Discussion of ‘A5 Llyn Ogwen peatslide, Capel Curig, North Wales’ by D. Nichol, G.K. Doherty & M.J. Scott, *Quarterly Journal of Engineering Geology and Hydrogeology*, 40, 293–299

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M. Long & N. Boylan write: The authors are to be congratulated on a very useful paper, which is an excellent addition to the growing body of literature on peat slides. The geomorphology, geology, details of the slide and the probable causal factors are well described and are in general consistent with the discussers’ experience from similar slides in Ireland (Boylan *et al*. 2008).

Although it was clearly not a main focus of the paper, the authors refer to limit state stability analyses of the slide where the undrained shear strength (s_u) of peat, as determined by the hand vane, was used as input.

The problems with using the vane test in peat were recognized some time ago but are worthy of reconsideration. For example, Quinn (1967) stated that the ‘test was open to criticism as the failure mechanism is one of tearing rather then shearing’. Helenelund (1967) concluded that the ‘test is not reliable in fibrous peat’. In a comprehensive review of the practice, Landva (1980) observed that a void was generated behind the blade into which the compressed peat in front of the blade drained, resulting in a modified peat (see Fig. 1).

It seems unlikely then that the test can be truly considered ‘undrained’. Helenelund (1967) and Landva (1980) also reported that a cylindrical shear surface occurred at a diameter 7–10 mm outside the edge of the blade and the length of the vane shear face was shorter as a result of the compression–void mechanism described above.

Therefore use of the conventional relationship between applied torque and the vane dimensions to obtain s_u is questionable. Unlike mineral soils, vane strength (s_{uv}) in peat has been found to decrease with increasing diameter, possibly because of the effect of the fibres (see, e.g. Landva 1980). Because of these considerations Landva (1980, 1986) concluded that the vane shear test is ‘of little engineering value in fibrous material’ and is also not suitable for organic soils.

Usually the field vane gives higher normalized undrained shear strength (s_u/σ'_{v0}) values than triaxial testing For example, Edil (2001) reviewed work on US peats and suggested that the range of s_u/σ'_{v0} for peat is between 0.4 and 0.8 for isotropically consolidated triaxial tests, with the ratio increasing with increasing organic content. Farrell & Hebib (1998) similarly reported s_u/σ'_{v0} values from triaxial and direct simple shear tests between 0.5 and 0.7 for peat from Raheenmore bog in Ireland. For field vane testing, however, there is much more scatter in the data, and s_u/σ'_{v0} lies in the range 0.3–1.5. Similar data from the University College Dublin research site at Loughrea, in western Ireland, are shown on Figure 2a. Numerous vane tests have been carried out and the results show a wide scatter, with s_u/σ'_{v0} varying between 0.8 and 2. There is no clear trend in the data with depth and only a weak correlation with von Post humification number (von Post & Granlund 1926).

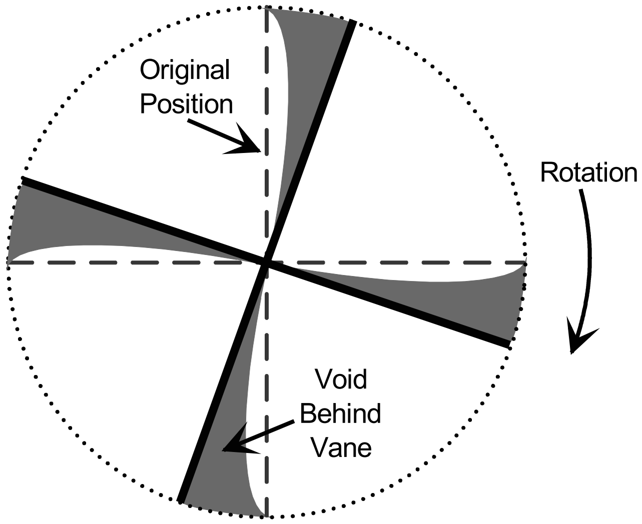

Fig. 1. Voids created behind vane during rotation in peat.

A significant cause of the scatter in the data is the natural anisotropy of the material. This strength anisotropy is mostly due to fibre reinforcing effects. It seems then that, in particular with respect to landslide analysis, the results of field vane testing can be directly misleading. As an alternative, the focus should be on tests where the mode of deformation is similar to that in landslides; that is, horizontal shearing, as takes place in direct simple shear testing (DSS).

Laboratory testing of peat is complicated by disturbance of the material during sampling, as it seems that even with the best equipment some compression of the peat occurs during sample tube insertion. In addition, the resulting specimen needs to be consolidated to very

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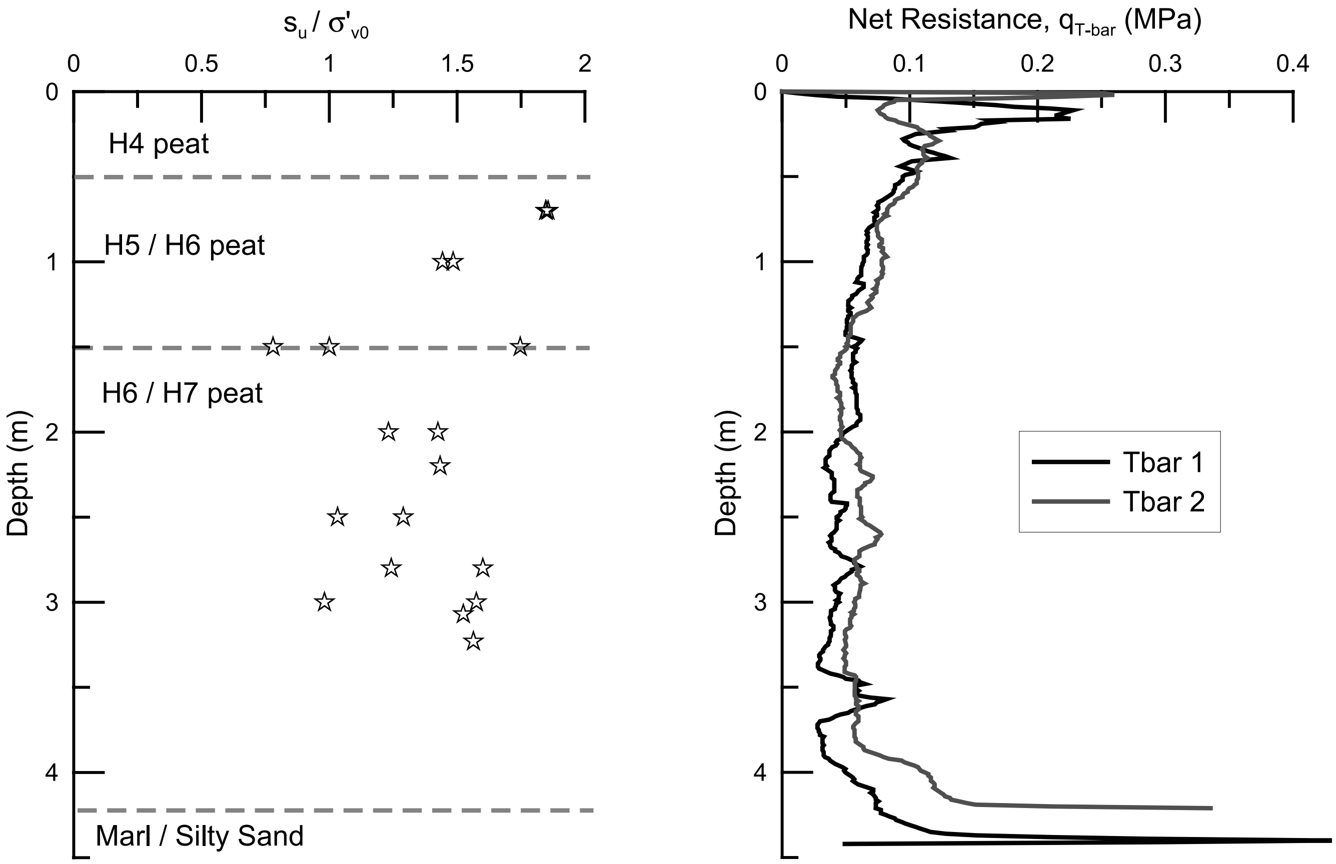

Fig. 2. (**a**) Field vane and (**b**) T-bar data for Loughrea site.

low effective stresses, which are usually outside the accuracy range of normal testing equipment.

In the opinion of the authors, consideration should then be given to determining the shear strength *in situ* using full flow penetrometers, where the deformation around the probe relates closely to an average shear strength (Randolph & Anderson 2006), which is often close to the shear strength measured in the DSS. Examples of such devices are the T-bar and ball probes as described by Boylan & Long (2006), Long (2005) and others.

Figure 2b shows an example of the measured resistance of the T-bar for the Loughrea site. In contrast to the vane test results, the T-bar penetration resistance shows a smooth, consistent and repeatable profile. The measured resistance ($q_{\text{T-bar}}$) is related to the undrained shear strength (s_u) using the equation

$$s_u = \frac{q_{\text{T-bar}}}{N_{\text{T-bar}}}$$

where $N_{\text{T-bar}}$ is a bearing capacity factor for the T-bar. Boylan & Long (2006) gave some early indications of the appropriate $N_{\text{T-bar}}$ values for peat. Research is currently focused on the appropriate $N_{\text{T-bar}}$ value for peat soils relating to a range of laboratory strength tests.

The assessment of peat stability necessitates that the strength of peat is measured in an accurate yet conservative manner. *In situ* vane tests are known to be highly problematic in peat and give directly misleading results, which could lead to false high factors of safety and unstable conditions. Peat strength should be measured in a mode of deformation that is appropriate to the failure mechanism being analysed (i.e. DSS for predominantly horizontal failure mechanism). *In situ* devices such as full flow penetrometers hold much promise for the development of a reliable method for the assessment of peat strength *in situ*.

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D. Nichol, G.K. Doherty & M.J. Scott reply: We are grateful for the discussion by Long & Boylan and thank them for their kind remarks.

Although we accept that using the vane test in peat has shortcomings, it remains one of the simplest field procedures available. Provided that limitations and accuracy are appreciated and findings are taken in context, we consider it plays a worthwhile role as an aid to understanding peat profiles (see Radforth, 1969, pp. 129–136).

We are particularly pleased that the application of an alternative testing method that we were previously unaware of has been brought to our and the wider geotechnical community's attention, and look forward to investigating its use in peat in the future.

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