Collapse Behaviour of Sand: Discussion

The authors appreciate Chu's continuous interest in sand behaviour. Chu suggests that constant deviator stress path achieved by controlling the back pressure may not be a "drained" stress path and hence, he compares the test procedures and results to instability or collapse induced by undrained condition (Lade et al 1988; Lade and Pradel 1990). Further, Chu postulates that the same test results can be achieved if the constant deviator stress paths were followed by changing cell pressure while keeping the back pressure constant. Therefore, he concludes that instability or collapse can only occur when continuous increase in pore water pressure is permitted.

In response to these comments the authors have the following remarks. A drained stress path can be followed by changing the effective confining stresses. The change in effective confining stress can be achieved by either changing the cell pressure while keeping the back pressure constant or changing the back pressure while keeping the cell pressure constant during triaxial loading. The triaxial samples would experience essentially similar changes in effective confining stress when a given stress path is followed by controlling the back pressure or cell pressure. The sand behaviour is governed by the effective confining stress and not by cell pressure or back pressure. Hence, a given stress path followed by controlling the back pressure or cell pressure would yield essentially similar behaviour for a given void ratio of a sand. It is the rate of change in effective confining stress, sand permeability and the drainage boundary conditions that determine whether a stress path is "drained" or "undrained" regardless of whether the stress path is followed by controlling the back pressure or cell pressure.

In this study, the triaxial samples were allowed to drain freely during the constant deviator stress path. The reduction in effective confining stress of 55 kPa for the 125 kPa deviator stress test took approximately 10 minutes and the reduction in effective confining stress of 160 kPa for the 100 kPa constant deviator stress path took approximately 35 minutes. During sample consolidation, for a 50 kPa effective confining stress increment the volume change became stable or constant within a minute. Thus, the rate of reduction in effective confining stress during constant deviator stress paths were very slow compared to the sand permeability and associated drainage path. Therefore, the sand samples would have drained freely during the constant deviator stress paths. During these free draining constant deviator stress paths the instability or collapse was triggered at particular stresses and void ratio by the structural re-arrangement of the sand particles. The small volume change observed during the constant deviator stress path is due to the elastic behaviour of the sand due to the unloading and not due to undrained conditions.

As a continuation of the present study, constant deviator stress path tests have been performed on very loose dry sand by changing the cell pressure (Skopek et al 1994). Pre-failure collapse and large deformation was also observed for dry sand when constant deviator stress paths tried to cross the state boundary. Large deformation during dry sand testing clearly showed that the increase in pore pressure is not a prerequisite for pre-failure instability or collapse. It is the structural rearrangement of sand grains that causes large volume changes which manifests as pore pressure increase in saturated sands. More details regarding the collapse process, stress paths and state boundary surface is presented by Sasitharan et al 1994. Dry sand testing by Skopek et al 1994 also shows that pre-failure collapse or instability can also be achieved by changing the cell pressure.

To the authors knowledge, there have not been any reported pre-failure instability or collapse in medium dense or dense sand. Further, medium dense and dense sand post peak/failure behaviour (Chu et al 1993) can not be simply compared to the loose sand pre-failure collapse behaviour without some framework that incorporates a state boundary.

References

Sasitharan, S., Robertson, P.K., Sego, D.C. and Morgenstern, N.R., 1994. State boundary surface for very loose sand and its practical implications. Accepted for publication, Canadian Geotechnical Journal, June.

Skopek, P., Morgenstern, N.R., Robertson, P.K. and Sego, D.C., 1994. Collapse of Dry Sand. Accepted for publication, Canadian Geotechnical Journal.