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Recovery of strength along shear surface in clay soils

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Studying the stability of old landslide is usual to assume that the operative shear strength along old failure surface is the residual one. So in the reactivation of old quiescent landslide it is not possible to have progressive failure because the minimum shear strength has just been reached along the whole shear surface. In this way it is not explainable how old quiescent landslide can be reactivated with brittle failure and progressive failure mechanism. To have this type of phenomenon it is necessary to suppose that there is the possibility to have a recovery of strength along the shear surface of landslide during the quiescence time. In this way it is possible also to explain how landslide stopped in a limit equilibrium condition can be remain stable for long periods without being subject to continuous reactivation. not always are. Recovery of strength along shear surface made it possible also to explain the observed delay in the reactivation of old landslide in clayey materials after seismic shocks. The delay is the time that has to be considered necessary to the develop of progressive failure.

It is well know hat remoulded clay leave in quiescence is subject to an increment of stiffness and shear strength with time, also if the clay material is not subject to variation of volume or water content. This phenomenon is called thixotropy. Along a shear surface in clay soils, when the landslide movement stops clay particles are normally iso-oriented. In that moment the energy applied to clay particles by landslide movement drop to zero, and the particles can flocculate in to a different fabric with a low energy level. In this way clay particle flocculating assume a different fabric that can be characterized by an higher value of shear strength allowing in this way a recovery of strength along the shear surface. During the quiescence period when the energy given by the shear movement is absent the arrangements of clay particles evolve toward the minimum energy fabric that can be different respect to the minimum strength fabric as a function of the clay mineralogy and of the chemistry of pore water.

To analyse this phenomenon a lot of tests on clay samples have been developed using

Bromhead ring shear apparatus. In the tests residual strength has been reached and than the movement of the apparatus has been stopped simulating the stop in landslide movement. After a quiescence time of different duration test has been started again evaluating the stress strain behaviour of clay sample. The test has shown that recovery of strength are present along the shear surface and that the stress stain behaviour is characterized by a brittle failure after that the strength along the shear surface fall again to the residual value until there is movement along the shear surface. The amount of shear strength recovery is function of the quiescence time and it grown up as a linear function of the logarithm of the quiescence time.

Test have been developed using Italian blue clay samples of medium plasticity (WL = 45%) and a smectite clay sample of really high plasticity (WL = 192%). Test have been developed using different values of the normal stress and changing the pore water chemistry by mean of a long leaching processes.

Tests results have shown that the amount of recovery of strength in percentage decrease with the increase of vertical load, while it grown with the salt content in pore water and with the plasticity of the clay. It is due to the fact that the phenomenon is related to the electrochemical forces between clay particle and pore water. When in the interaction between clay particle electrochemical forces have a relevant percentage role respect to mechanical forces (low normal stress; low plasticity clay) there are more severe recovery of strength because clay particles have an higher freedom degree in the rearrangements of their fabric, obtaining more rigid structure. When the mechanical forces between clay particles are much more higher than electrochemical one (High normal stresses, leached clays, low plasticity clay) it is difficult to a have a good clay particle rearrangement and recovery of strength are less relevant.

Analysing stress-strain behaviour after the recovery of strength it appears that stiffness and brittleness are conditioned by the same factors. For low normal stress the stiffness and the brittleness are higher. When normal stress increase there is a decrease of stiffness and of brittleness. Variation of pore water chemistry as a consequence of leaching has no effects on the stiffness but induce a decrease of brittleness. The duration of the quiescence period is do not affect in relevant way stiffness and brittleness.