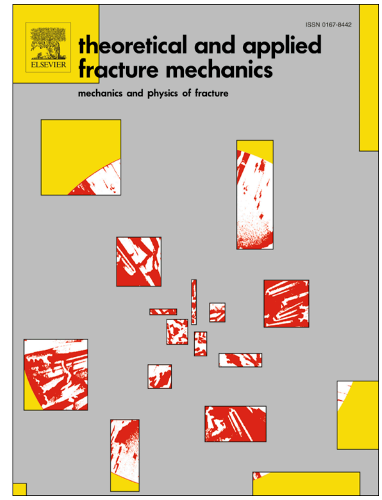
Accepted Manuscript



Notch effect on the fracture of several rocks: application of the theory of critical distances

J. Justo, J. Castro, S. Cicero, M.A. Sánchez-Carro, R. Husillos

PII: S0167-8442(17)30248-3
DOI: http://dx.doi.org/10.1016/j.tafmec.2017.05.025
Reference: TAFMEC 1877

To appear in: *Theoretical and Applied Fracture Mechanics*

Received Date: 11 May 2017
Revised Date: 24 May 2017
Accepted Date: 24 May 2017

Please cite this article as: J. Justo, J. Castro, S. Cicero, M.A. Sánchez-Carro, R. Husillos, Notch effect on the fracture of several rocks: application of the theory of critical distances, *Theoretical and Applied Fracture Mechanics* (2017), doi: http://dx.doi.org/10.1016/j.tafmec.2017.05.025

NOTCH EFFECT ON THE FRACTURE OF SEVERAL ROCKS: APPLICATION OF THE THEORY OF CRITICAL DISTANCES

J. Justo[a], J. Castro[a*], S. Cicero[b], M.A. Sánchez-Carro[c], R. Husillos[d]

[a]Group of Geotechnical Engineering, Universidad de Cantabria, E.T.S de Ingenieros de Caminos, Canales y Puertos, Av/ Los Castros 44, 39005, Santander, Spain
[b]LADICIM (Laboratory of Materials Science and Engineering), Universidad de Cantabria, E.T.S de Ingenieros de Caminos, Canales y Puertos, Av/ Los Castros 44, 39005, Santander, Spain
[c]Group of Engineering Geology. Universidad de Cantabria, E.T.S de Ingenieros de Caminos, Canales y Puertos, Av/ Los Castros 44, 39005, Santander, Spain
[d]Group of R+D+i Cartographic Engineering and Mining, Escuela Politécnica de Ingeniería de Minas y Energía, Boulevard Ronda Rufino Peón nº 254. 39316 Torrelavega – Cantabria.

* Contact person: castrogj@unican.es

ABSTRACT

The paper analyses the fracture behaviour of several rocks, namely a sandstone, a limestone and two marbles, one of them being a Carrara marble. The experimental program comprises in total 216 fracture specimens, tested in 4-point bending conditions and including specimens with notch radii varying from 0.15 mm up to 15 mm. The notch effect is analysed through the evolution of the apparent fracture toughness and the application of the Theory of Critical Distances.

The present study aims to generalize a previous study on a granite and a limestone to a broader range of rocks. The point and line methods of the Theory of the Critical Distances successfully explain the notch effect on the fracture specimens. The value of the critical distance of these rocks is of the order of mm. Finally, the results show a correlation between the microstructural features of the rocks, specifically the grain size, and their critical distances.

KEYWORDS: Notch effect, Apparent fracture toughness, Theory of Critical Distances, marble, sandstone, limestone.

1. INTRODUCTION

It is well known that stress risers have a direct influence on the load-bearing capacity of structural components no matter what their nature: cracks, notches, holes, etc. Their presence plays a key role in the analysis of the corresponding structural integrity, and there are different approaches depending on the kind of stress riser that is studied. With regard to rocks, they cannot be considered a homogeneous continuum due to the small discontinuities like microcracks, pores, grain boundaries, etc. that accompany the rock matrix. These defects act as stress risers generating stress concentrations around them, leading to crack initiation and propagation and, eventually, to brittle failure. This problem can be of interest for several fields within civil (e.g., slopes, foundations), mining (e.g., tunnelling, drilling) and energy engineering (e.g., exploitation of geothermal energy). In addition to the above geometric aspects, stress concentration can also be caused by loading conditions such as bending and torsion, which tend to concentrate stresses at the surface leading to stress gradients. However, this paper will focus on the effect of geometric features, since loading stress concentration is generally negligible in comparison to the other aspects [1].

Microscopic defects are certainly likely to be found in geological materials. However, notches or defects with relatively large radii should not use the same expression as cracks to describe the stress field near the defect. Stress fields in the notch tip have already been modelled by numerous authors who generally observe a stress reduction acting perpendicular to the notch plane [2-5]. This stress reduction becomes more significant with the increase in the notch radius, which means that a given component will have a higher