Paper Number: 672

Prediction of consistency limits and undrained shear strength by a single and simple tool

Kayabali, K.[1]

[1]Geological Engineering Department, Ankara University, Ankara 06100, Turkey
kayabali@ankara.edu.tr

Consistency limits not only constitute a fundamental part of geotechnical investigations, but also play an important role in indirectly determining the parameters of certain soil mechanics. The most common consistency limits used for such applications are the liquid limit (LL) and the plastic limit (PL). The shrinkage limit (SL), to a lesser extent, constitutes the third important consistency limit. Each of these consistency limits has been subjected to decades of research. Different tools and techniques were established for each consistency limit. Because they are considered similar to each other, numerous attempts have been made to devise a single tool to determine the LL and the PL together. One other important point to note is that the consistency limits are closely related to the undrained shear strength. The scope of this investigation is to examine the potential of a single and simple tool to predict all three consistency limits. The study was also extended to cover the undrained shear strength to illustrate whether it can be predicted using the same apparatus.

Remolded soils were employed for the investigation. Fifty soils of varying plasticity level were used. The LLs of these soil samples ranged from 28 to 110. The soil specimens were wetted with tap water and the mixtures were kept inside a desiccator long enough for water equalization. The LL tests were conducted using the fall-cone test. At least five different water contents were tested to obtain the appropriate plot. The PL tests were also repeated at least five times using the roll-plate method. The average was taken as the PL value. Likewise, the SL tests were repeated at least five times using the wax method.

The alternative method presented is the reverse extrusion, which recently came into use in soil mechanics. This method requires a container 38 mm in diameter and a rammer with a die orifice of 6 mm. The rammer has a slightly smaller diameter than the container for smooth movement inside the container. The wet mixture that was prepared for the LL test was also subjected to the reverse extrusion test. The wet soil specimen was compressed by the rammer inside the container, and the extrusion force, which is recorded at the time of the extrusion of the soil from the die orifice like a worm, was recorded as the failure force. At least five reverse extrusion tests were performed and five pairs of water content – extrusion force data were collected for each soil sample. The results were plotted for each soil sample on a semi-logarithmic diagram and an equation in the form of y = a exp(b) was obtained by curve fitting.

Multiple regression analyses were conducted between measured LL values and the coefficients of a and b determined for each soil. The same procedure was applied to the measured PL and SL data. Three equations were established to predict the LL, PL, and SL using the a and b coefficients. The regression coefficients of the empirical relationships established through the multi-regression analyses for LL, PL, and SL are 0.97, 0.90, and 0.80, respectively.

The vane shear test (VST) was also used as an accessory tool. The wet mixtures prepared for the LL test for each soil was also subjected to the VST, and the corresponding undrained shear strengths were determined. A multiple regression analysis was also performed using the water content, liquidity index, and the extrusion force to predict the undrained shear strength empirically. A regression coefficient of 0.95 resulted.

The present investigation showed that three consistency limits and the undrained shear strength could all be determined by a single tool. The testing tool is extremely simple and robust. Substituting the four different methods with the reverse extrusion technique also saves a great deal of time.