C. R. Mecanique 339 (2011) 63–66

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Reply to the comment by M. Rahman on "Influence of inter-granular void ratio on monotonic and cyclic undrained shear response of sandy soils" by M. Belkhatir et al. [C. R. Mecanique 338 (2010) 290–303]

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ARTICLE INFO

Article history:
Available online 26 January 2011

The authors would like to thank M. Rahman for his comment on our work, and for trying to establish new correlations in term of the equivalent void ratio for a range of 0–33% of fines content.

In his commentary, the author focuses his discussion on the use of the equivalent void ratio instead of the inter-granular void ratio. Certainly, the equivalent void ratio cited and detailed by many researchers offers many advantages, especially in evaluating the determination of the fines fraction participating in force chain of the soil mixture. Moreover, a unique function of dilatancy can be established for a certain range of fines content where the equivalent void ratio is a state parameter.

In our Note, three different types of samples (loose, medium dense and dense) are investigated with non-plastic fines content ranging from 0 to 50%. In our tests, the undrained shear strength was evaluated from monotonic consolidated undrained triaxial tests on reconstituted samples.

Indeed, experimental tests on silty sands reported by Zlatovic and Ishihara [1], and Thevanayagam et al. [2] demonstrated that deformation characteristics and pore water generated in samples with non-plastic fines content were quite different from clean sands and the steady state decrease until 30% of fines content and the pore water generation is maximum at critical fines content. It is recognized that the threshold fines content (F_{thre}) is evaluated from the turning point of the reverse movement of the steady state line (SSL).

We may not agree with the author when he reported that our Fig. 11 (reproduced here) showed a reversal trend on shear strength at phase transition in between 30% to 40% fines content. Fig. 11 shows clearly that the undrained shear strength at the phase transition decreases with the decrease of the global void ratio and the increase of the fines content for all densities ($D_r = 12$, 50 and 90%). Beyond $F_c = 30\%$, the undrained shear strength at the phase transition continues to decrease with the increase of the global void ratio and fines content. Based on that, we can say that the global void ratio is not a pertinent parameter to be used for liquefaction analysis of sand-silt mixtures. Therefore, the inter-granular void ratio (Kenny [3]; Kuerbis et al. [4]; Mitchell [5]) was introduced to explain liquefaction behavior of such soils and was considered as a state parameter (Belkhatir et al. [6]).

Contrary to what was written in the commentary, we think that the interpretation of the data up to 50% fines contents in terms of e_s is reasonable. They should be better interpreted with e_s provided that $F_c \leqslant 50\%$. The threshold fines

DOI of original article: 10.1016/j.crme.2010.12.009.
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1631-0721/$ – see front matter
doi:10.1016/j.crme.2011.01.001

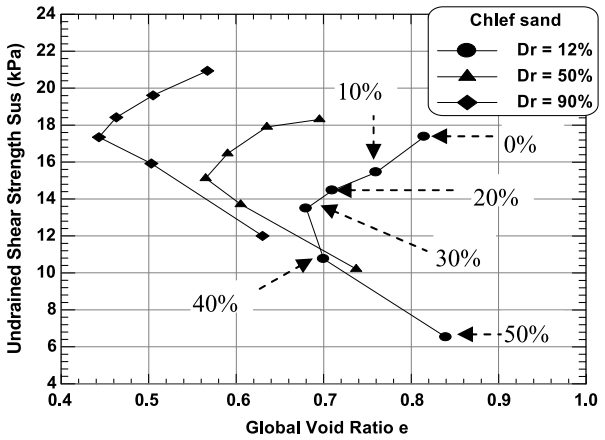

Fig. 11. Undrained shear strength at the phase transition point versus global void ratio and fines content ($\sigma'_3 = 100$ kPa).

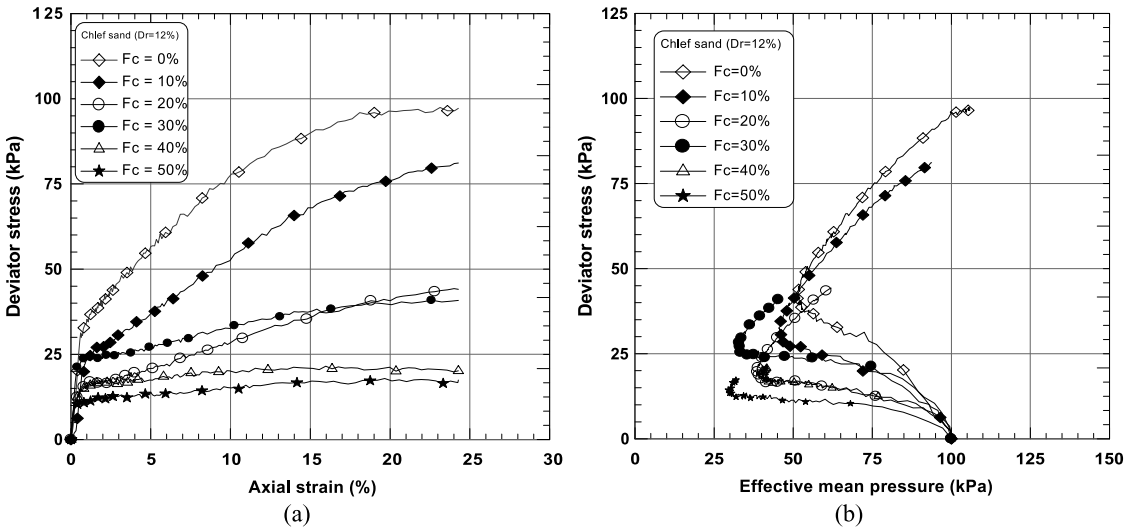

Fig. 7. Influence of the fines content on the undrained response of the sand-silt mixtures ($\sigma'_3 = 100$ kPa, $D_r = 12\%$).

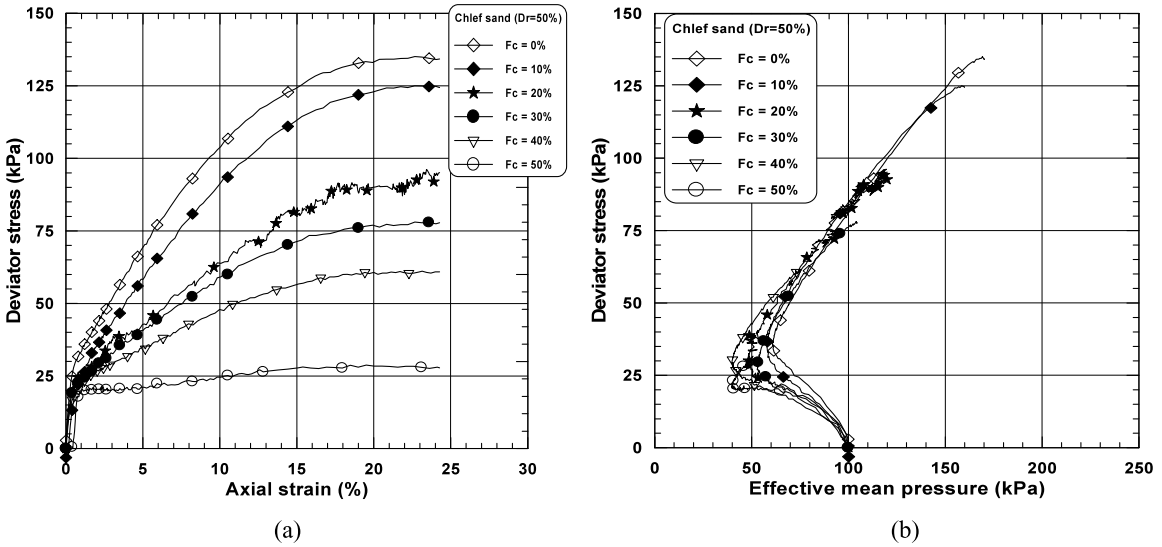

Fig. 8. Influence of the fines content on the undrained response of the sand-silt mixtures ($\sigma'_3 = 100$ kPa, $D_r = 50\%$).

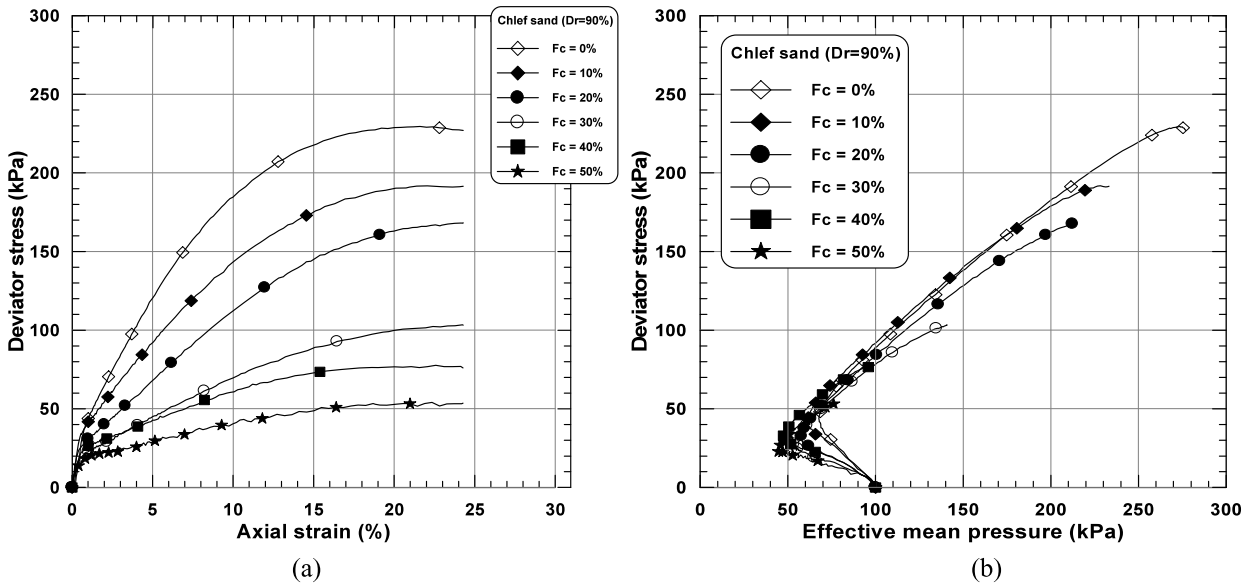

Fig. 9. Influence of the fines content on the undrained response of the sand-silt mixtures ($\sigma'_3 = 100$ kPa, $D_r = 90\%$).

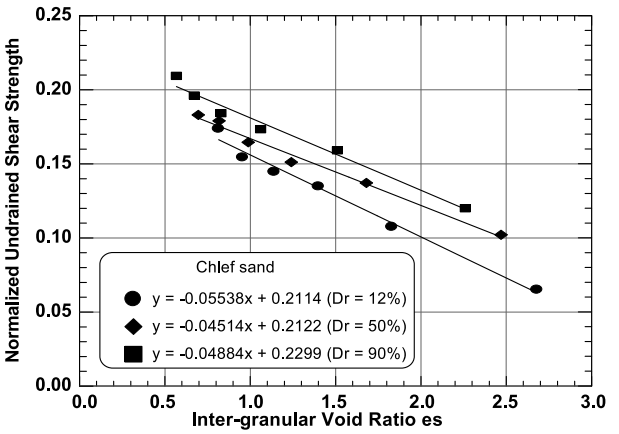

Fig. 13. Normalized undrained shear strength at the phase transition point versus inter-granular void ratio ($\sigma'_3 = 100$ kPa).

content parameter introduced by the author in the commentary for Chlef sand ($F_{thre} = 33\%$) is not consistent with Fig. 11. Indeed, our results (Figs. 7, 8 and 9, reproduced here) did not confirm the existence of the reversal trend up to 50% fines content.

Fig. 1 of Rahman [7] does not bring any new information concerning the tendency of the sand-silt mixtures compared to our Fig. 13. Moreover, it fails to predict undrained shear strength at phase transition for higher fines contents.

Formula (6) of [7] is questionable since there is not enough information on steady state, available in the published literature.

One of the advantages of our results is that the relationships obtained in term of inter-granular void ratio for undrained shear strength at phase transition are valid till 50% fines content. However, the relationship expressed in term of the equivalent void ratio by the author seems to be valid till 33% of fines content. Also, it is important to notice that the undrained shear strength is getting lower beyond the limiting value of fines content F_{thre} proposed by the author.

In our future investigations, we are seeking F_{thre} (point of reversal trend) using the formula (6) of [7] with new fitting parameters in order to generalize our study for a wide range of fines contents.

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