Soil Fabric and Anisotropy as Observed Using Bender Elements during Consolidation

Yi Zhao, Ph.D., P.E., M.ASCE1 ; Nabeel Mahmood, Ph.D.2 ; and Richard A. Coffman, Ph.D., P.E., P.L.S., A.M.ASCE3

Abstract:

This study examined the effects of soil minerals on soil anisotropy and determined the amount of changes in anisotropy during the consolidation process of soils. Soil fabric and anisotropy of kaolinite-rich and illite-rich soils were investigated through shear wave measurements using a newly fabricated consolidation device. Shear wave measurements were performed by placing the bender elements in the horizontal and vertical directions through soil specimens. Two sets of bender elements enabled collection of two types of shear wave measurements: (1) horizontally propagated, vertically polarized shear waves; and (2) horizontally propagated, horizontally polarized shear waves. For both the kaolinite-rich and illite-rich soil types, the measured horizontally propagated, horizontally polarized shear wave velocity (Vs;HH) was higher than the measured horizontally propagated, vertically polarized shear wave velocity (Vs;HV) at corresponding applied stress levels. During the back-pressure saturated, constant rate-of-strain consolidation with bender elements tests on the kaolinite-rich soil type, the fabric anisotropy (in terms of shear wave velocity) began when the vertical effective stress was larger than 400 kPa; for the illite-rich soil type, the fabric anisotropy began at effective stress larger than 600 kPa. The strain-induced anisotropy dominated the soil behavior for both soil types; the rearrangement of soil particles within the soil structure resulted in plastic deformation. These phenomena were much more pronounced for soil samples that were initially mixed at higher values of initial water content from slurry sample prior to preconsolidation. The clay sample prepared with higher initial water content had more particles in the preferred orientation