ELASTIC AND PLASTIC ANISOTROPY IN KAOINITE CLAY

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Recent experiments [1] on clays have shown unusual cross-anisotropic behavior patterns. As isotropic stress levels are increased, the plastic strain increment vector rotates counterclockwise from an initial position pointing below the hydrostatic axis to a position parallel to the hydrostatic axis and then finally well above the hydrostatic axis. These results indicate 'reverse' cross-anisotropic behavior at higher stresses where the horizontal strains become smaller than the vertical strains. This peculiar behavior was attributed to soil fabric which may have horizontal clay particle alignment. Sands typically do not exhibit this behavior pattern. Tests on sands under isotropic compression indicate that the plastic strain increment vector rotates counterclockwise, but finally become fixed in a parallel direction with the hydrostatic axis indicating pure isotropic behavior at high stresses. Sand behavior is attributed to particle crushing at high pressures which destroys the initial soil fabric. Other recent experiments on clays [2] used bender elements to measure shear wave velocities have shown similar trends as in the first study cited, however, with greater horizontally measured shear moduli than in the vertical direction. Similar reasons were cited to explain this unusual behavior. Also, it was noted that higher clay content appeared to correlate with this pattern of behavior. Experiments on clays with lower clay content showed conventional cross-anisotropic behavior.

This paper presents an experimental study on laboratory-consolidated specimens composed of kaolinite clay. Tests were performed to examine elastic and plastic anisotropy evolution during isotropic compression. The specimens were initially consolidated from a slurry-state to a vertical a preconsolidation stress of approximately 100 kPa under one-dimensional compression conditions. The specimens were then trimmed and mounted in a triaxial cell where both the vertical and volumetric strains were measured during isotropic consolidation using the application of incremental stress increases up to approximately 3,000 kPa. Approximately ten stress increments were used. GDS bender elements were used to measure horizontal and vertical shear wave velocities in the saturated clay. Three different sets of isotropic consolidation tests were performed. Each of the series varied the clay content with the addition of Sil-Co-Sil, which is a non-plastic ground quartz whose particle size is in the silt range.

This study examined and compared both the measured evolution of elastic and plastic anisotropic behavior in clay specimens during isotropic compression under a wide confining stress range. Different clay contents were used to investigate whether the patterns of anisotropic behavior significantly changed with this factor.

References

[1] Y. Liu "The stress-strain behavior of kaolinite clay in triaxial compression and extension tests at elevated pressures," Ph.D. Dissertation, University of Delaware, Newark, DE 19716, 2004.

[2] S. Yamashita, T. Hori and T. Suzuki, “Anisotropic stress-strain behavior at small strains of clay by triaxial and bender element tests,” Proceedings of the Second Japan-US Workshop on Testing, Modeling and Simulation, 2005.