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DISCUSSION

Liquefaction susceptibility of clayey sands under saturated and partially saturated conditions

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Contribution by Fausto Molina-Gómez and Rubén Galindo

The discussers commend the authors on their significant and engaging study concerning the characterisation of cyclic behaviour in partially saturated sands with varying fines content (Fardad Amini & Yang, 2023). The discussers would like to address two key points regarding the influence of fines content on the relationship between the correction factor for 20 loading cycles (K_{S20}) and the seismic wave ratio (V_p/V_s) to describe the enhancement in cyclic resistance resulted by soil desaturation.

The first point focuses on the assumption of Poisson's ratio (v) as a constant value of 0·3. While this value was adopted by the authors for simplicity, it is worth highlighting that v can be characterised by measuring both the P-wave velocity (V_p) and the S-wave velocity (V_s) in dry conditions, as recommended by Kumar & Madhusudhan (2012). This value can be computed using equation (1):

$$v = \frac{0{\cdot}5V_p^2 - V_s^2}{V_p^2 - V_s^2} \quad (1)$$

Obtaining v in the laboratory before saturation or desaturation may yield results different from the assumed value. Therefore, it is essential to consider the variability of this parameter in the analysis. In this context, v can be obtained in the laboratory before saturation or desaturation, showing results that differ from 0·3.

The second point concerns the recommendation to use a single equation to describe the variation of K_{S20} as a function of V_p/V_s. Opting for a singular equation is problematic because the V_s results change with the fines content (Wichtmann *et al.*, 2015; Yang & Liu, 2016). In contrast, the variation in V_p with the fines content remains consistent, as P-wave propagation is primarily influenced by the pore fluid, which is represented by the degree of saturation, rather than the wave propagation through the soil skeleton (Santamarina *et al.*, 2001). This observation suggests that the evolution of K_{S20} can indeed be described by a single equation including only V_p, as detected in clean sands by Molina-Gómez *et al.* (2023) and Zuo *et al.* (2024). However, concerning the relationship between K_{S20} and V_p/V_s, multiple models may need to be derived for the fines under consideration, similar to the approach for partially saturated sands with various relative densities by Molina-Gómez *et al.* (2023), which reveals different curves. It is important to note that the model describing the evolution of K_{S20} as a function of V_p/V_s also depends on v, as addressed previously.

These points emphasise the impact of initial soil fabric on the estimation of both v and V_s in sands with different fines content, capturing the complex interactions between soil properties and liquefaction resistance and consequently impacting the estimation of K_{S20} in partially saturated conditions.

Authors' reply

The authors would like to thank the discussers for their interest in the work. The discussers raised two points: (*a*) the adoption of a Poisson's ratio (v) with a constant value of 0·3; and (*b*) the impact of fines (i.e. clay) content on the K_{S20}–V_p/V_s relationship. In what follows, the two points are addressed in order.

Impact of Poisson's ratio (ν) on K_{S20}–V_p/V_s relationship

The authors agree that Poisson's ratio can be estimated from the measurements of V_p and V_s using the relationship shown by equation (1) in the discussion contribution. A detailed discussion about the evaluation of Poisson's ratio under full saturation, partial saturation and dry conditions was given in Yang & Sato (2000). In the discussed paper as well as in Yang (2002) and Yang *et al.* (2004), the value of 0·3 was adopted for the skeleton Poisson's ratio (v) for simplicity. This value is considered to be roughly representative for sands and sandy soils. For example, Kokusho (2000) suggested the same value (0·3) for the skeleton Poisson's ratio based on field data from downhole tests in sandy and gravelly soils. Tsukamoto *et al.* (2002) proposed an average value of 0·35 for Toyoura sand, irrespective of relative density and confining stress, which is close to the value used by the authors.

To examine the possible influence of Poisson's ratio (v), the authors consider different values of v over a wide range, between 0·15 and 0·4, in the model (i.e. equation (10) of the paper under discussion). The results are shown in Fig. 17, where additional data from the literature are also included. It can be seen that use of the Poisson's ratio of 0·3 leads to a reasonable average. The test materials in Tsukamoto *et al.* (2002) and Nakazawa *et al.* (2004) include Toyoura sand, Niigata sand, Koshigaya sand and Takenouchi silt. All three sands were clean and uniformly graded, while Takenouchi silt had a uniformity coefficient of ∼3.

Impact of fines (clay) content on K_{S20}–V_p/V_s relationship

To examine the possible influence of clay content (CC) on the K_{S20}–V_p/V_s relationship, the authors re-interpret the data for different CCs and re-plot the results in Fig. 18. For the purpose of comparison, the original model derived from all data for both clean Toyoura sand and the sand–clay mixtures

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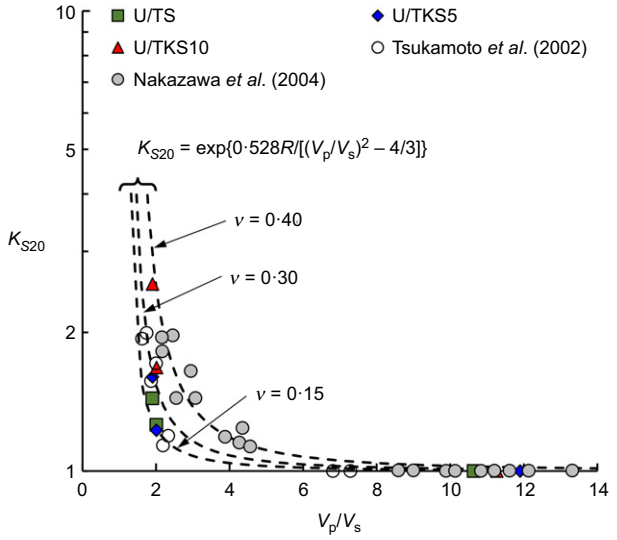

Fig. 17. Impact of ν on K_{S20}–V_p/V_s relationship

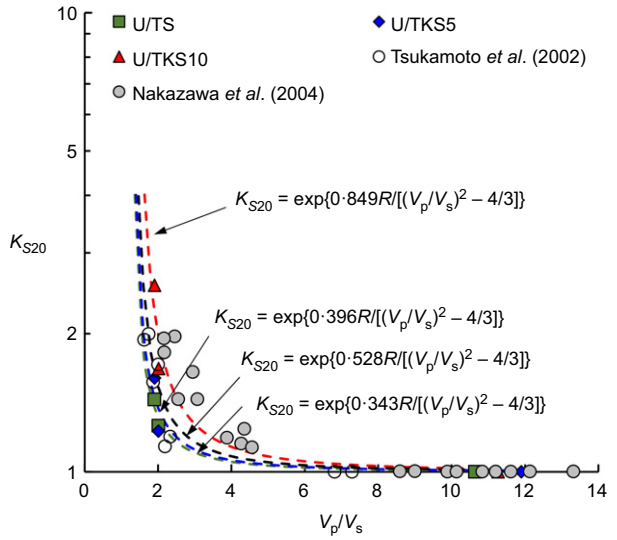

Fig. 18. Impact of CC on K_{S20}–V_p/V_s relationship. A full-colour version of this figure can be found on the ICE Virtual Library (www.icevirtuallibrary.com)

(i.e. the black dashed curve) and the data from the literature are also included in the figure. It can be seen that the impact of CC on the proposed model is not significant, and the deviation appears to be more obvious for V_p/V_s values between 2 and 4. From the practical point of view, the unified K_{S20}–V_p/V_s relationship derived in the paper under discussion provides a simple yet reasonable approximation. For the case of higher clay contents, further experiments would be worthwhile.

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