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Reply to the Discussion submitted by Yosif Dallo of our paper entitled, "Threshold Fines Content and the Behavior of Sands with Non-Plastic Silts"

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The authors would like to thank Dr. Dallo for his insights into our technical note "Threshold Fines Content and the Behavior of Sands with Non-Plastic Silts". In reducing the article from its original form as an approximately 10,000-word-equivalent paper to an approximately 4000-word-equivalent technical note, some of the finer details were necessarily removed and the authors are thankful for this opportunity to clarify some of the items discussed in the note.

1. Formation of soil samples

For the constant-volume cyclic simple shear specimens tested in the study, specimen formation was performed using dry deposition, in which the soil was deposited in the mold using a funnel with zero drop height. Initially, this produced a relative density close to 0%. Subsequent to initial deposition, the upper platen was placed on the specimen and a surcharge of 25 kPa was applied. The upper platen was then lightly and symmetrically tapped with a mallet until the specimen reached the thickness corresponding to a relative density of 40%.

2. Calculating threshold fines content

The authors presented Equations 1 and 2 in their note, which are intended for use in calculating the upper- and lower-bound threshold fines content. Dependent upon the void ratio of the sand skeleton and the void ratio of the silt, the amount of silt in the voids (and thus the fines content) at the time when the soil transforms from silt grains contained in a sand matrix to sand grains contained in a silt matrix can cover a range of values.

The sand skeleton void ratio is the void ratio that would exist in a soil if all of the fine-grained material was removed, leaving only the sand grains behind. The sand skeleton void ratio is often assumed to range between the maximum and the minimum index void ratios of the sand.

A soil with a sand skeleton void ratio equal to its maximum index void ratio, e_{max}, and that has its voids filled with silt grains at their minimum void ratio, $e_{f,min}$, produces the largest possible value of threshold fines content. Conversely, a soil with a sand skeleton void ratio equal to its minimum index void ratio, e_{min}, and that has its voids filled with silt grains at their maximum void ratio, $e_{f,max}$, produces the smallest possible threshold fines content.

Dr. Dallo is correct in his assertion that Equation 1 presented in the technical note corresponds to the equation presented by Hazirbaba (2005). This equation yields the upper-bound threshold fines content, which is the largest possible value of the threshold fines content and corresponds to the case where the sand skeleton is at its maximum void ratio and the silt contained within the voids is at its smallest possible void ratio.

Equation 2 presented in the technical note is a modified form of Equation 1. Equation 2 yields the lower-bound threshold fines content, which is the smallest possible value of the threshold fines content and corresponds to the case were the sand skeleton is at its minimum void ratio and the silt contained within the voids is at its largest possible void ratio.

It should be noted that depending on the sand skeleton void ratio and the void ratio of the fines within the voids, it is quite likely that the soil will have a threshold fines content somewhere between the upper- and lower-bound threshold fines contents.

For the sake of clarity, the authors propose the equations 1 and 2 in the technical note be modified to:

$$\text{UBTFC} = \frac{G_{sf}(e_{max})}{G_{sf}(e_{max}) + G_{ss}(1 + e_{f,\,min})} \tag{1a}$$

$$\text{LBTFC} = \frac{G_{sf}(e_{min})}{G_{sf}(e_{min}) + G_{ss}(1 + e_{f,\,max})} \tag{2a}$$

Where: G_{ss} is the specific gravity of the sand; e_{max} is the maximum index void ratio of the sand; e_{min} is the minimum index void ratio of the sand; G_{sf} is the specific gravity of the fines; $e_{f,max}$ is the maximum index void ratio of the fines; and $e_{f,min}$ is the minimum index void ratio of the fines.

3. About the data presented in Figre 1 [Polito and Sibley (2019)]

In his discussion, Dr. Dallo presents an alternative interpretation of the Figure 1, which presents a plot of friction angle, ϕ’, versus silt content. The alternative interpretation is based on the assumption that the threshold fines contents for the soil are different than those obtained using the equations presented in the technical note. The authors acknowledge that the new interpretation fits the data very nicely.

The authors, however, are not comfortable with the idea that the upper-bound threshold fines content is larger than the value calculated using equations. As explained in the previous section, the threshold fines content cannot be larger than the upper-bound threshold fines content unless the silt is at a void ratio smaller than the minimum value determined in a suitable index test. Such a density of silt would seem exceedingly unlikely to occur in a soil where the sand skeleton is its loosest possible configuration.

Additionally, both the number of cycles to liquefaction and the normalized dissipated energy per unit volume, presented in Figures 1 and 2 of the original paper, indicate that the upper-bound threshold fines content of 27.3% is a reasonable value. Both of these parameters were developed from tests conducted at relatively small levels of shear strain (<0.5%). The friction angles determined were obtained from tests run to 20% shear strain. For soils close to the upper-bound threshold fines content, these larger displacements almost certainly led to some sand grain to sand grain contact, resulting in the higher friction angles recorded, whereas the smaller displacements in the cyclic tests did not displace the particles enough to initiate any sand grain to sand grain contact.

Conclusions

The authors again wish to thank Dr. Gallo for his insightful commentary and hope that this reply has clarified any confusion created by our original paper.

References

Hazirbaba, K. (2005) “Pore Pressure Generation Characteristics of Sands and Silty Sands: A Strain Approach,” PhD Thesis, University of Texas at Austin, 2005.

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