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Some observed and possible effects of an intra-aggregate soil structure

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An intra-aggregate soil matrix is usually considered to be a homogeneous porous medium with shrinkage-swelling at drying-wetting. That is, the mixture of clay particles, silt and sand grains, as well as pores with some size distribution, is considered to be homogeneous in the volume and scale of aggregates. We assume the following structural features of an intra-aggregate matrix: (1) a superficial aggregate layer which is deformable, but, unlike the intra-aggregate matrix, does not shrink at drying; and (2) so-called lacunar pores that appear at sufficiently low clay content. These are micro-cracks or specific pores in a clay matrix inside aggregates. Typically, the lacunar pores are associated with silt and sand grains and rather larger than usual inter-particle pores of the clay matrix. Note that the assumptions about the existence of the above intra-aggregate structural features a priori have a clear theoretical or experimental substantiation. We consider the observed and possible quantitative and qualitative effects of these intra-aggregate structural features as applied to soil shrinkage and cracking as well as to soil water retention. The key point of the analysis is the detail accounting for contributions of the surface aggregate layer and intra-aggregate matrix to the soil volume and water content during shrinkage. Still another important point is the introduction of the concept of a reference shrinkage curve. This curve, by definition, only relates to the soil matrix volume and does not include the volume of cracks that develop at shrinkage. For this reason the reference shrinkage curve is a single-valued soil characteristic. The expression for the reference shrinkage curve is derived from the above model of the intra-aggregate structure and determined, in general (at any clay content), by eight physical parameters that can be measured or estimated inde-

pendently of an experimental soil shrinkage curve (i.e., without fitting). The model tracks down and explains, step by step, the transition from the shrinkage curve of a pure clay to the reference shrinkage curve of the soil that is contributed by the clay. Based on the above structural assumptions and in agreement with many observations, the model predicts two major outward features of experimental soil shrinkage curves (unlike pure clay shrinkage curves): (1) convexity upward in the structural shrinkage area; and (2) the value of the slope in the basic shrinkage area that is a constant between unity and zero depending on the soil clay content. Using the reference shrinkage curve in combination with the approach from Chertkov and Ravina (1998, 1999) permits an essential improvement of the prediction accuracy of the shrinkage crack network characteristics. Similarly, using the reference shrinkage curve in combination with the approach from Chertkov (2004) allows one to track down the transition to the soil water retention curve from the water retention curve of the contributing clay and to predict a possible relation between them. The consideration of the effects of the intra-aggregate structure is illustrated by the results of the quantitative analysis of available experimental data on soil shrinkage and cracking for a number of soils.

References

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