Soil Characteristics of Selected Earthen Dams in the State of Mississippi

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Abstract

As part of a multi-component research project that concerns the improvement of semi-empirical equations used to estimate breach parameters for embankment dams, a series of field surveys were carried out at sixteen earthen dams throughout the state of Mississippi. Soil samples were collected at each dam for jet testing, bulk density measurements, and soil texture analysis. The jet testing was used to find the critical shear stress and erodibility coefficient of the soil. Bulk density measurements, sieve analysis and pipette testing for soil texture for finer particles were performed at the USDA-ARS National Sedimentation Laboratory. The data will be used in a numerical model study to develop parametric breach equations that take in to account geophysical and geotechnical characteristics of dams. This paper summarizes the results of these field and laboratory tests.

Measurements and Results

Soil samples were collected at sixteen earthen dams in the state of Mississippi. 6-in diameter, 6-in high cylindrical cores were collected from each dam for jet testing (JET), and 2-in diameter, 2-in long cylindrical cores were collected for soil texture and bulk density (BD) measurements. The list of dams and number of collected samples are presented in Table 1.

Table 1. List of dams and the total number of collected samples

State ID	County	# of JET samples	# of BD samples
MS02667	Lauderdale	3	9
MS02756	Lauderdale	3	6
MS06155	Lauderdale	3	6
MS03385	Oktibbeha	3	6
MS00344	Oktibbeha	3	6
MS02473	Forrest	2	4
MS00132	Lamar	2	4
MS02472	Forrest	2	4

State ID	County	# of JET samples	# of BD samples
MS01305	Rankin	2	4
MS03249	Hinds	2	4
MS01743	Hinds	2	4
MS01790	Hinds	2	4
MS01259	Rankin	2	4
MS03104	Lafayette	2	4
MS02734	Panola	2	4
MS03301	Lafayette	2	4

Both JET and BD samples were collected approximately 6 inches below the surface of the dam, near the mid-section. One of each JET and BD samples were collected from the downstream sloping face of each dam. The soil tests were performed at the USDA-ARS, National Sedimentation Laboratory in Oxford, MS. The 2-in diameter samples were used to obtain bulk-density, soil texture through pipette analysis, and particle-size distribution through sieve analysis. The 6-in dimeter samples provided erosion characteristics of each soil sample thorough standard Jet Erosion Test (Hanson and Cook, 2004).

The analysis results showed that the bulk densities of the soils varied between 1.1 g/cm^3 and 1.7 g/cm^3. Figure 1 shows the distribution of the 2-in samples on the soil texture triangle. The type of soils vary significantly across the selected sites but the sand and silt content was moderately high for some sites.

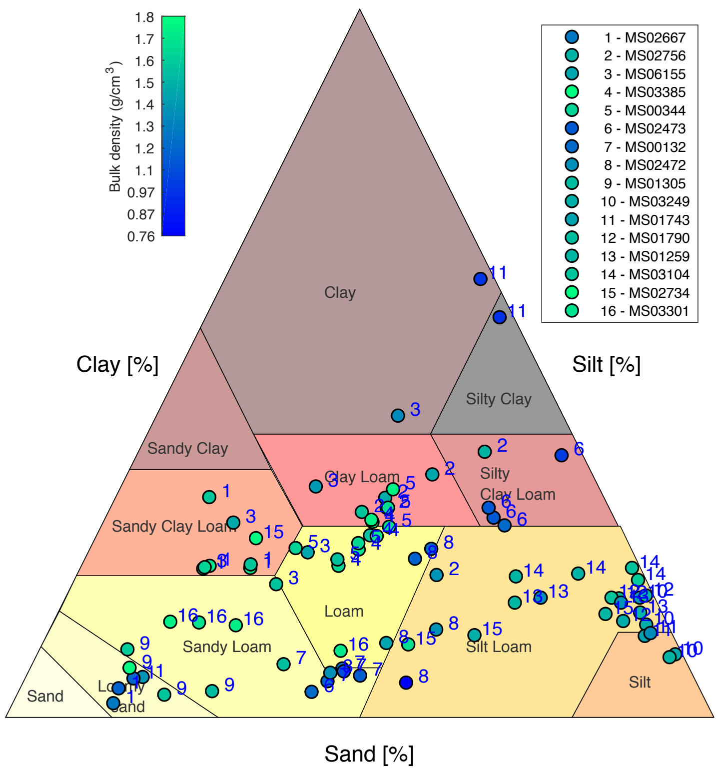

Figure 1. Soil texture and bulk density of soil samples from earthen embankments in Mississippi. The site numbers in the legend correspond with those in Table 1.

Preliminary results show that JET measurements strongly depended on the initial head chosen. If the initial head was too high, the soil specimen eroded too quickly, preventing the collection of sufficient data for predicting erosion parameters. Dense, fibrous root networks in the soils limited soil detachment in the upper layers and reduced erodibility. Consolidated soils with high clay content were eroded slowly and created shallow scour holes using the standard jet test device. The small values of scour depth for the high-clay samples, which were difficult to measure accurately, led to higher measurement errors. Figure 2 shows the erodibility coefficients, and Figure 3 shows the critical shear stresses of the 6-in samples based on three methods used to determine the erodibility coefficient, k_d, and the critical shear stress, τ_c. In Blaisdell method, the equilibrium depth was determined using a nonlinear regression of a logarithmic-hyperbolic function to the scour depth time series, and the erodibility coefficient, k_d was determined by curve-fitting measured values of scour depth versus time, and minimizing the error of the measured time versus the predicted time. In iterative method, first, k_d and τ_c values were determined using the Blaisdell solution. Then, an upper bound was computed for τ_c. Finally, a simultaneous solution that minimized the root-mean-square error between the measured and predicted time was obtained for both k_d and τ_c. Linear method simply used a logarithmic fit to the erosion rate and time data to estimate the k_d and τ_c values.

In spite of the uncertainties involved, the data revealed that there is an inverse relationship between the erodibility coefficient and critical shear stress estimates from the jet erosion tests. Older dams with consolidated clay had relatively lower erodibility and higher critical shear stress. Erodibility and critical shear stress estimates in these plots vary within an order of magnitude, and in general there is an inverse relationship between the critical shear stress and the erodibility coefficient, such that the soils with critical shear stress tend to have lower erodibility coefficients. The results demonstrate the potential for measuring the erodibility of dams through laboratory testing and also provide a database that can be used in efforts to model breaches in existing dams.

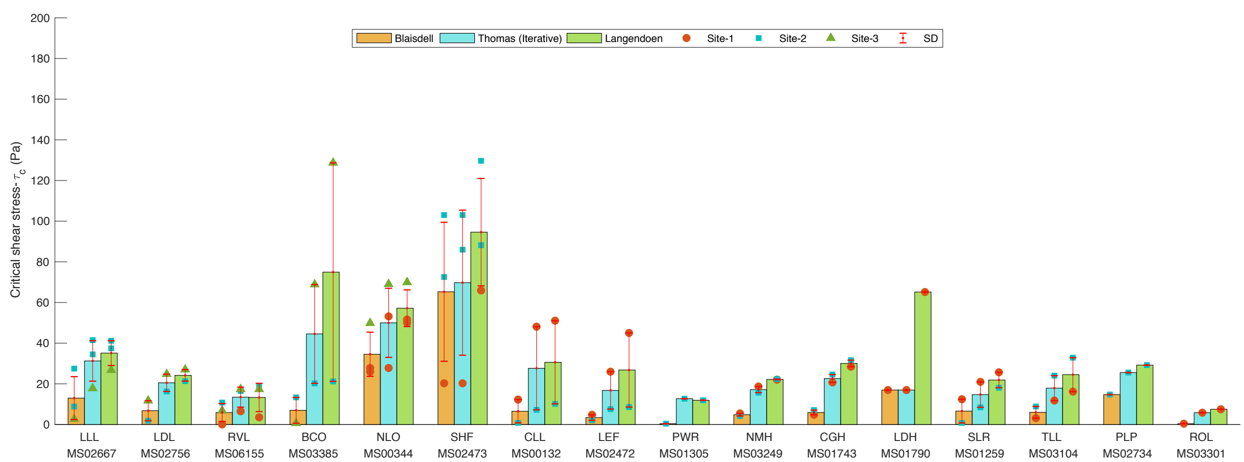

Figure 2. Critical shear stress estimates from JET tests on intact soil samples collected from 16 earthen dams in Mississippi.

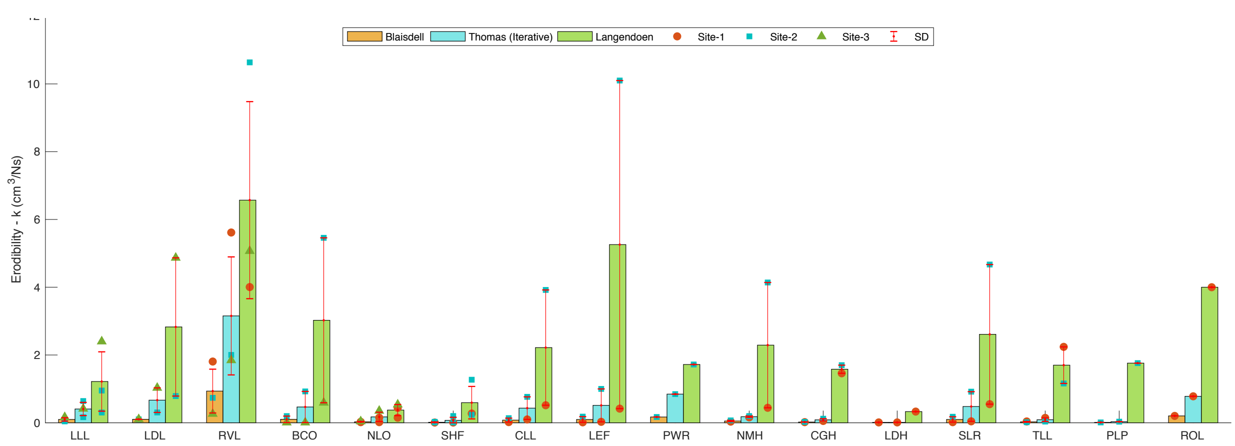

Figure 3. Soil erodibility estimates from JET testing of earthen dams in Mississippi.

References

Hanson, G. J., and Cook, K. R. 2004. “Apparatus, test procedures and analytical methods to measure soil erodibility in situ,” Applied engineering in agriculture, 20(4), 455–462.