View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by Crossref

Houlsby, G. (2004). *Géotechnique* **54**, No. 10, 615

Editorial

Editorials in *Géotechnique* appear only infrequently, and are usually devoted to announcements or to administrative matters. I hope readers will not regard it as an abuse of privilege if I use this Editorial to address a technical matter: the principle of effective stress.

When Terzaghi formulated the principle of effective stress he resolved a whole class of otherwise incomprehensible problems relating to the interactions between soil and water. His theory is so fundamental to our discipline, that one could almost adopt the definition of a 'soil mechanic' as 'someone who understands the principle of effective stress'.

The principle is so all-pervading that perhaps we give it too little thought, and many geotechnical engineers would in fact be hard pressed to provide a concise and rigorous definition of the principle. In teaching soil mechanics I have found it useful to divide the principle into two halves. The first is purely a definition: the effective stress is *defined* as the total stress minus the pore pressure $\sigma' = \sigma - u$. The second is a hypothesis: that the mechanical behaviour of soils is governed solely by the effective stress.

To test the hypothesis we need to be a little more precise about what we mean by 'mechanical behaviour', which is something of a catch-all for strength, stiffness and other aspects of behaviour. A slightly more rigorous statement of the hypothesis would be that the strains in a soil depend solely on the effective stresses (and their history). This hypothesis is testable experimentally, and has repeatedly been shown to be accurate for saturated soils, except in certain rather unusual circumstances.

The success of the principle cannot be simply because of chance: there must be an 'explanation' as to why it is so accurate. Several different explanations have been proposed. The classical one involves the assumption that soil behaviour is governed principally by the forces at relatively small particle-to-particle contacts, and considerations of equilibrium show that these in turn depend only on the effective stresses. Other explanations have been proposed based, for instance, on concepts of work, energy and thermodynamics. Of course several explanations may all be valid (as long as they are consistent) but different ones may prove more convincing to different people.

If the principle is so well established, and so successful, why is it worth addressing now? The reason I do so is because of its restriction to saturated soils only. The understanding of the behaviour of unsaturated soils has received a huge amount of attention (for instance in the 2003 *Géotechnique* Symposium in Print). In spite of much excellent research, an accepted fundamental principle for unsaturated soils has yet to emerge with the clarity and applicability that Terzaghi's principle achieves for saturated soils.

It is in this context that I think it is useful to divide the principle into the two stages of definition and hypothesis. In the science of unsaturated soils there are many possible quantities that can be defined: total stress minus pore water pressure, total stress minus pore air pressure, total pressure minus some combination of the two, etc. There is much debate about which is the 'right' generalisation of Terzaghi's effective stress, and several new names have been coined. It is important to realise that there is no 'right' or 'wrong' in the matter of the definition: each author is at liberty to define whatever quantity they like (although the plethora of new terms can be confusing). It is only when the hypothesis is introduced that the theory becomes testable, and the goal is of course to find the definition of a stress on which the mechanical behaviour solely depends. If, however, an author defines a quantity as 'effective stress' it is important that they explicitly state whether they are implying the hypothesis as well as the definition.

The above somewhat over-simplifies the picture, as it is now widely recognised that the mechanics of unsaturated soil is (almost certainly) not explicable in terms of a single 'effective stress', but that a further variable (e.g. the difference between the pore air pressure and pore water pressure) is needed too. Even so, the unequivocal identification of the best choice of two variables on which to base the hypothesis has not, I believe, yet been achieved.

It is a challenge to our readers to achieve the same breakthrough for unsaturated soils that Terzaghi did for saturated materials. We need clear definitions, empirical proof that the mechanical behaviour of unsaturated soils does indeed depend on the chosen variables, and preferably a satisfying 'explanation' in terms of well-articulated principles. It is not an easy task.

On a slightly different note, I can announce that Professor Simon Wheeler of Glasgow University has been invited to give the 2005 *Géotechnique* Lecture: he has studied the issues I have described above for several years, and I look forward to his lecture.

Prof. Guy Houlsby, Oxford University
Honorary Editor

Downloaded by [] on [03/10/21]. Copyright © ICE Publishing, all rights reserved.