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Closure to "Particle Shape Effects on Packing Density, Stiffness, and Strength: Natural and Crushed Sands" by Gye-Chun Cho, Jake Dodds, and J. Carlos Santamarina

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Gye-Chun Cho[1]; Jake Dodds[2]; and J. Carlos Santamarina[3]

[1]Associate Professor, Dept. of Civil and Environmental Engineering, Korea Advanced Institute of Science and Technology (KAIST), Daejeon 305-701, Republic of Korea (corresponding author). E-mail: gyechun@kaist.edu

[2]Civil Engineer, National Resources Conservation Service, Price, UT 84501.

[3]Professor, School of Civil and Environmental Engineering, Georgia Institute of Technology, Atlanta, GA 30332. E-mail: carlos.santamarina@ce.gatech.edu

The discussers suggest an alternative interpretation of the shear wave velocity versus stress data, taking into consideration packing density and void ratio correction functions $f(e)$. The link between the writers' and discussers' approaches is identified in the following analysis, which augments the discussion presented in the original manuscript (p. 597):

- Low perturbation shear wave propagation through a soil mass is a small-strain, constant fabric phenomenon. Therefore, it is a "measure of state" (i.e., contact stiffness and fabric).
- When stresses are increased, the contact stiffness increases as well (i.e., flatter contacts, hertzian-type behavior). In addition, fabric changes take place if the strain level exceeds the elastic threshold strain. Therefore, the change in shear wave velocity reflects the increase in contact stiffness and fabric changes.
- At constant fabric, the β-exponent captures the stress sensitivity to contact stiffness. For uncemented coarse grains, the exponent may range from $\beta=1/6$ for smooth spherical particles (Hertz contact) to $\beta=1/4$ for cone-to-plane contacts, as in angular particles.
- If the coordination number increases when the effective confining stresses increase, the β-exponent exceeds the values indicated above by as much as ~0.05 or even ~0.1. Therefore, higher β-exponents are expected for the more angular particles given their wider range in e_{max}-to-e_{min} and higher compressibility that suggest a more pronounced increase in coordination upon loading. [Note: To minimize the effect of changes in void ratio, all specimens were tested under dense conditions (relative density ~90%); refer to original paper].

One may attempt to correct V_s-σ' data for void ratio changes to remove the contribution of fabric changes to the β-exponent. However, one should determine the correction function $f(e)$ for each soil. Selecting a single function for all soils adds noise to the analysis and weakens correlations. Therefore, we opted for analyzing the data without $f(e)$ corrections, and to retain void ratio effects in both α and β parameters.

Finally, the complete statement of the conclusion (pp. 597 and 600) indicates that particle irregularity leads to "decrease in small-strain stiffness (α-coefficient), yet increased sensitivity to the state of stress (β-exponent)." Recognizing that the α-coefficient implies low confining stress [1 kPa, Eq. (3)], both observations are supported by the figure presented by the discussers.

Discussion of "Raked Piles—Virtues and Drawbacks" by Harry G. Poulos

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William J. Neely, P.E., M.ASCE[1]

[1]Vice President, The Reinforced Earth Company, 1660 Hotel Circle North, Suite 304, San Diego CA 92108. E-mail: wneely@reinforcedearth.com

The author is commended for drawing attention to the influence of vertical and/or lateral ground movements on the behavior of raked piles through the use of an elegant parametric study. This discussion presents the results of field measurements of axial strains in a series of vertical and raked precast concrete piles subjected to vertical ground movements associated with consolidation of a thick clay layer. Consolidation of the clay layer was due to a temporary surcharge fill.

The field measurements presented in this discussion were originally presented as part of lecture notes on the use of preloading techniques in the development of sites underlain by soft soils. The notes were prepared by Dr. P. Davies (Davies 1978) for a lecture series in South Africa in the late 1970s. As far as the discusser is aware, the information relating to the performance of vertical and raked piles subjected to vertical ground movements summarized here has not been formally published.

The test piles were installed at a site where soil conditions comprise about 10 m of sand underlain by a layer of clay approximately 20 m thick (see Fig. 1). A 3.5 m high surcharge fill was used to accelerate consolidation of the clay. The test piles comprised 1,000-kN capacity precast concrete piles installed in pairs. Two piles were installed vertically, two were installed at a rake of 1 in 4 (rake angle of 14.0°) and two piles were installed at a rake of 1 in 8 (rake angle of 7.1°). One pile in each pair was coated with a bitumen slip-coat over the upper 15 m of its length in order to determine the effectiveness of the slip-coat in reducing downdrag loads due to negative skin friction.