

# Influence of Anisotropy on the Swelling Properties of Alentejo Flysch Rocks (Portugal)

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## 1 INTRODUCTION

This paper aims to contribute to the knowledge of the swelling properties for the rock materials belonging to the Baixo Alentejo Flysch Group (BAF) in the south of Portugal. These formations are flysch-type deposits constituted by sequences of usually thick greywacke beds alternating with thin soft shale beds, which include sometimes intercalations of conglomerate beds. All the sedimentation of these flysch formations was controlled by tectonics. At the same time, should have occurred along with the first Hercynian deformation phase, a low-grade metamorphic event (chlorite zone), that affected these flysch deposits.

The geotechnical characterization is a difficult task, mainly in shales, due to the anisotropy and heterogeneity of these rock materials. The anisotropy verified in some properties is caused by foliation, which besides making the sample preparation difficult to the laboratory tests, it also gives rise to a scattering of the measured properties values, as for example, the swelling, the strength and the deformability. The heterogeneity is related to the typical characteristics of the BAF flysch formations, where thinly stratified greywacke and soft shale beds are common, which sometimes may affect the laboratory tests results making them less representative.

The heterogeneity and anisotropy revealed in the rocks of BAF, are also verified at rock mass scale. The rock masses of BAF are characterized by a great structural complexity, with intense folding and shearing, that affects the flysch formations with alternation of shales and greywackes beds with distinct mechanical properties. As a result of its complex structure, the rock masses of BAF present a weathering zone with irregular boundaries, sometimes several metres unlevelled between the fresh to slightly weathered rock mass and the highly to completely weathered rock mass constituted by soft rocks and residual soils.

In this study, an attempt is made to evaluate the swelling properties of these flysch rocks, mainly of the soft shales, in what concerns to the assessment of the influence of anisotropy on the swelling behaviour of these rock materials.

## 2 METHODOLOGY

The study is made by using both shales and greywackes that constitute these flysch-type deposits in order to evaluate their swelling properties, mainly of the soft shales. A laboratory swelling testing program was carried out on a set of sound or slightly weathered specimens of shale and greywacke. These samples were selected to test the rock materials according to three different orientations of the foliation with respect to the axis of the specimens (0°, 45° and 90°), in order to evaluate the anisotropy of these materials in this physical property.

The swelling tests were performed according to the method suggested by ISRM (1999), which allows the determination of axial and radial deformation by free swelling of a clayey rock sample, unconfined, when immersed in water. This case study is part of a more comprehensive experimental study, about these rock materials, described in previous works (Pinho 2003, Pinho et al. 2004, Pinho et al. 2007, Pinho et al. 2009 and Pinho et al. 2015).

## 3 RESULTS AND CONCLUSION

Some considerations will be made from the results obtained in the study about physical properties of these flysch rocks, mainly the shales ones, relative to the assessment of the influence of anisotropy of these rock materials on their swelling behaviour.

**KEYWORDS:** Swelling properties, soft rocks, anisotropy, laboratory testing, Baixo Alentejo Flysch Group.