Postprint of: Bałachowski L., Konkol J., Discussion of "Stress-Displacement Response of Sand–Geosynthetic Interfaces under Different Volume Change Boundary Conditions" by Aliyeh Afzali-Nejad, Ali Lashkari, and Alejandro Martinez, JOURNAL OF GEOTECHNICAL AND GEOENVIRONMENTAL ENGINEERING, Vol. 148, iss. 10 (2022), 07022032, DOI: 10.1061/(ASCE)GT.1943-5606.0002861

Discussion of "Stress-Displacement Response of Sand–Geosynthetic Interfaces under Different Volume Change Boundary" by A. Afzali-Nejad, A. Lashkari and A. Martinez

Lech Bałachowski[1], Jakub Konkol[2*],

[1,2] Faculty of Civil and Environmental Engineering; Department of Geotechnics, Geology and Marine Civil Engineering; Gdańsk University of Technology (GUT); 11/12 Gabriela Narutowicza Street; 80-233 Gdańsk; Poland

[1]e-mail: lech.balachowski@pg.edu.pl

[2]e-mail: jakub.konkol@pg.edu.pl

* Corresponding author

The Authors presented an interesting study on the influence of normal boundary conditions on the behavior of sand-geosynthetics interface during ~~when~~ shearing. ~~The~~ Discussers would like to raise issues related to the application of boundary conditions in ~~direct shear or~~ simple shear interface tests. When interface shear test is analyzed it is not possible to completely separate the behavior of the interface and the surrounding soil in the upper part of the shear box (Boulon, 1991, Fakharian and Evgin, 1997), see Figure 1a. In case of CNS or CV interface tests ~~some~~ the following corrections ~~of the applied volume boundary conditions~~ should be considered:

1. ~~The first is~~Correction related to the compressibility of the inert zone of the soil in the upper part of ~~n~~ the box;
2. ~~The second one is~~Correction related to the compressibility of the tested material (geosynthetic).

In case of dilatancy within the interface, the compressibility of the soil in the inert zone ~~or~~and the geosynthetic material will ~~temper~~ restrain the increase of the mobilized normal stress during shearing. On the other hand, when contractancy within the interface is observed, the mobilized normal stress will be reduced during shearing due to unloading of the soil in the inert zone ~~or~~ and unloading of the geosynthetic material.

Authors estimate the shear zone thickness as 3.5 mm (dense sand-WGTX interface) and 4.24 mm (dense sand-GMB interface) based on PIV analysis (Lashkari and Jamali, 2021). As the thickness of the soil sample is quite small (11mm) the ratio of sample hight to sample width is equal 0.11.~~These values lower then used soil sample thickness (11mm). Consequently, the is an significant amount of inert soil zone in the upper frame (7.5 mm for dense sand-WGTX interface and 6.75 mm for dense sand-GMB interface) for medium dense and lose sand the inert zone thickness will be much higher.~~ Discussers are interested in Authors opinion on the influence of grain size and small aspect ratio of samples on the strength mobilization in simple shear apparatus. ~~this subject.~~

As an introduction to the analyzed~~considered~~ problem, ~~Let~~ let us consider simple, one dimensional elastic compression of the soil-interface modelled as a series of springs k_1 (normal stiffness applied to l~~a~~oading cap of the box), k_2 (normal stiffness of the soil in the inert zone, and k_3 (normal stiffness (compressibility) of geosynthetic).~~, where:~~

~~k1 – applied normal stiffness to the box,~~

~~k2 – normal stiffness of the soil in the inert zone,~~

~~k3 – normal stiffness (compressibility) of geosynthetic.~~

Taking into account simple ~~calculations of the force~~ vertical stress equilibrium ~~during shearing~~ in the set of springs we ~~get~~obtain:

$$\Delta\sigma_n = k_1\Delta x_1 = k_2\Delta x_2 = k_3\Delta x_3 \quad (1)$$

~~$F = k1x1 = k2x2 = k3x3$~~

Or

$$\Delta\sigma_n = k(\Delta x_1 + \Delta x_2 + \Delta x_3) \quad (2)$$

~~$F = k(x1 + x2 + x3)$~~

where $\Delta\sigma_n$ = change in normal stress during shearing; k ~~is~~ = resulting normal stiffness, Δx_1 = loading cap normal displacement during shearing, Δx_2 = inert soil zone displacement during shearing, Δx_3 = geo~~n~~synthetic deformation during shearing.

The resulting normal stiffness can be expressed as:

$$k = \frac{k_1\Delta x_1}{\Delta x_1+\Delta x_2+\Delta x_3} = \frac{k_2\Delta x_2}{\Delta x_1+\Delta x_2+\Delta x_3} = \frac{k_3\Delta x_3}{\Delta x_1+\Delta x_2+\Delta x_3} \quad (3)$$

~~$k = \frac{k1x1}{x1 + x2 + x3}$~~

In case of CNL condition k_1 =0~~is zero~~, ~~k_2 =0 and k_3=0 (no vertical stress change during shearing), so the~~ resulting normal stiffness k ~~is also equal zero~~=0.

~~When CV condition is applied Δx_1 is zero=0 and the resulting normal stiffness is expressed as:~~

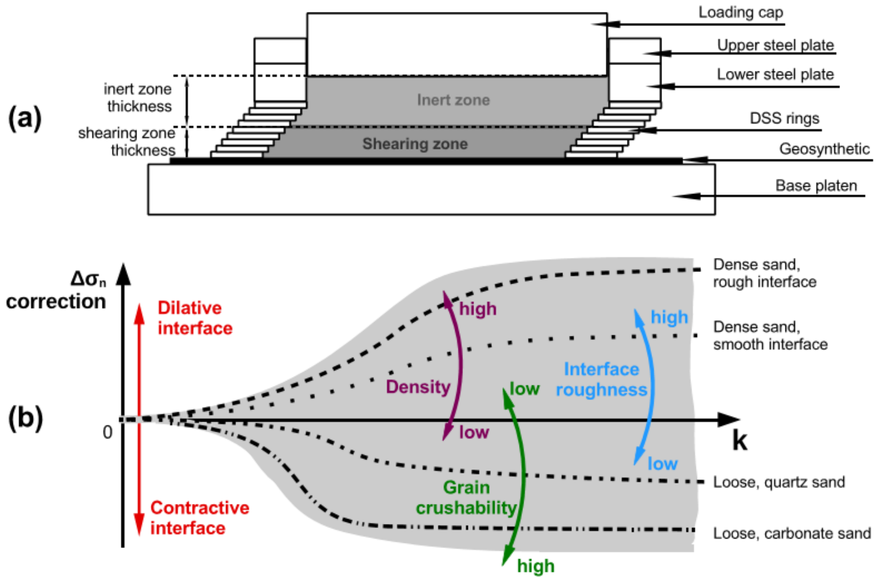
~~$k = \frac{k_2\Delta x_2}{\Delta x_2+\Delta x_3} = \frac{k_3\Delta x_3}{\Delta x_2+\Delta x_3}$ (4)~~

~~$k = \frac{k2x2}{x2 + x3} = \frac{k3x3}{x2 + x3}$~~

~~The above relation is simplified if~~ For l~~L~~low compressible materials like concrete or steel in contact with soil ~~are considered (x3=0)~~one can admit~~induce~~ Δx_3=0. In this case the resulting normal stiffness will be equal to the normal stiffness of the soil in the upper part of the shear box (k=k_2).~~:~~

~~$k = k2$~~

One should remark that the ~~resulting normal stiffness~~k will be smaller than k_1~~applied to the upper part of the box~~ if CNS or CV conditions are used. Some corrections including the compressibility of the inert zone or the geosynthetic should be thus considered to meet the fixed boundary conditions directly at the interface level (in the shearing zone). The compressibility of the inert zone during the interface direct shear tests with CNS and CV was studied by Boulon~~,~~ (1991) and Mutraji~~,~~ (1992), who performed ~~pseudo~~ oedometric-like tests during direct shearing. They suggested to use oedometric modulus or unloading-reloading pressuremeter modulus to take into consideration the correction for the soil compressibility in the inert zone. This correction will increase ~~the mobilized interface friction and~~ normal stress (and the mobilized interface friction) in case of dilatant contact or decrease ~~these values~~ normal stress (and the mobilized interface friction as well) when contractancy is observed within the interface. In ~~this~~ such a way ~~a~~ scale effects in interface tests (Bałachowski, 2006) will be produced by a function of the imposed normal stiffness, being the highest for CV boundary condition. ~~It will~~The normal stress correction will be positive for dilatant interface and negative for contractive ~~soil behavior within interface~~interface. Tentative correction for the mobilized interface friction/normal stress is given on Figure 1b including the effects of soil density, interface roughness and grain crushability.



~~Figure 1. (a) shearing zone and the inert soil zone in the upper part of the shear box, (b)Tentative correction for the mobilized interface friction/normal stress for dilative or contractive interface behavior.~~

References

Bałachowski L. (2006). “Scale effect in shaft friction from the interface direct shear tests.” *Archives of Civil and Mechanical Engineering*, Vol.6, No.3, pp. 13-28.

Boulon, M. (1991). “Le comportement d’interface sol-structure: aspects expérimentaux et numériques.” *Revue Française de Géotechnique*, No.54, 27-37.

Fakharian, K. and Evgin, E. (1997). ”Cyclic simple shear behavior of sand-steel interfaces under constant normal stiffness condition.” *Journal of Geotechnical and Geoenvironmental Engineering,* Vol. 123, No. 12, 1096-1105.

Lashkari, A., and V. Jamali. 2021. “Global and local sand–geosynthetic interface behavior.” Géotechnique 71 (4): 346–367. https://doi.org/10 .1680/jgeot.19.P.109

Mutraji, J. (1992). *Etude expérimentale et numérique du cisaillement direct silt-structure. Application à l'amélioration du frottement lateral dans du sols fins*. *Thèse de doctorat*, Université Joseph Fourier, Laboratoire Sols, Solides, Structures, Grenoble, France.