

Influence of cross-anisotropy on the interpretation of plate load tests

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Plate load tests (PLT) have been widely used for soil investigation purposes in various geotechnical engineering applications, including for foundation, pavement and earthwork design, primarily as a means to obtain some form of stiffness parameter from the analysis of the load-settlement curves. In pavement design, the Mechanistic Empirical Design Guide (MEPDG) currently used throughout the United States requires the input of values of the elastic (resilient) modulus for all materials constituting the unbound base and subgrade layers. This property can be obtained from laboratory and in-situ tests, with plate load tests more closely representing actual field loading conditions. While the testing equipment and procedures for conducting plate load tests have undergone significant development, approaches currently used in practice for the interpretation of PLT data continue to be based on simplified assumptions. In particular, they rely on linear-elastic isotropic soil response, that does not represent true in-situ conditions for compacted aggregates.

This study sought to investigate the impact of material modulus anisotropy, plate stiffness, Poisson ratio and stratification on the interpretation of PLT data by performing a parametric analysis using the commercial software ABAQUS. Ground and geometry conditions modeled were based on those existing at Purdue University's SBRITE site where automated plate load tests were carried out as part of this project. The analyses showed that stratification and the cross-anisotropic properties of the subbase layer have a significant impact on predicted values of stresses and deformations generated under both flexible and rigid plates. In particular, increasing settlements are predicted with increasing modulus anisotropy ratio ($n=E_h/E_v$). Moreover, anisotropy plays a role even when the thickness of the aggregate subbase layer is relatively small. Further analyses were performed to assess the accuracy of the methods currently used in practice for predicting elastic modulus from plate load test data. It was found that for the conditions existing at the testing site, the conventional approach for interpreting PLT data underestimated the modulus of the subgrade. Additionally, the shape factor which is conventionally assumed to be a constant value was shown to vary significantly with stress level, reflecting the impact of other factors beyond the already known effect of plate stiffness. Finally, FEM analyses of the field data yielded values of the subbase modulus lower than those predicted using current practice that relies on off-center deflection measurements and the Odemark method.

An alternate approach to continuum mechanics, for quantifying load-induced stresses in granular media such as aggregate layers, is offered by the particulate mechanics stress diffusion theory. It has been proposed that the sole parameter controlling the diffusion of interparticle forces, the diffusivity coefficient, reflects the medium anisotropy, among other properties. The relationship between stress diffusivity in particulate mechanics and anisotropy ratio in elasticity theory was investigated by comparing stress fields obtained from each theory for the same problem of a surface loading on a plane-strain model of granular material. An empirical relationship between the two parameters was obtained which confirms the role of anisotropy in the stress diffusion theory. The non-linear shape of the relationship is reminiscent of a similar influence of overconsolidation on the coefficient of earth pressure at-rest.

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