Behaviour of locked sand during cavity expansion

Stephanus Jacobus van Eeden

The oil sand deposits in Alberta, western Canada, are a peculiar material in relation to the conventional understanding of the stress-dilatancy and drainage properties of sands. These deposits have a dense locked sand structure with high viscosity bitumen occupying a large portion of their void space. Steam Assisted Gravity Drainage is a method widely used for extraction of oil from these deposits and is known to cause shear dilation in the undepleted material surrounding the continuously growing underground pressure chamber. The geomechanics of the process results in an increase of the absolute permeability of the soil skeleton, resulting in increased fluid flow which aids the extraction process. A lack of reliable information complicates design modelling of these underground reservoirs and the geomechanical enhancements are often neglected. Therefore cavity expansion, in the form of a pressuremeter testing, has been proposed as an alternative method for gathering insitu material data from these deposits. The self-boring pressuremeter is an insitu testing tool with which reliable material parameters can be obtained at appropriate stress levels, but has not yet been used to test the behaviour of locked sands saturated with viscous oil. The current research used a combination of laboratory scale testing and finite element modelling to investigate the behaviour of locked sand subjected to drained cavity expansion. The derived set of input parameters was found to correlate well with conventional triaxial compression results and the stress dilatancy theory in literature. Other specimens were saturated with 30 000 cSt silicone oil to study the generation of localised excess pore pressures during quasi-static cavity expansion in dense sand. A sequence of dissipation stages were used to study the change in drainage characteristics with increasing shear dilation. The distribution of diffuse dilation taking place in a finite volume of dense sand during cavity expansion was investigated using a combination of resin impregnation and computed tomography scanning. Overall, the research illustrated that there is potential for using a combination of cavity expansion and consolidation theory to study the change in permeability due to shear dilation of dense sands, if saturated with a sufficiently viscous fluid, as is the case for oil sands.