

# Geotechnical factors affecting rock slope stability in Gaia riverside (NW Portugal)

H.I. Chaminé, M.J. Afonso, R. Santos Silva, P.F. Moreira, J. Teixeira

*Laboratório de Cartografia e Geologia Aplicada (LABCARGA/ISEP), Dep. Eng. Geotécnica, Instituto Superior de Engenharia do Porto/ISEP, Portugal; and Centro GeoBioTec/UA. (hic@isep.ipp.pt)*

J.F. Trigo

*LABCARGA/ISEP, Dep. Eng. Civil, Instituto Superior de Engenharia do Porto/ISEP, Portugal.*

R. Monteiro

*Câmara Municipal de Vila Nova de Gaia, Portugal.*

P. Fernandes, S. Pizarro

*TECNOGEO – Tecnologia em Geotecnia, Lda, Lisboa, Portugal.*

Rockfall and landslides are awfully common processes in slope urban areas. Rock slope instabilities are among those which can cause most damage for human activities, often originating economic losses, property damages and maintenance costs, as well as injuries or fatalities. The study of discontinuous rock mechanics on rock masses has developed enormously. It has been recognized that discontinuities have a major influence on the mechanical properties of a rock-mass, namely on slopes. Slope failure mechanisms resulting unlike failure types (e.g., plane sliding, wedge failure, partial toppling and buckling) and are dependent on the orientations of slope and discontinuities. For constructions, such as slopes, foundations and shallow tunnels it has been recognized that discontinuities have a major influence on the mechanical properties of a rock mass. This perception has major consequences for the assessment of the engineering behavior of a rock-mass. Engineering geology descriptions, engineering geological maps and calculations for engineering structures in/or on a rock-mass have to include discontinuity.

The present work presents the results of a combined geological and geotechnical studies of the Afurada granitic slopes, in order to better understand the rock slopes stability on a fragile area – Porto and Vila Nova de Gaia riverside downtown (NW Portugal, Iberian Peninsula) – with a historical record on slopes rockfall activity. Gaia is one of the largest cities in Portugal with a constant need for urban development and expansion. Porto and Gaia cities are built along the hillsides on a littoral platform characterized by a quite regular planation surface dipping gently to the west. This platform was cut by the Douro River in a steep-walled valley with sharp and high slopes that constitutes the so-called riverside downtown with its typical entrenched geomorphological framework.

The scanline sampling technique of discontinuities has been applied to the study of basic geotechnical description of free rock-mass faces. In order to classify the quality of the granitic rock-mass, basic Rock Mass Rating (RMR) and Slope Mass Rating (SMR) geomechanical classification systems were applied, and the Geological Strength Index (GSI) was estimated. Afurada rock-mass exposure is constituted by medium to fine grained granite, two-mica, sheared (Afurada/Arrábida granitic unit) which outcrops slightly to moderately weathered and locally highly weathered. The slope area is an important scarp fault, trending NE-SW, limited at the top by the Afurada Church and at the base by the river Douro. Afurada slope area showed historical signs of active small to medium failures and there have been reported rockfall events. The preliminary susceptibility failure of the rock slope was evaluated in terms of the computed SMR values. The interdisciplinary methodology proved to be valuable to a better understanding of rock slope stability and it can be applied to the accurate prediction of future slope instabilities. A structural and geotechnical solution for the stabilization of the slopes is outlined.