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Deriving the suction stress of unsaturated soils from water retention curve, based on wetted surface area in pores

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The evaluation of suction stress in unsaturated soils has important implications in several practical applications. Suction stress affects soil aggregate stability and soil erosion. Furthermore, the equilibrium of shallow unsaturated soil deposits along steep slopes is often possible only thanks to the contribution of suction to soil effective stress. Experimental evidence, as well as theoretical arguments, shows that suction stress is a nonlinear function of matric suction. The relationship expressing the dependence of suction stress on soil matric suction is usually indicated as Soil Stress Characteristic Curve (SSCC).
In this study, a novel equation for the evaluation of the suction stress of an unsaturated soil is proposed, assuming that the exchange of stress between soil water and solid particles occurs only through the part of the surface of the solid particles which is in direct contact with water. The proposed equation, based only upon geometric considerations related to soil pore-size distribution, allows to easily derive the SSCC from the water retention curve (SWRC), with the assignment of two additional parameters. The first parameter, representing the projection of the external surface area of the soil over a generic plane surface, can be reasonably estimated from the residual water content of the soil. The second parameter, indicated as H0, is the water potential, below which adsorption significantly contributes to water retention. For the experimental verification of the proposed approach such a parameter is considered as a fitting parameter. The proposed equation is applied to the interpretation of suction stress experimental data, taken from the literature, spanning over a wide range of soil textures. The obtained results show that in all cases the proposed relationships closely reproduces the experimental data, performing better than other currently used expressions. The obtained results also show that the adopted values of the parameter H0, allowing for a good fitting of the experimental data, are in agreement with the values of water potential marking the limit between capillary and adsorptive soil water retention, which can be estimated from the shape of the water retention curve. Therefore, with the proposed approach, at least in principle it is possible to derive the SSSC directly from the knowledge of the SWRC.