Discussion and Response

Liquefaction resistance of sand reinforced with geosynthetics

Altun, S., Göktepe, A. B. & Lav, M. A. (2008). *Geosynthetics International*, 15, No. 5, 322–332

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Discussion by C. S. Vieira¹

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The discussor read this paper with interest because our research team has recently performed triaxial tests and simple shear tests to characterize the behaviour of geosynthetic reinforced sand under cyclic loading (Vieira 2008). However, the discussor has some doubts about the justification presented by the authors of the paper related to the better performance of the test specimens reinforced with nonwoven geotextiles. In the experimental study reported in the paper, it is mentioned that the test specimens were prepared layer by layer using the air pluviation method with a drop height of 200–250 mm to adjust the relative density of the sand to approximately 50%. Although the mass per unit area of the two geotextiles is not very different (the nonwoven geotextile is 41% heavier than the woven geotextile), the nonwoven material has a thickness three times greater than the woven geotextile (Table 2). It is not clear in the paper what methods were adopted to maintain a similar relative density of the sand on the two types of reinforced specimens (with woven geotextile or nonwoven geotextile). Is it possible that for the specimens reinforced with nonwoven geotextile, the sand was denser than for the specimens with woven geotextile? Assuming that this could have occurred, the explanation for the greater resistance to liquefaction of sand samples reinforced with nonwoven geotextile could be different from the one presented by the authors. In Section 4 of the paper the authors conclude that 'a nonwoven (needle-punched) geotextile is more effective in improving the liquefaction resistance of specimens. This strength improvement comes from the fact that needle-punched geotextiles have better mechanical and frictional properties than woven geotextiles'. Nevertheless the values presented in Table 2 do not confirm better mechanical properties for the nonwoven geotextile (see, for instance,

the unidirectional tensile strength or the punching strength). In the same paragraph, the sentence 'A nonwoven geotextile has a higher angle of friction' is not accurate since geotextiles themselves have no friction. The better performance of the specimens reinforced with nonwoven geotextile is justified, in the conclusions of the paper, by the denser structure and lower elastic modulus of these geotextiles. In the opinion of the discussor, the explanation presented by the authors for the greater resistance to liquefaction of the sand samples reinforced with needle-punched geotextile is not convincing. It is very difficult to guarantee the intended relative density of the sand when geotextile samples (particularly nonwovens) are placed within small sand specimens. The thickness variation under different pressures and the deposition process of the sand have an important influence on the final relative density of the specimens. It is possible, the authors may have complemented the experimental study with other test results that corroborate, or not, the conclusions presented in the paper. There is no doubt that reinforcing with geosynthetics reduces the liquefaction potential of granular soils, but the influence of geosynthetic type may not be so simple.

Response by S. Altun¹, A. B. Göktepe² and M. A. Lav³

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First of all, the authors would like to thank the discussor for her interest in our work. We believe that this contribu-

tion helps to improve the quality of information in the paper by providing us the opportunity to give additional information and clarification.

The discussor raised concerns regarding the achievement of similar relative density of sands with two different geotextile types having different thicknesses. In all experiments, sand amounts were calculated based on specimen size, geotextile type and number of layers. Namely, in order to obtain similar relative density values, less sand was used in samples prepared with nonwoven geotextiles which are thicker. Furthermore, thickness data for the geotextile subjected to compressive pressures were gathered from the manufacturing company and used in the sample preparation calculations. Hence, extreme care was taken in the preparation of samples using the air pluviation method. Consequently, the authors do not agree with the discussor that specimens prepared with nonwoven geotextiles are denser, and thus their liquefaction resistance should be higher.

The discussor implies that the reason for better performances of samples prepared with nonwoven geotextiles cannot be explained by the mechanical properties given in Table 2. Moreover, the discussor states that some mechanical properties of woven geotextiles are better than woven ones. The authors also underlined this issue in the paper and stated that nonwoven geotextiles exhibited better performance contrary to expectations based on mechanical properties. In fact, our research team also carried out direct shear tests to investigate the behaviour of sand-geotextile interfaces (Erdoğan *et al.* 2008). The results of this study indicated that the woven geotextiles showed better performance than nonwoven geotextiles. However, the results of the experiments performed by means of a torsional shear apparatus showed that sand samples reinforced with nonwoven geotextile gave better liquefaction resistance. This was considered an important conclusion of the experimental study which indicates that liquefaction strength is influenced by several other factors (other than the mechanical properties of utilized geotextiles) such as

permeability, particle size and distribution, loading conditions, etc.

In the study under discussion, liquefaction susceptibility of sand samples reinforced with different geotextiles and considering additional layers were evaluated using a dynamic torsional shear test apparatus. Basically, two types of geotextiles, woven and nonwoven, were used for the reinforcement. The selected woven geotextile was the thinnest and had the lowest mechanical properties of all woven geotextiles produced by the company. On the other hand, traditional loading conditions were not reproduced in the test. For example, principle stress axes were rotated continuously during the cyclic loading. In addition, very low cyclic loading frequency (0.01 Hz) was used in the tests.

As the discussor stated, geotextiles do not have an angle of friction. The parameter used in the paper is the interfacial friction angle with sand which is given in Table 2 and obtained from the manufacturer.

As a result, the lower liquefaction resistance of sand samples prepared with woven geotextiles can be explained by several factors, such as material type, testing conditions, and particle size properties of the sand. The results of our study show that nonwoven geotextiles exhibited better performance than woven geotextiles which is consistent with conclusions by Krishnaswamy and Isaac (1995).

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