ABSTRACT

Knowledge of water movement through unsaturated bentonite clays is important in numerous geotechnical engineering applications such as landfills, mine tailings, buffer and backfill material in high–level nuclear waste (HLNW) repositories. Theoretical infiltration analysis in these studies requires an estimation of hydraulic functions of the compacted bentonites viz. soil water characteristic curve (SWCC) and hydraulic conductivity function (HCF). Available studies on the estimation of hydraulic functions of compacted bentonites are scarce due to difficulties associated in controlling/measuring the suction over a wide range of saturation. Lack of independently estimated hydraulic functions of the compacted bentonites, further, limits the validation of existing infiltration models. Therefore, the main objective of this research work is to study the influence of soil plasticity and compaction density on the SWCC, HCFs, and infiltration characteristics of compacted Indian bentonites under the volume-restrained conditions.

Four commercially available bentonites of different quality (i.e., plasticity) were used in the present study. Drying SWCC behavior of initially slurried bentonites under zero applied stress and wetting SWCC behavior of compacted bentonites in volume-restrained conditions were experimentally investigated by independent methods viz. osmotic technique, vapor equilibrium technique, and chilled-mirror dew-point potentiometer (i.e., WP4). The measured drying SWCC data, in terms of gravimetric water content versus matric suction ($SWCC_w$), were combined with the volumetric shrinkage data to establish SWCC in terms of volumetric water content versus matric suction ($SWCC_\theta$) and degree of saturation versus matric suction (SWCCSR). The influence of measurement errors in the volumetric shrinkage data by different procedures was investigated based on the estimated $SWCC_{SR}$ data. A theoretical procedure

based on the hysteretic model was proposed for the estimation of wetting SWCC of compacted bentonites from the drying SWCC data and validated with the independently obtained data over a wide suction range. In addition to that, the application of rectangular hyperbola method was verified for linearizing the kinetic hydration data in vapor equilibrium technique for estimating SWCC data in the high suction range. The HCFs predicted from the SWCC data using statistical model were used in the Richards' infiltration model for theoretically studying the transient water infiltration profiles. The infiltration model was validated with the experimental observations of spatial and temporal moisture content distribution in compacted bentonites. Several controlled experiments were carried out by considering the influence of water density, hydraulic head, and specimen size in the infiltration tests for investigating the measured deviation of water movement from the theory.

Keywords: Unsaturated bentonite clays, Soil water characteristics curve, Hydraulic conductivity function, Compaction density, Plasticity, Volumetric Shrinkage, Infiltration studies.