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Graphite Black shale of Vendas de Ceira, Coimbra, Portugal

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The graphite black shale of Vendas de Ceira located in south of Coimbra (Portugal), caused serious instability problems in recent road excavation slopes. The problems increased with the rain, transforming shales into a dark mud that acquires a metallic hue when dried. The black shales are attributed to the Devonian or eventually, to the Silurian.
At the base of the slope is observed graphite black shale and on the topbrown schist. Samples were collected during the slope excavation works. Undisturbed and less altered materials were selected. Further, sampling was made difficult as the graphite shale was covered by a thick layer of reinforced concrete, which was used to stabilize the excavated surfaces.
The mineralogy is mainly constituted by quartz, muscovite, ilite, ilmenite and feldspar without the presence of expansive minerals. The organic matter content is 0.3 to 0.4%.
The durability evaluated by the Slake Durability Test varies from very low (Id2 of 6% for sample A) to high (98% for sample C). The grain size distribution of the shale particles, was determined after disaggregation with water, which allowed verifying that sample A has 37% of fines (5% of clay and 32% of silt) and 63% of sand, while sample C has only 14% of fines (2% clay and 12% silt) and 86% sand, showing that the decrease in particle size contributes to reduce durability. The unconfined linear expansion confirms the higher expandability (13.4%) for sample A, reducing to 12.1% for sample B and 10.5% for sample C.
Due the shale material degradated with water, mercury porosimetry was used. While the dry weight of the three samples does not change significantly, around 26 kN/m3, the porosity is much higher in sample A with 7.9% of pores, reducing to 1.4% in sample C. The pores size vary between 0.06 to 0.26 microns, does not seem to have any significant influence in the shale behaviour. In order to have a comparison term, a porosity test was carried out on the low weatherable brown shale, which is quite abundant at the site. The main difference to the graphite shale is the high porosity of the brown shale with 14.7% and the low volume weight of 23 kN/m3, evidencing the distinct characteristics of the graphite schists.
The maximum strength was evaluated by the Schmidt hammer, as the point load test could not be performed as the rock was very soft. The maximum estimated values on dry samples were 32 MPa for sample A and 85 MPa for sample C.
The results show a singular material characterized by significant heterogeneity. It can be concluded that for the graphite schists the smaller particle size and higher porosity make the soft rock extremely weatherable when decompressed and exposed to water, as a result of high capillary tension and reduced cohesion. They also exhibit high expansion and an enormous degradation of the rock presenting a behaviour close to a soil.
The graphite black schist is a highly weatherable soft rock, without expansive minerals, with small pores, in which the porosity, low strength and low cohesion allow their rapid degradation when decompressed and exposed to the action of Water.