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APPLICATION OF FRACTURE MECHANICS TO ASSESS THE CONCRETE DAMAGE DUE TO CYCLIC FREEZING AND THAWING

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The modelling of the behavior, damage and fracture processes of concrete is extensively discussed in the literature [1-3, 5]. The fracture mechanics as one of the most significant field of science, is widely used to analyze the material behavior in structure. The various issues related to concrete properties as well as the durability of concrete structures are explained by the presence of defects or by initiation and propagation of cracks in concrete microstructure. The relation between microstructure evolution and macroscopic response is crucial in design and modelling of heterogeneous materials. Considering the heterogeneous microstructure of concrete and other cement based materials and their low resistivity to initiation and propagation of cracks, the typical average strength parameters are not fully sufficient for description of their behaviour in structural element under load. The fracture mechanics methods allow analyzing the failure process of this sort of materials as well as the degradation evolution due to environmental influence [3].

The fracture mechanics parameters are used in different applications to formulate the classic criteria of failure as well as in the advanced computational methods for the analysis of structures made from concrete and other brittle materials.

The models based on fracture parameters need the experimental validation. The damage and failure of concrete structures can only be understood if the deterioration of microstructure is properly included in the modelling. The critical stress intensity factor K_{Ic}^{s} is the parameter widely used in the failure criteria. The material parameter K_{Ic}^{s} depends on the service life condition of concrete structure. Other parameters, such as fracture energy G_F or crack tip opening displacement $CTOD_c$, are also sensitive to the changes in concrete microstructure [4].

Apart from the mechanical load, the environmental influence may also have to be taken into account for appropriate description of concrete's behavior. The behavior of concrete subjected to a variety of physical processes is important engineering challenge. Assuming the fracture parameters are strongly influenced by flaws development in concrete microstructure, they can be useful to assess the internal degradation process caused by the influence of environmental destructive factors. The paper deals with the durability of concrete and the variations in K_{Ic}^{s} for concrete subjected to cyclic wetting, freezing and thawing, which cause the internal cracking. Frost damage is the typical deterioration in concrete structures in the countries with subzero temperature conditions [2, 4, 5]. It is advisable to validate the existing models considering the results of experimental investigation because not considering the variability of this parameter under service life conditions properly may lead to inadequacy of the model. The data from experimental tests are indispensable for proper understanding the physical phenomenon and provide the numerical tools (accurate and efficient models) for predicting its evolution in time [1, 2]. The experimental findings have to be used as an input to validate the proposed model formulation, which in turns provides a further physical understanding the material behavior.

In the presented study the fracture parameters were determined in a three-point bend test on concrete beams with initial notches, after freeze/thaw cycles. Beside K_{Ic}^{s}, other concrete properties were analyzed. The optical microscopy was applied to microstructure defects identification. The significant changes in the *P*–CMOD plot for specimens after different number of freeze/thaw cycles were observed. The test results obtained allowed analyzing the variations in the fracture parameters due to environmental influence. The analysis of results revealed the applicability of fracture mechanics methods to study the process of freeze/thaw damage accumulation in concrete. Thus, they may be used for the prediction of concrete structure durability.

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