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# EVALUATION OF WEDGE-SPLITTING TEST RESULTS FROM QUASI-BRITTLE PRISMATIC SPECIMENS USING THE DOUBLE-*K* FRACTURE MODEL

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**Abstract:** . *The fracture-mechanical parameter values of concrete, a quasi-brittle composite material, are determined from records of experiments on specimens with stress concentrators. One of the fracture models applicable to concrete is the double-K model. This model combines the concept of cohesive forces acting on the effective crack increment with a criterion based on the stress intensity factor. The outputs of the model are critical crack tip opening displacement and fracture toughness values, including the initiation stress intensity factor value corresponding to the beginning of stable crack propagation. In this paper, a method of calculation by means of the double-K fracture model is verified using published data and the results of a pilot wedge-splitting test performed by the authors.*

**Keywords:** ***Double-K fracture model, concrete, prismatic specimen, wedge-splitting test.***

## 1. Introduction

Cement-based composites are one of the most widely used building materials. Concrete may be classified as a so-called quasi-brittle material. Studying the mechanical response of specimens made of such composites under static and dynamic/fatigue loading is complicated due to their highly nonlinear nature. Numerical tools for modelling both elastic (elastic-plastic) behaviour and also the fracture process are commonly used to predict or assess the response of structures fabricated from quasi-brittle materials. Such tools − often based on the finite element method or physical discretization of the continuum − are usually equipped by exploiting a type of nonlinear fracture model simulating the cohesive nature of cracking of quasi-brittle material. The parameters of this fracture model are determined from records of fracture tests; this is carried out either using evaluation methods built on the principle of the used non-linear fracture model, e.g. the work of fracture method or the size effect method, or using inverse analysis with the possible application of advanced identification methods.

The utilization of existing methods for the evaluation of test records can result in the obtaining of fracture parameter values influenced by both the size and shape of the test specimen and the test geometry (the boundary conditions of the test). Such parameters cannot be used as relevant inputs to an analysis using the above-mentioned numerical tools. A similarly distorted description of the fracture may be indirectly caused by utilization of the methods for evaluation of the fracture model parameters – through the identification methods used – if this procedure is applied to the results of only one type of test and specimen size/shape. The effects of the specimen's size/geometry/free boundaries directly affect the recorded load–deflection or the load–crack mouth opening displacement diagram by means of which the inverse analysis is carried out.

Research into the above-mentioned effects of the characteristics of the specimen or the test has been the subject of considerable attention in recent decades. Various methods are used for the determination of the characteristics of fracture models for concrete test geometries on notched specimens; the three-point bending of notched beams or wedge-splitting of compact notched

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specimens are among the most common. The model referred to as the "double *K*" (double-*K* or double-*G*) is similar in this respect. In principle, this model combines the concept of cohesive forces acting on the faces of the fictitious (effective) crack increment with a criterion based on the stress intensity factor (SIF). This model can determine the critical crack tip opening displacement and the fracture toughness and is capable of describing different levels of crack propagation: an initiation part, which corresponds to the beginning of stable crack growth (at the level of reaching the stress intensity factor), and a part featuring unstable crack propagation (after reaching the unstable fracture toughness).

In this paper, a selected method of calculation exploiting the double-*K* fracture model parameters is verified using published data (Zhang & Xu, 2011). Subsequently, it is employed in processing the results of the authors' own pilot wedge-splitting test performed on a prismatic concrete specimen ("Specimen 2" in Tab. 1). Note that the shape function of the wedge-splitting test specimen used in the evaluation procedure was prepared from data published in Seitl et al. (2011).

## 2. Evaluation of the wedge-splitting test on concrete specimens: results

This paper is primarily focused on the functionality of the double-*K* fracture model. The results of the calculations of the values of selected parameters of this model can be found in Tab. 1. The values in parentheses for "Specimen 1" are taken from Zhang & Xu (2011).

*Tab. 1: The resulting values.*

| Parameter | Symbol | Unit | Specimen 1 | Specimen 2 |
|---|---|---|---|---|
| Critical effective crack length | $a_c$ | mm | 119.59 (119.84) | 31.62 |
| SIF (unstable fracture) | $K_{Ic}^{un}$ | MPa·m$^{1/2}$ | 1.557 (1.557) | 0.918 |
| SIF (cohesive toughness) | $K_{Ic}^{c}$ | MPa·m$^{1/2}$ | 0.868 (0.885) | 0.141 |
| SIF (initiation toughness) | $K_{Ic}^{ini}$ | MPa·m$^{1/2}$ | 0.689 (0.672) | 0.777 |
| Critical crack tip opening | $CTOD_c$ | mm | 0.03992 (0.03938) | 0.101 |

## 3. Conclusions

The concept of the double-*K* fracture model is not currently used in the Czech Republic (except for in a study reported in the paper Keršner & Matesová (2001), which focused on three-point bending of notched prismatic concrete specimens), but the worldwide scientific and professional public interest in this model has recently been increasing. In this paper, the utilization and results of a method for calculation of the double-*K* fracture model parameters were shown. The procedure was programmed and verified using published data and the results of the authors' own pilot wedge-splitting test. The applicability of the used approach was demonstrated via the comparison of the evaluated results of WST experiments on prismatic-shaped concrete specimen with published data.

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