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SIZE EFFECT IN CRACK PATTERN OF NATURAL AND MAN-MADE MATERIALS

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Depending on the scale of observation, many engineered and natural materials show different mechanical behaviour. Thus, size effect theories, based on a multiscale approach, analyse the intrinsic (due to microstructural constraints, e.g., grain size) and extrinsic effects (caused by dimensional constraints), in order to improve the knowledge in materials science and applied mechanics (Bazant and Planas 1997). Nevertheless, several problems regarding Solid Mechanics and Materials Science cannot be solved by conventional approaches, because of the complexity and uncertainty of materials proprieties, especially at different scales. It is sufficient to think, for instance, to the concept of void nucleation, or to localisation of deformations at microscopic level produced by the non-linear phenomena occurring at mesoscopic level (Collini, 2010).

For this reason, a simple model, capable of predicting crack patterns at different scale, has been developed and presented in this paper. This model is based on the Golden Ratio, which was firstly defined by Euclide as: "*A straight line is said to have been cut in extreme and mean ratio when, as the whole line is to the greater segment, so is the greater to the less*". Intimately interconnected with the Fibonacci sequence (1, 2, 3, 5, 8, 13, . . .), this number controls growth in Nature and recurs in many disciplines, such as art, architecture, design, medicine, etc.. As for the classical tension-stiffening approach, the Golden Ratio permits to define the relationship between the average crack spacing and the thickness of quasi-brittle materials. In these cases, the theoretical results provided by the Golden Ratio, used to calibrate a size-effect law of crack spacing, are in accordance with the experimental measurements taken in several test campaigns (Ladeira and Price 1981; Mandal 1994; Fantilli and Chiaia 2013, Chiaia et al. 2013) carried on different materials (i.e., rocks, ice, and concrete).

Thus, we argue that the centrality of the Golden Ratio in the crack pattern of quasi-brittle materials has profound physical meanings and reveals the existence of the size-effect law of crack spacing. As a consequence, by means of the proposed model, the crack pattern of large structures can be simply and rapidly predicted, without knowing the material performances but by testing prototypes of the lower dimensions.

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