spectrum. From another point of view,Jovicic et al. [4] stated that increasing of input signal frequency may be lead to calculate S-wave travel-time with higher exactitude. Recently, Lings and Greening [5] expressed that main problem with bender-extender element was the calculation of shear wave travel-time. Sharifipour et al. [6, 7] used temporal methods and cross-correlation function to evaluate S-wave travel-time in bender-extender tests. At the same time, Lee and Santamarina [8] proposed travel-time corresponding to peak of cross-correlation function as a correct S-wave travel-time. It was observed that by multiple reflection signals, all additional destructive transfer functions could be cancelled to some extent, and the signal might be better interpreted. Murillo et al. [9] also utilizedtemporal methods and cross-correlation function in their studies on intermediate soils (a mixture of sand and clay).

In this paper, it is tried to review mathematical basis and physical meaning of the different methods to evaluate shear wave travel-time in granular soils in very small strain.In addition to previous studies,herein similarities and differences of these methods are explained and their exactitudeis challenged. Experimental examples are given wherever it is needed.To calculate accurately mathematical relationships, wherever it was needed, the commercial software Matlab has been used [10].

2. MATERIALS AND METHODS

In this paper, some results of authors' experimental tests using bender-extender elements on sample of soda lime glass beads with diameter of 1 mm in different conditions are presented. Their specific gravity, elastic modulus and Poisson's ratioare 24.92 kN/m3, 60 GPa and 0.3, respectively. The beads were placed manually, without well-ordered structure, and compacted by shocks under no saturation condition. Samples were 100 mm