IJG> Vol.2 No.4, November 2011

OPEN ACCESS

A Statistical Model for the Relative Hydraulic Conductivity of Water Phase in Unsaturated Soils

PDF (Size:531KB) PP. 484-492 DOI: 10.4236/ijg.2011.24051

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ABSTRACT

Permeability coefficients of fluids occupying the pore space of a porous medium have significant influence on the flow of these fluids through the porous medium. In the case of unsaturated soils, in addition to other parameters such as void ratio, void distribution, particle size distribution and initial density the degree of saturation also affects the permeability coefficient of water. The degree of saturation, in unsaturated soil, is directly related to the matric suction of the soil through soil water characteristic curve. Matric suction is one of the two stress state variables widely used to characterize the deformation behavior of unsaturated soils. Therefore, it can be stated that both flow and deformation behaviors of unsaturated soil are affected by the permeability coefficient of water. Numerical modeling of coupled deformation-flow behavior of unsaturated soil requires a mathematical equation that relates the permeability coefficient to the degree of saturation. Since the parameters that affect the permeability coefficient of water in unsaturated soil have similar direct or indirect effects on the soil water characteristic curve, permeability can be effectively predicted using the soil water characteristic curve as done in statistical models. In this paper, a statistical model is proposed for the permeability of water in unsaturated soil using soil water characteristic curve of the soil. The calibrated parameters of the soil water characteristic curve are directly used in the prediction of permeability with- out additional calibration using measured permeability data. The predictive capability of the new equation is verified by matching the measured data of eight different soils found in the literature.

KEYWORDS

Unsaturated Soils, Permeability Function, Relative Permeability of Unsaturated Soils, Relative Permeability Using Soil-water Characteristic Curve

Cite this paper

N. Ravichandran and S. Krishnapillai, "A Statistical Model for the Relative Hydraulic Conductivity of Water Phase in Unsaturated Soils," *International Journal of Geosciences*, Vol. 2 No. 4, 2011, pp. 484-492. doi: 10.4236/ijg.2011.24051.

References

[1] A. Hazen, "Water Supply," American Civil Engineers Handbook, Wiley, New York, 1930.

[2] R.P. Chapuis, "Predicting the Saturated Hydraulic Conductivity of Sand and gravel Using Effective Diameter and Void Ratio," Canadian Geotechnical Journal, Vol. 41, No. 5, 2004, pp. 787-795. doi:10.1139/t04-022

[3] C. P. K. Gallage and T. Uchimura, "Effects of Dry Density and Grain Size Distribution on Soil-Water Characteristic Curves of Sandy Soils," Soils and Foundations, Vol. 50, No. 1, 2010, pp. 161-172. doi:10.3208/sandf.50.161

[4] A. Lloret and E. E. Alonso, "Consolidation of Unsaturated Soils Including Swelling and Collapse Behavior," Géotechnique, Vol. 30, No. 4, 1980, pp. 449-477. doi:10.1680/geot.1980.30.4.449

[5] D. G. Fredlund, A. Xing, S. Huang, "Predicting the Permeability Function for Unsaturated Soils Using the Soil-Water Characteristic Curve," Canadian Geotechnical Journal, Vol. 31, No. 4, 1994, pp. 533-546. doi:10.1139/t94-062

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[6] D. G. Fredlund and A. Xing, "Equations for the Soil- Water Characteristic Curve," Canadian Geotechnical Journal, Vol. 31, No. 3, 1994, pp. 521-532. doi:10.1139/t94-061

[7] G. P. Wind, "Field Experiment Concerning Capillary Rise of Moisture in Heavy Clay Soil," Netherlands Journal of Agricultural Science, Vol. 3, 1955, pp. 60-69.

[8] W. R. Gardner, "Some Steady State Solutions of the Unsaturated Moisture Flow Equation with Application to Evaporation from a Water Table," Soil Science, Vol. 85, 1958, pp. 228-232. doi:10.1097/00010694-195804000-00006

[9] R. H. Brooks and A. T. Corey, "Hydraulic Properties of Porous Media," Hydrology Paper, Colorado State University, Fort Collins, 1964.

[10] P. E. Rijtema, "An Analysis of Actual Evapotranspiration," Agricultural Research Reports, Wageningen, 1965, p. 659.

[11] J. M. Davidson, L. R. Stone, D. R. Nielsen and M. E. Larue, "Field Measurement and Use of Soil-Water Properties," Water Resources Research, Vol. 5, 1969, pp. 1312-1321. doi:10.1029/WR005i006p01312

[12] J. D. Campbell, "Pore pressures and volume changes in unsaturated soils," Ph.D. Thesis, University of Illinois at Urbana-Champaign, Urbana, 1973.

[13] Y. Mualem, "Hysteretical Models for Prediction of the Hydraulic Conductivity of Unsaturated Porous Media Media," Water Resources Research, Vol. 12, No. 6, 1976, pp. 1248-1254. doi:10.1029/WR012i006p01248

[14] Y. Mualem, "A New Model for Predicting the Hydraulic Conductivity of Unsaturated Porous Media," Water Resources Research, Vol. 12, No. 3, 1976, pp. 513-522. doi:10.1029/WR012i003p00513

[15] M. Th. van Genuchten, "A Closed Form Equation for Predicting the Hydraulic Conductivity of Unsaturated Soils," Soil Science Society of America Journal, Vol. 44, No. 5, 1980, pp. 892-898. doi:10.2136/sssaj1980.03615995004400050002x

[16] E. C. Leong and H. Rahardjo, "Permeability functions for unsaturated soils," Journal of Geotechnical and Geoenvironmental Engineering, Vol. 123, No. 12, 1997, pp. 1118- 1126. doi:10.1061/(ASCE) 1090-0241(1997)123:12(1118)

[17] D. G. Fredlund and A. Xing, "Equations for the Soil- Water Characteristic Curve," Canadian Geotechnical Journal, Vol. 31, No. 4, 1994, pp. 533-546. doi:10.1139/t94-062

[18] D. G. Fredlund, M. D. Fredlund and N. Zakerzadeh, "Predicting the Permeability Function for Unsaturated Soils," International Conference on Clays and Clay Minerology, Shioukoza, 11-13 January 2001, pp. 215-222.

[19] J. P. Lobbezoo and S. K. Vanapalli, "A Simple Technique for Estimating the Coefficient of Permeability of Unsaturated Soils," Proceedings of the 55th Canadian Geotechnical Conference, Niagra Falls, 2002.

[20] H. K. Shada and N. Ravichandran, "New Soil-Water Characteristic Curve and Its Performance in Finite Element Simulation of Unsaturated Soils," International Journal of Geomechanics, accepted with minor revision, October 2010.

[21] L. A. Richards, "Water Conducting and Retaining Properties of Soils in Relation to Irrigation," Proceedings of International Symposium on Desert Research, Jerusalem. 1952, pp. 523-546.