NRC Research Press

DISCUSSION

Discussion of "Influence of particle-size distribution homogeneity on shearing of soils subjected to internal erosion"[1]

Yousif A.H. Dallo

Li et al. (2020) presented a very good paper studying the internal erosion process of granular soils. In that paper, a very interesting new method was proposed to obtain a homogenous soil sample after subjecting it to internal erosion. However, this discussion presents a few simple observations regarding the test procedure and preparation of soil samples.

1. Predicted largest eroded particle size

To design the drainage system of the experimental device, Li et al. (2020) (the paper under discussion) based their design on a relationship stated by Wan (2006) to predict the largest eroded particle as 15% (or less) of the maximum particle size. From that relationship, Li et al. (2020) determined the maximum eroded particle for their tested soil as 2 mm. Hence, the size of the holes of the perforated plates was chosen to be 2 mm — a size thought to be large enough to prevent clogging by the fine soil particles and small enough to prevent washing out of large particles (main soil skeleton particles). The perforated plates act as parts of the drainage system and were placed on the top and bottom of the soil sample in the experimental device.

Actually, the relationship presented by Wan (2006) is a very rough estimate and it is not suitable to be adopted as a criterion for designing experimental devices. The method of Aberg (1992), which is based on a solid mathematical model and experimental tests, is more reliable to determine the delimiting particle size, DPS, that separates the coarse grains (those forming the main soil skeleton) from the fine particles (which are loosely distributed in the voids among the coarse particles). The DPS can be computed as (Aberg 1992)

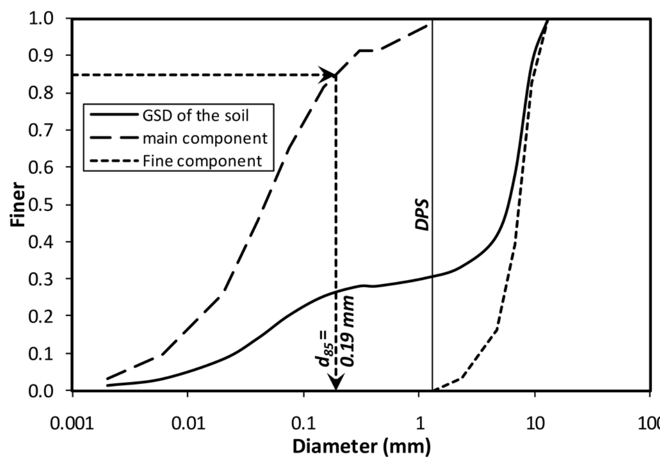
(D1) $$\mathrm{DPS} = \frac{2c}{2c + 1 + 2d}\frac{A_a}{B_a^2}$$

(D2) $$A_a = \int_{y_a}^{f} \frac{y}{x_{(y)}}dy - y_a\int_{y_a}^{1}\frac{dy}{x_{(y)}}$$

(D3) $$B_a = \int_{y_a}^{1}\frac{dy}{x_{(y)}}$$

where c is a constant (= 0.75) for gravel and sand, d is a constant related to the relative density, y is finer percentage, $x_{(y)}$ is the grain diameter corresponding to y, and y_a is the finer percentage corresponding to the DPS.

Fig. D1. DPS and main and fine components grain-size distribution (GSD) of the soil tested in the paper under discussion.



The discusser used the above relationships and determined the value of DPS and grain-size distribution, GSD, of both the main soil skeleton and the fines. The results are shown in Fig. D1, from which the maximum size of the expected erodible particles can be determined as the particle diameter corresponding to 85% of the GSD of fines, d_{85}. The maximum erodible particle size is predicted to be 0.19 mm, which is very close to the 0.15 mm obtained from the laboratory results of Li et al. (2020) (fig. 4 in the paper under discussion) as analyzed by the discusser using the curve-matching method suggested by Kenney and Lau (1985), and the results are presented in Fig. D2.

2. Grain-size distribution of the soil and its compaction

Li et al. (2020) chose a soil with a gravel amount of about 60% and compacted it to a relative density of 50% (<65%) to increase its likelihood of being internally unstable. Actually, these specifications are very general and can be misleading in many cases. To assess the internal stability of granular soils more accurately, the methods of Kenney and Lau (1985, 1986), Wan and Fell (2008), and Dallo et al. (2013), among others, can be used.

3. New method to obtain homogeneous soil sample after erosion

Li et al. (2020) proposed a new method to obtain homogenous GSD after conducting the erosion test. The conventional method

Received 3 March 2020. Accepted 14 March 2020.

Y.A.H. Dallo. Department of Civil Engineering, Tishk International University, Erbil, Iraq.
Email for correspondence: yousif.abduallah@tiu.edu.iq.

[1]Appears in the Canadian Geotechnical Journal, **57**(11): 1684–1694 (2020) [dx.doi.org/10.1139/cgj-2019-0273].

Published at www.nrcresearchpress.com/cgj on 5 November 2020.

Fig. D2. Pre- and post-erosion GSD curve, and the curve-matching of the conventional method.

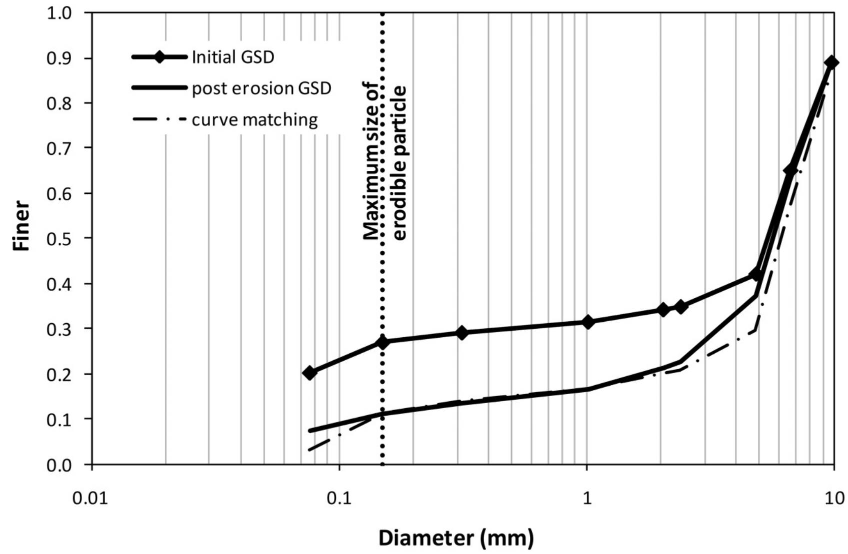
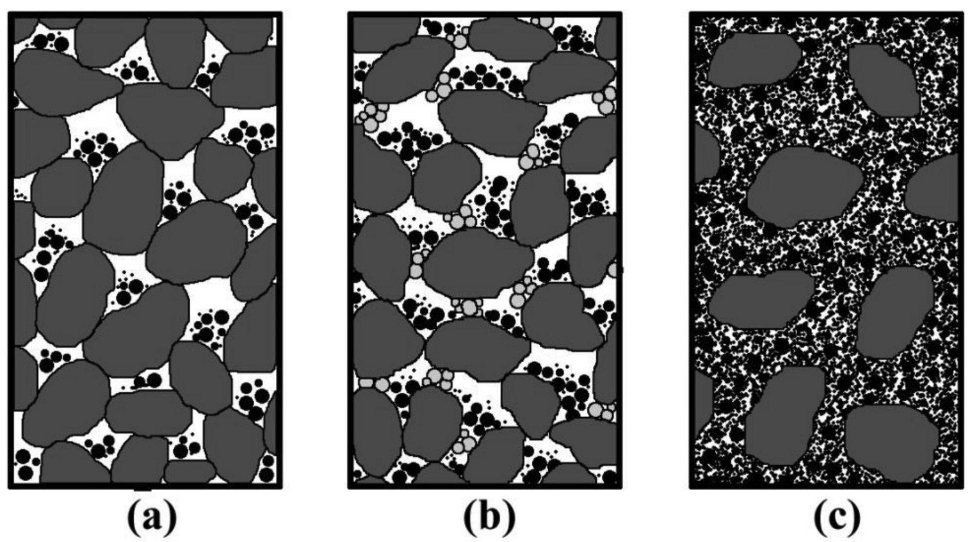


Fig. D3. Effect of fines content on the fines–coarse particles mixtures: (*a*) main soil skeleton (dark grey) and loosely distributed fine particles (black); (*b*) some of the fine particles that contribute to the main soil skeleton (light grey); (*c*) coarse-grained particles that have lost their contact.



involves compacting a soil with a known GSD in the mold and then subjecting it to erosion. Such a process results in formation of heterogeneous post-erosion GSD with depth. In other words, if the soil sample is divided into four quarters (indicated as first, second, third, and fourth from top to bottom), the post-erosion GSD curves are different in each quarter. Based on the results of the conventional method, Li et al. (2020) used a different GSD (by changing the amount of fine materials) for each quarter to obtain the same GSD curve for every quarter after conducting erosion tests, and thus a homogenous soil specimen was obtained.

The discusser believes that the theoretical base of the new method of Li et al. (2020) is very interesting; however, the experimental procedure needs some improvement.

To clarify the discusser's idea, some fundamental facts about the role of fines in the fines–coarse particles mixtures are given with the aid of Fig. D3. (Interested readers can refer to Thevanayagam (1998) and Thevanayagam et al. (2002) for more information.) When the fines content is low, they do not contribute to the main skeleton of the soil and they are loosely distributed within the voids of the coarse particles (see Fig. D3*a*). When more fines are mixed with the coarse particles, these fines will start contributing to the main soil skeleton (Fig. 3*b*; see the light grey particles). This case happens if the fines are more than a certain threshold value, FC_{th}, defined by Thevanayagam et al. (2002) as

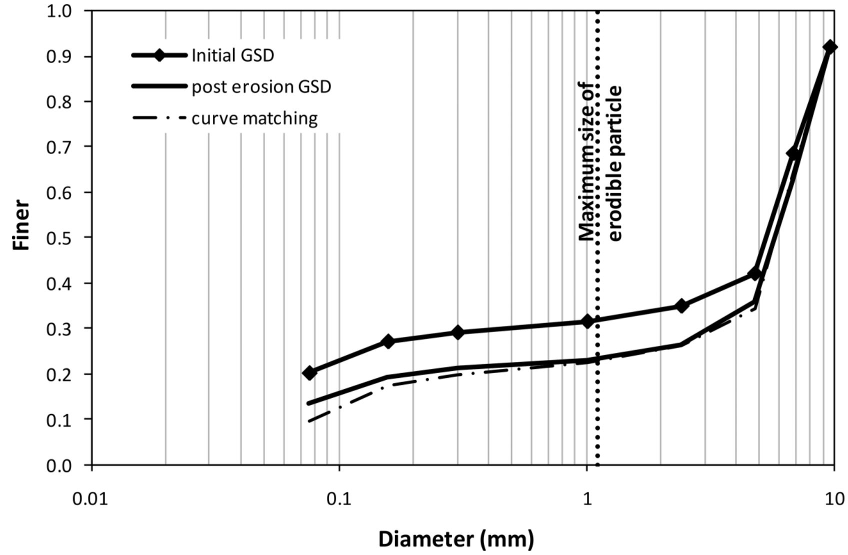
$$\text{(D4)} \qquad FC_{th} \leq \frac{100e_s}{1 + e_s + e_{max,HF}}\% = \frac{100e}{e_{max,HF}}\%$$

where e_s is the skeleton void ratio of mixture, $e_{max,HF}$ is the maximum void ratio of fine grains, and e is the global void ratio.

When more fines are mixed with coarse grains, the coarse soil particles will lose their contact (see Fig. D3*c*).

The threshold value of fines (of the soil tested by the authors) cannot be computed here because the value of $e_{max,HF}$ was not given in the paper under discussion. However, it can be expected that the soils used for preparing the homogeneous post-erosion grain-size curves had fines greater than the threshold value. The

Fig. D4. Pre- and post-erosion GSD curve, and the curve-matching of the Li et al. (2020) new method.



discusser re-analyzed the data of fig. 7 in the paper under discussion using the curve-matching method, and found that the maximum size of erodible particles is 1.1 mm (see Fig. D4). Recall that this value was 0.15 mm for soil tested using the conventional method (see Fig. D2). This means that the structure of the soil tested in the conventional and the new methods is not the same, and this, unfortunately, may mean that some of the conclusions drawn in the paper under discussion need to be rewritten.

4. Final remarks

The discussion presented here does not mean that the new method of Li et al. (2020) has shortcomings, but it does mean that its application may be limited to finer content lower than the threshold fines content, FC_{th}.

References

Aberg, B. 1992. Void ratio of noncohesive soils and similar materials. Journal of Geotechnical Engineering, **118**(9): 1315–1333. doi:10.1061/(ASCE)0733-9410(1992)118:9(1315).

Dallo, Y.A.H., Wang, Y., and Ahmed, O.Y. 2013. Assessment of the internal stability of granular soils against suffusion. European Journal of Environmental and Civil Engineering, **17**(4): 219–230. doi:10.1080/19648189.2013.770613.

Kenney, T.C., and Lau, D. 1985. Internal stability of granular filters. Canadian Geotechnical Journal, **22**(2): 215–225. doi:10.1139/t85-029.

Kenney, T.C., and Lau, D. 1986. Internal stability of granular filters: Reply. Canadian Geotechnical Journal, **23**(3): 420–423. doi:10.1139/t86-068.

Li, S., Russell, A.R., and Muir Wood, D. 2020. Influence of particle-size distribution homogeneity on shearing of soils subjected to internal erosion. Canadian Geotechnical Journal, **57**(11): 1684–1694. doi:10.1139/cgj-2019-0273.

Thevanayagam, S. 1998. Effect of fines and confining stress on undrained shear strength of silty sands. Journal of Geotechnical and Geoenvironmental Engineering, **124**(6): 479–491. doi:10.1061/(ASCE)1090-0241(1998)124:6(479).

Thevanayagam, S., Shenthan, T., Mohan, S., and Liang, J. 2002. Undrained fragility of clean sands, silty sands, and sandy silts. Journal of Geotechnical and Geoenvironmental Engineering, **128**(10): 849–859. doi:10.1061/(ASCE)1090-0241(2002)128:10(849).

Wan, C.F. 2006. Experimental investigations of piping erosion and suffusion of soils in embankment dams and their foundations. Ph.D. thesis, University of New South Wales, Australia.

Wan, C.F., and Fell, R. 2008. Assessing the potential of internal instability and suffusion in embankment dams and their foundations. Journal of Geotechnical and Geoenvironmental Engineering, **134**(3): 401–407. doi:10.1061/(ASCE)1090-0241(2008)134:3(401).