From Dr. D. J. Hagerty, P.E., University of Louisville [teaching a graduate course on design of earth structures for 35 years; consultant to U.S. Army Corps of Engineers on Stability of Stream Banks for 32 years; consultant and researcher for U.S. Environmental Protection Agency on disposal of stack gas cleaning wastes]

The most accurate way to analyze slope stability in a mass of soil is to use effective stress parameters for shear strength and to measure pore water pressures for use in an effective stress analysis. If soil such as fine-grained silts and clays are loaded rapidly, and volume change cannot occur, and if pore water pressures cannot be measured for some reason, "the analysis may be performed using an *undrained* Mohr-Coulomb failure envelope with $\emptyset_u = 0$." (Slope Stability and Stabilization Methods, 2nd Ed., Abramson, L. W., Lee, T.S., Sharma, S. and Boyce, G.M., Wiley, New York, 2002). However, if steady-state seepage occurs, it is absolutely necessary to obtain pore water pressures in the field and to use an effective stress analysis in evaluating slope stability.

The necessity for effective stress analysis has been demonstrated repeatedly since 1960 when the case of stability under the edges of a fill was described and evaluated by Bishop and Bjerrum at the conference on shear strength of cohesive soils in Boulder, Colorado. (Bishop, A. W., and Bjerrum, L., "The relevance of the triaxial test to the solution of stability problems." *Proceedings of the Research Conference on Shear Strength of Cohesive Soils,* ASCE, p. 437-501.) While the use of the undrained analysis may be appropriate under certain limited conditions during construction of a fill or embankment, use of effective stress analysis is required after construction when seepage has reached a steady state condition.

John Lowe pointed out the errors commonly made in trying to use consolidated undrained test results in stability analysis, and his explication of the errors illustrated the point that correct interpretation of consolidated undrained test results requires prior knowledge of the effective stress shear strength parameters. (Lowe, J. 1967, "Stability analysis of embankments." *Journal of Soil Mechanics and Foundations Division,* ASCE, Vol. 93, No. SM4, 1-34).

Long-term stability analyses, which reflect conditions after swelling and consolidation are complete, are analyzed using drained strengths and pore water pressures corresponding to steady state seepage conditions. (Duncan, J. M., and Wright, S.G., *Soil Strength and Slope Stability*, Wiley, New York, 2005, p. 33).

Clearly, pore water pressure measurements were required for an adequate analysis of the failure of the TVA Kingston ash facility.