THE INFLUENCE OF TEST PARAMETERS ON THE EROSION OF SOILS

Nguyen Van Nghia
Division of Hydropower and Renewable Energy, Thuyloi University,
Email: nghia_nvn@tlu.edu.vn

1. INTRODUCTION

Erosion of soils is one of the main mechanisms causing the failure of earth construction. Modelling erosion phenomena is based on the following equation [Hanson, 1990]:

$$dJ/dt = k_D(\tau_e - \tau_c) \text{ or } \dot{\varepsilon} = k_D(\tau_e - \tau_c); \quad (1)$$

where dJ/dt (or $\dot{\varepsilon}$) represents the mass (or volume) of soil eroded by water by unit of time and surface, k_D the erosion coefficient, τ_e the effective shear stress at the soil-water interface and τ_c a threshold shear stress, J the distance between the nozzle of jet and the surface of soil.

The questions remain unresolved concerning the use of this equation: are k_D and τ_c reliable parameters for characterizing the "erodibility" of the soil independently from the type of test and from the test parameters. In order to gain a better insight into the role of test parameters and their effect on the erosion parameters, a device "Jet Erosion Test" was used to characterize the erosion of soil. The study was performed on two soils: a natural clayey silty and a mixture of clay and sand.

2. EXPERIMENTAL DEVICE

The improved Jet Erosion Test was used (figure 1), which was described in the work of Nguyen (Nguyen, 2014), this device creates a water jet touching on the soil surface and allows us to measure the erosion depth. The Proctor mold with the sample is placed in a reservoir under the jet, the sample is submerged in the downstream reservoir, and the jet is centrally located above the sample. The scour depth is measured at given times and the acquisition data center automatically records the measured data. The chosen times were: 5 s, 10 s, 20 s, 30 s, 50 s, 70 s, 100 s, 130 s, 190 s, 250 s, 370 s, 490 s, 610s , 730 s, 850 s.

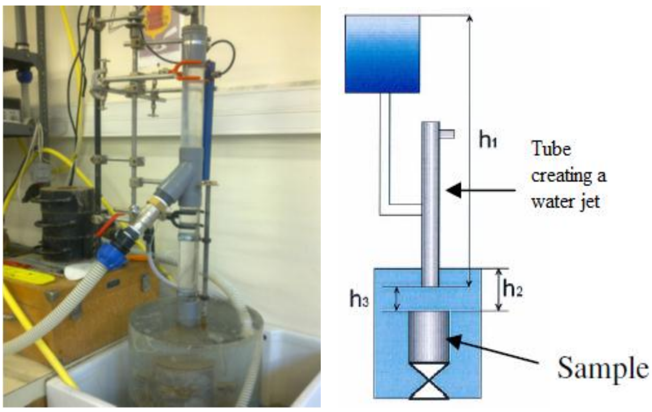

Figure 1: *Photo of the device*

3. MATERIAL

Two materials are a natural clayey silty and a mixture of clay P300 and sand. Clayey silty possessing the optimum water content (w_{OPN}) is 17.2%, and the corresponding maximum dry unit weight γ_{dOPN} is about 16.8kN/m^3. Clay P300 is an industrial clay containing about 95% of pure kaolin also known under the name of yellow clay, some identification parameters are given in table 1 and, the Hostun RF sand is a quartz sand whose characteristics are shown in table 1 as follows:

Table 1: Characterisation of Kaolin P300, and Hostun RF sand.

Index/ Material	D_{max} (µm)	D_{60} (µm)	D_{10} (µm)	< 80 (µm %)	w_L (%)	w_P (%)	γ_s/γ_w	w_{OPN} (%)	γ_{dOPN} (kN/m^3)
Kaolin	20	2	0.05	100	40	20	2.65	24	15,7
Hostun RF Sand	800	350	10	10	-	-		4-16	≈ 16

4. RESULT AND DISCUSSION

For the tests (sections b, c, d), time of test is during 850s, the head hydraulic h_1=130cm; h_2=10cm; h_3=5cm. The erosion parameters (erosion coefficient, k_D, critical shear stress, τ_c and equilibrium erosion depth, P_e) were derived by Nguyen's method (Nguyen, 2014) based on equation (1) using the evolution of erosion depth (like figure 3).

a) Influence of the reproduction of sample

The tests were performed on two materials (5 samples of clayey silty: ρ_d=1.66g/cm^3; w=18% and 6 samples of mixture of clay and sand: ρ_d=1.92g/cm^3; w=11.3%), the samples were at the same condition, the result show an influence negligible of the reproduction on the erosion parameters (figure 2).

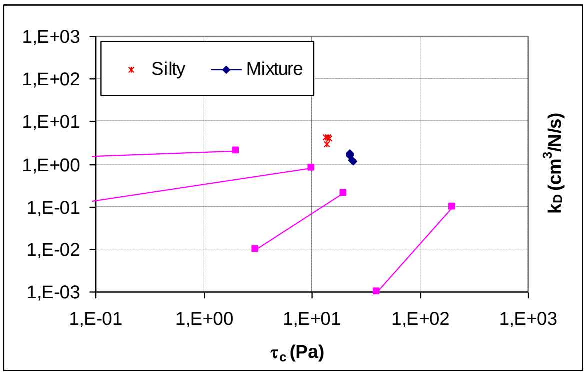

Figure 2: *Influence of the reproduction on clayey silty and mixture of clay and sand*

b) Influence of application duration of jet

Objective of this section is to see if the extrapolation of curves derived is valid or not. To avoid the influence of the change of the initial parameters, we performed the test of jet on the 12.11.25a1 sample (w = 13.5%, ρ_d = 1.75g/cm^3) for 2310 s (Figure 3 below). We used the measured depth data corresponding to the measured times of jet 850 s, 1210 s, 1570 s, 2310 s, respectively, to deduce the erosion parameters. The results obtained are shown in figures 3 and 4, it found that in this case the duration of jet has no influence on erosion parameters.

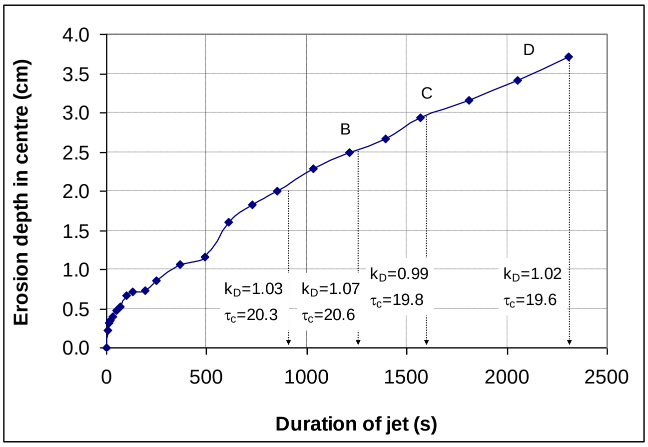

Figure 3: *Relationship erosion depth-duration of jet (clayey silty soil)*

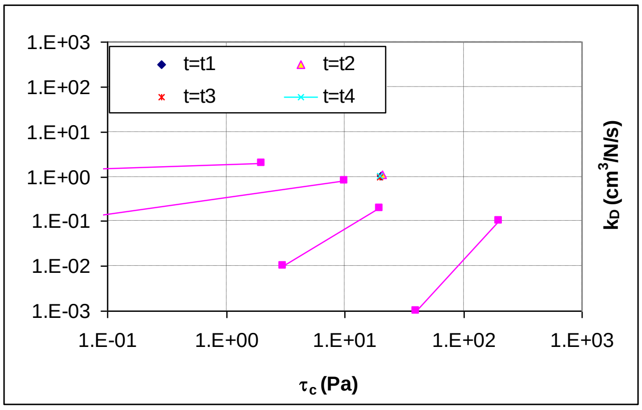

***Figure 4**: Influence of duration of jet*

c) Influence of compaction mode

Objective of this section is to study the influence of compaction mode that will create a different soil structure. In this work, samples of silty are manufactured by two different compaction modes: dynamically by Proctor rammer (12.11.05p1, 12.11.08p3, 12.11.23.p1 and 13.01.04.a1) and statically by hydraulic press (12.11.13.p1, 12.11.15.p2, 12.11.23.p1 and 12.12.04.p1).

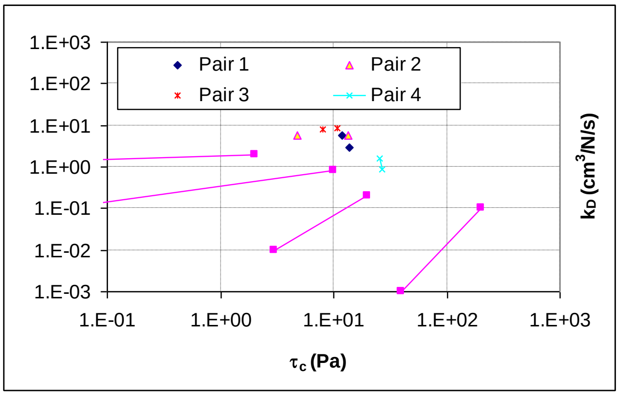

***Figure 5:** Influence of compaction mode*

In figure 5 and table 2 show a minor influence of compaction mode on the erosion parameters, especially on the equilibrium erosion depth (P_e). Compaction mode plays a minor role in the erosion of the soil in the case where the dry density or the water content is close to the optimum, which is in agreement with the conclusion of Hanson and Robinson [Hanson and Cook, 1993].

d) Influence of surface state

Studying the influence of the surface state of the sample submitted under the jet on erosion parameters, two cases are presented in this section:

- The bottom surface, that is to say the one which is in contact with the mold during the compaction; for jet test, the sample is returned and is put under the jet of water:

- The upper surface, that is to say one that is leveled at the end of compaction. In this case, it is the leveled surface which is subjected to the action of the jet.

Four pairs of sample of silty were performed whose the compaction conditions are similar except the surface state. The obtained results show an influence negligible of surface state on erosion parameters (figure 6).

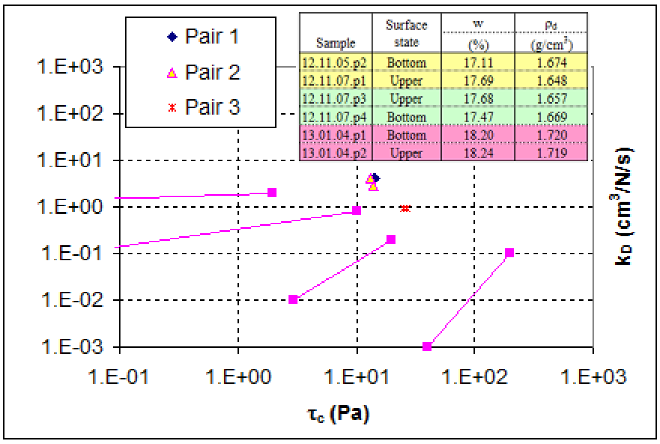

***Figure 6**: Influence of surface state*

Table 2: Influence of compaction mode on erosion parameters of clayey silty

Sample	w	ρ_d	k_D	τ_c	P_e	Sample	w	ρ_d	k_D	τ_c	P_e
	(%)	(g/cm^3)	(cm^3/N/s)	(Pa)	(cm)		(%)	(g/cm^3)	(cm^3/N/s)	(Pa)	(cm)
12.11.05.p1	16.33	1.658	2.88	13.71	6.12	12.11.09.a1	14.21	1.606	8.57	10.79	7.57
12.11.13.p1	16.79	1.652	5.59	11.92	6.98	12.11.23.p1	14.87	1.601	8.25	7.97	9.63
12.11.08.p3	15.70	1.640	5.71	13.46	6.23	13.01.04.a1	18.18	1.718	3.33	21.63	3.86
12.11.15.p2	15.72	1.648	5.91	4.77	13.92	12.12.04.p1	18.62	1.704	4.14	19.87	4.20

5. CONCLUSION

Based on the results obtained, we conclude that: The samples can be reproduced with 2 materials. The duration of jet plays a negligible role on the erosion parameters, the erosion parameters were influenced by compaction mode, but minor role; and an influence negligible of surface state on the erosion parameters. For these factors, the influence of compaction mode is important.

6. REFERENCES

[1] Hanson G.J (1990), "Surface erodibility of earthen channels at high stresses. Part I – Open channel testing", Transaction of ASAE, 33(1), p127-131.

[2] Nguyen V.N (2014), "Caractérisation de l'érosion des sols par le Jet Erosion Test". PhD thesis report, Ecole Centrale Paris, Paris.