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Hydraulic Conductivity Anisotropy of Heterogeneous Unsaturated Soils

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The effects of saturation degree (or capillary pressure) on hydraulic conductivity anisotropy in unsaturated soils have not been fully understood. This study developed an approach based on a conceptualization of combining the neural network based pedo-transfer function (PTF) results with the thin layer concept to explore the capillary pressure-dependent anisotropy in relation to soil texture and soil bulk density. The main objective is to examine how anisotropy characteristics are related to the relationships between hydraulic parameters and the basic soil attributes such as texture and bulk density. The hydraulic parameters are correlated with the texture and bulk density based on the pedo-transfer function (PTF) results. It is demonstrated that non-monotonic behavior of the unsaturated soil anisotropy in relation to the capillary pressure is only observed when the saturated hydraulic conductivity and the shape parameter are both related to the mean particle diameter. When only one hydraulic parameter is related to the grain diameter or when both are not related to the same attribute simultaneously, the unsaturated soil anisotropy increases monotonically with the increasing capillary pressure head. Therefore, it is suggested that this behavior is mainly due to the coupled dependence of the layer saturated hydraulic conductivities and the shape factors on the texture and bulk density. The correlation between the soil grain diameter and bulk density decreases the anisotropy effects of the unsaturated layered soils. The study illustrates that the inter-relationships of soil texture, bulk density, and hydraulic properties may cause vastly different characteristics of anisotropic unsaturated soils.