Soil mechanics theory slammed by experts

GREATER ATTENTION needs to be paid to the looping process of field observation and theoretical development, if theoretical developments in modern soil mechanics are to serve geotechnical design, according to geotechnical engineers at a recent meeting in London.

During the debate 'Does modern theoretical soil mechanics serve geotechnical design?' organised last month by the ICE Ground Board, modern theoretical soil mechanics was given a comprehensive critique.

Of the three invited contributions only Dr Brian Simpson of Ove Arup, a former Rankine lecturer, made any attempt to support soil mechanics.

While accepting that 'prediction of events in the working state remains very difficult', Simpson described the application of new theory in a variety of areas. He pointed out that critical state concepts have introduced the understanding of safe states. Realisation that soil stiffness is highly non linear has helped explain why earlier theoretical methods over predicted movements. He said very recent laboratory-based research on particle crushing and stiffness anisotropy have already been incorporated in complex geotechnical projects, using the foundations for London's proposed Millennium tower and settlement predictions resulting from tunnelling on the Jubilee Line Extension as examples.

Simpson was the first of many during the evening to emphasise the need to more closely interact field observation and theoretical development. But he also warned against the recent obsession of measuring increasingly small strain stiffnesses 'which are of little practical significance,' and said that calculation must not loose contact with what is measured.

Summing up his contribution, Simpson said he thought theory supported design but added 'what we learn from theoretical developments must be carefully weighed against the recorded experience of previous constructions'.

In contrast Ken Fleming of Kværner Cementation Foundations suggested that soil mechanics framework needs a comprehensive overhaul. 'There are two big problems in soil mechanics,' he said, 'its practice and its theory.'

Fleming added that as a young engineer he believed most of what he was told, but now he questions more and more. Fleming expressed concern that 'as an industry many questions are addressed only in a muddled way'.

'Theory of design makes very little effort to account for construction affects,' he said, 'which can be either favourable or unfavourable depending on circumstances.'

Fleming continued by saying that published papers curtail original thinking, and then briefly put forward an alternative framework in which soil behaviour can be described by stress-strain-time functions. 'Soil mechanics is simply a branch of material science,' he said, 'but soil mechanics research mostly side steps the subject of time functions which are commonly accepted in material science.' He asked 'are we looking into the wrong end of the telescope?'

Fleming, a widely recognised expert in pile behaviour, claimed that in predicting pile settlement he has not used soil mechanics consolidation theory for ten years, but instead uses linear fractional functions. These he said could equally be used to predict the sagging of electricity cable between pylons or the extension of nylon fishing line.

Malcolm Puller, the final speaker, revisited Terzaghi's 1939 James Forrest lecture, in which Terzaghi described the successful application in the 1920s and 1930s of new soil mechanics 'to correct the widely used but ill-conceived rules of thumb methods of the time'.

Having done so, Puller suggested: 'A sceptic might conclude that the last 60 years has not shown as much progress in soil mechanics theory as the 25 years reviewed by Terzaghi.'

Puller continued with the observation that the problem may partly lie in that many geotechnical designers do not understand modern theory, a point later supported from the floor by David Muir Wood of Bristol University who said 'we should be asking whether geotechnical design takes advantage of modern theory'.

Puller however then went on to identify problems where soil mechanics theory could not help the designer make safe and economic decisions.

While much of the debate skirted around the perennial geotechnical concerns of poor site investigation and whether research should be pure or applied, William Powrie of Southampton University eloquently steered the debate back on course by pointing out that it is very easy to save millions of pounds on good design, and this buys a lot of research. Data collection, said Powrie, 'is futile if you do not have the theory to hang it on. If data does not fit the model then you need a better model, this process of looping needs to be more widely practised'.

This was supported by Arup Geotechnics' David Twine, who believed the loop is currently over extended on the analytical side, and research must switch to taking very good measurements because researchers are short of data and input parameters.

Twine's colleague Duncan Nicholson made the sensible observation that the correct use of soil mechanics closes the gap between predicted and measured performance, perhaps providing the closest the evening came to a consensus view.