Discussion of “Column Supported Embankments with Geosynthetic Encased Columns: Validity of the Unit Cell Concept”

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by

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Full reference of the discussed article:

Khabbazian M, Kaliakin VN, Meehan CL (2015) Column Supported Embankments with Geosynthetic Encased Columns: Validity of the Unit Cell Concept. Geotech Geol Eng 33 (3): 425-442.

The authors present numerical analyses of an embankment underlain by geosynthetic reinforcement and supported by geosynthetic encased columns (GRCSE). In the last part of the paper, the transverse and longitudinal tensile forces in the geosynthetic reinforcement, which underlays the embankment, are compared using a 3-d strip model and the Unit-Cell concept, both in a 3-d model and in a 2-d axisymmetric model. The results of both Unit-Cell models are very similar. The authors show that the Unit-Cell models are not able to capture the transverse force (T_x), which seems obvious, nor the longitudinal force (T_y), which may not be so obvious.

The discusser would like to explain that in the authors' case the longitudinal force (T_y) is not properly captured by the Unit-Cell models because of the "so-called" Poisson effect. A measure of this effect is the Poisson's ratio (ν=-$\varepsilon_y/\varepsilon_x$) (Figure 1). In the 3-d strip model, T_x is notably higher than in the Unit-Cell models, as expected. The authors use a Poisson's ratio of ν=0.3 for the geosynthetic reinforcement, and then, the higher value of T_x causes an additional tensile force in the perpendicular direction (T_y) because of the Poisson effect. Assuming plane strain conditions in the longitudinal direction (ε_y=0),

$$\varepsilon_y = 0 = \frac{1}{E}\left(\sigma_y - \nu\sigma_x\right) = \frac{1}{E}\left(\frac{T_y}{t} - \nu\frac{T_x}{t}\right) \tag{1}$$

the following relationship may be derived

$$T_y = -\nu T_x \tag{2}$$

where E is the isotropic Young's modulus of the geosynthetic and t is its thickness.

Eq. (2) allows to estimate the longitudinal tensile force (T_y), if the transverse force (T_x) is known or has been estimated, for example, following EGBEO (2011) or as the authors propose in the paper (e.g. Eq. 1 of the original paper). Only the tensile forces caused by the differential settlement between soil and column would be missing. It is worth noting that Eqs. (1) and (2) are strictly valid for plane strain conditions (e.g. a 2-d plane strain model), while for the 3-d strip model of the authors, they are just approximations because ε_y is slightly different from 0 due to the differential settlement between soil and column.

In the limit case of v=0, there is no contribution to the longitudinal direction and the Unit-Cell models would provide an accurate value of the longitudinal force (T_y). Many woven geotextiles used for reinforcement present two nearly independent sets of fibres in each direction (transverse and longitudinal), consequently, they work nearly independently and using v=0 is appropriate (Figure 2). Besides, using v=0 makes easier to consider the anisotropic behaviour of geosynthetics (E_x and E_y). Consequently, some finite element codes, e.g. Plaxis (Brinkgreve et al. 2012), directly assume v=0 for the type of membrane elements that are normally used to model geosynthetics.

The value of the Poisson's ratio of the geosynthetic reinforcement is an important input parameter when modelling geosynthetic encased columns (GEC). For example, the discusser thinks that the differences in the numerical results found by Pulko et al. (2011) and Khabbazian et al. (2011) are caused by the different Poisson's ratios of the geosynthetic encasement, v=0 and v=0.3, respectively. A value of v=0.3 causes the encasement to further expand radially due to its vertical compression and consequently, the apparent circumferential stiffness and the hoop force in the encasement are lower than with v=0. The discusser thinks that values close to 0 are more realistic for the Poisson's ratio of common geosynthetics used to encase granular columns. Further information may be found in the literature about the Poisson effect and the Poisson's ratio of different geosynthetics (e.g. Soderman and Giroud 1995).

References

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EBGEO (2011) Recommendations for Design and Analysis of Earth Structures using Geosynthetic Reinforcements – EBGEO. German Geotechnical Society. Ed. Wilhelm Ernst and Sohn, Berlin

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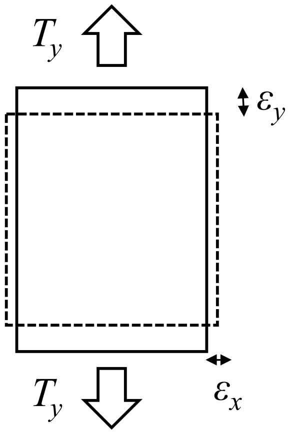

Figure 1. Poisson effect in uniaxial tension.

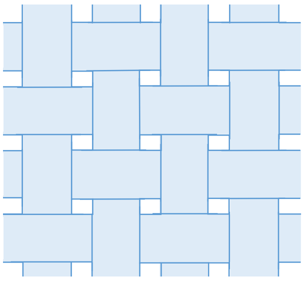

Figure 2. Sketch of woven geotextile with two sets of fibres.