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Development of Dynamic Simple Shear Apparatus for Small Strain Dynamic Tests on Unsaturated Granular Soils by Bender Element and Ultrasonic Sensors

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ABSTRACT:

Shear modulus and confined modulus are important parameters for static and dynamic analysis in geotechnical applications. Cyclic simple shear apparatus had been developed by mounting bender element and ultrasonic sensors to measure continuous shear wave and pressure wave velocities for determination of Gmax and M. For this purpose two new pedestals have been fabricated on which HAE ceramic disc and sensors were mounted. A pressure control panel and a hanging column system have been designed to apply high and low matric suction values with high accuracy. Finally, some tests was conducted to verify the result of device performance and to compare with the theoretical results of unsaturated soils.

Key words: Dynamic Simple Shear Apparatus, Bender Element, Ultrasonic, Unsaturated soils, Maximum shear modulus.

1- Introduction

Classic soil mechanics focused on the study of saturated and dry soils but Most of soils involved in many engineering applications such as embankments, earth dams, and mechanically stabilized earth (MSE) walls are unsaturated soil. Soil stiffness, especially shear modulus, is one of the most important parameters in geotechnical engineering especially in dynamic response. Maximum Shear modulus and confined modulus at very small strain (0.001%) are calculated based on elastic theory for propagation of waves at homogenous material. Measurement of soil stiffness using piezoelectric transducers has been implemented in many laboratory equipment such as: Oedometers, Torsional resonant column apparatus and Triaxial cells [1]–[6] but, never implemented in cyclic simple shear before. Kjellman (1951) is pioneering researcher described cyclic simple shear for geotechnical testing which can be attributed to Swedish Geotechnical Institute (SGI). This apparatus was used to determine shear strength [7]. Bjerrum & Landva (1966) developed the Norwegian Geotechnical Institute (NGI), to restrict the specimen form radial strain [8]. Silver & Seed (1971) modified the NGI-type simple shear apparatus by adding a lever arm in the apparatus to carry out small shear strain amplitude. Ishihara & Yamazaki (1980) developed cyclic simple shear, incorporating two pneumatic cyclic loaders in two mutually perpendicular horizontal direction [9]. Boulanger & Seed (1995) developed bi-direction cyclic simple shear for investigating liquefaction on saturated soil under dynamic and monotonic loadings [10]. In this investigation two bender element and ultrasonic sensors was added to cyclic simple shear