Experimental determination of the critical COD of rock-like materials using Digital Image Correlation

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Introduction: Crack Opening Displacement (COD) is a convenient tool for the quantification of the capacity of materials containing crack-like defects to deform before crack extension. In addition its critical value (i.e. its value at the crack initiation moment) is often used as a 'geometric' fracture criterion. In spite of some doubts regarding its natural foundation [1] COD is an irreplaceable tool especially for in-situ applications. In this context the COD is determined here experimentally for rock-like materials in an effort to determine the load-COD relation and to explore the dependence of the critical COD on the dimensions of the notch with respect to the size of the specimens used.

Experimental procedure: Direct tension tests with Double Edge Notched Tensile (DENT) specimens and 3-Point Bending (3PB) tests with Single Edge Notched (SEN) specimens were carried out (Fig.1). The specimens were made either from marble or porous stone (materials used extensively for restoration projects of various cultural heritage monuments [2]). The experiments were quasi-static under displacement control mode at a rate of 0.2 mm/min. The force was measured using a 50 kN load cell calibrated with a certified compression ring of sensitivity 10.62 N. The response of the cell was linear throughout the load range of interest and the deviation did not exceed 0.3%. The displacement was calibrated using a certified micrometric calibrator. Again the response was linear and the deviation did not exceed 0.5%. The displacements around the notch-tip were measured using a novel non-contact 3D Digital Image Correlation (DIC) system by LIMESS. In addition the Notch Mouth Opening Displacement (NMOD) was measured using a suitable clip-gauge.

Fig.1 Typical specimens

Results and discussion: The experimental results (Fig. 2) indicate that for relatively small notch length the critical COD strongly depends on the geometric characteristics of the specimen, in accordance to the results of previous studies [3]. Only for "sufficiently long" notches the critical COD becomes geometry independent and therefore it can be used as a fracture criterion, independently from the procedure used for its determination. In other words after a material dependent threshold it is the presence of the notch itself that plays a crucial role rather than its size. In addition it was proved that the results obtained from DENT and SEN specimens were almost identical at least for relatively long notches. The values of the critical COD obtained from extrapolation of the clip gauge data for the NMOD were in qualitative agreement with those of the DIC, however some quantitative deviations were observed.

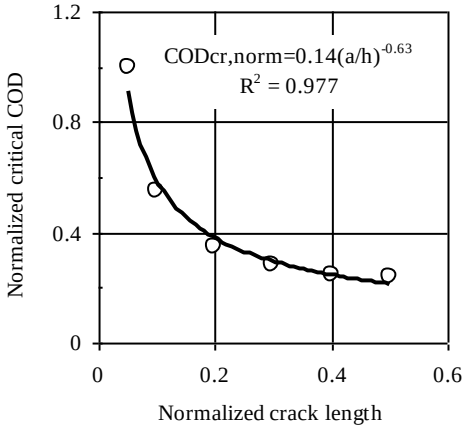

Fig.2 The dependence of critical COD on the notch depth

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