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Evaluation of Fracture Tests of Concrete Specimens via Advanced Tool for Experimental Data Processing

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Abstract: Cement-based composites are traditionally used building materials. Concrete is the basic representative of this type of materials which exhibit the so called quasi-brittle response. Quantification of mechanical fracture parameters is performed using fracture tests on specimens with a stress concentrator. Load versus crack mouth opening displacement (*P–CMOD*) diagrams are recorded during these tests. In order correctly to evaluate these diagrams an advanced own developed software tool was used for the data filtering and appropriate modifications. In this paper, the programmed Java utility is generally introduced and its utilization demonstrated on the set of recorded *P–CMOD* diagrams, which are further evaluated using Double-*K* fracture model.

Introduction

Concrete is the most commonly used material in civil engineering structures. Its resistance to stable crack propagation expressed via values of mechanical fracture parameters such as fracture toughness, fracture energy, tensile strength, modulus of elasticity etc., is quantified through evaluation of fracture tests on specimens with a stress concentrator – typically the three-point bending test or wedge splitting test (WST). Records from these experiments in the form of diagrams showing load versus deflection or load versus crack mouth opening displacement (*P–CMOD* diagrams) are evaluated using one of relevant fracture models; the *P–CMOD* data are typically processed/purified for further analysis.

Double-*K* fracture model presents one of such approaches; it combines concepts of the cohesive crack model and the equivalent elastic crack model. Its advantage is that it describes different levels of crack propagation: an initiation part which corresponds to the beginning of stable crack growth (at the level where the stress intensity factor, K_{Ic}^{ini}, is reached), and a part featuring unstable crack propagation (after the unstable fracture toughness, K_{Ic}^{un}, has been reached).

In the presented research, the GTDiPS software for filtering and other modifications the recorded diagrams is introduced in general features. Subsequently, this software is applied on the set of *P–CMOD* diagrams from wedge splitting tests on concrete specimens. Further, in this way the modified diagrams are evaluated using Double-*K* fracture model.

Fracture tests and methods of evaluation of the recorded data

Cube-shaped specimens were prepared and subjected to wedge splitting test (see Fig. 1) at the Research Center of Building Construction and Maintenance, Vienna University of Technology (TU Wien). For details of the concrete mixture, specimen curing and preparation for the fracture test see the full-length paper.

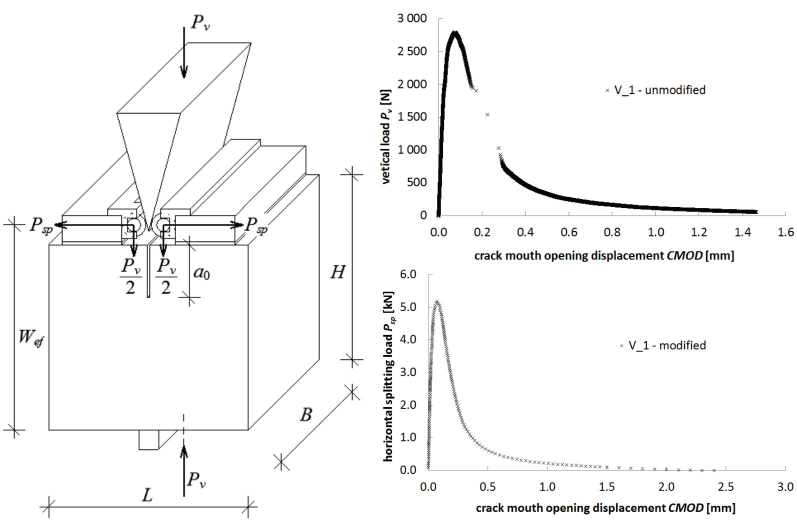

Fig. 1: Wedge splitting fracture test geometry (a), recorded P_v–*CMOD* curve (b), processed P_{sp}–*CMOD* curve (c)

The GTDiPS application serves for processing extensive point sequences by using advanced transformation methods. Each point sequence may contain an arbitrary number of dimensions. The GTDiPS application offers an intuitive GUI for efficient work with transformation methods as well as for browsing and saving the results. The recorded P_v–*CMOD* point sequences (see Fig. 1b) are purified and transformed by a number of implemented techniques into P_{sp}–*CMOD* sequences for their further processing via fracture models.

From the processed diagrams the input data for the Double-*K* fracture model were deducted, i.e. the maximum load $P_{sp,max}$ and its corresponding critical crack mouth opening displacement $CMOD_c$, and the load $P_{sp,i}$, which is deducted from the linear part of the diagram, and its corresponding $CMOD_i$ value. Subsequently, the unstable fracture toughness K_{Ic}^{un} and the cohesive fracture toughness K_{Ic}^{c} were calculated. For details on the numerical procedure with the implemented Double-*K* fracture model see the full length paper. Note that special shape function (*K*-calibration curve) for calculation of the values of fracture toughness and compliance function for calculation of the value of critical effective crack length were created for the utilized test geometry based on ANSYS FEM calculations.

Results

Mean values (and coefficients of variation) of selected results – after eliminating far-off measurements – are summarized in Table 1: elasticity modulus *E*, fracture toughness K_{Ic}^{un}, and the K_{Ic}^{ini}/K_{Ic}^{un} ratio, i.e. the ratio expressing the resistance to stable crack propagation, respectively.

Table 1: Mean values of selected parameters (coefficients of variation in %)

	E [GPa]	K_{Ic}^{un} [MPa·m$^{1/2}$]	K_{Ic}^{ini}/K_{Ic}^{un} [–]
V set	28.4 (9.1)	0.941 (9.5)	0.204 (30.3)

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