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NUMERICAL PREDICTION OF PARASITIC ENERGY DISSIPATION IN WEDGE SPLITTING TESTS ON CONCRETE SPECIMENS

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Abstract: *Undesirable energy dissipation taking place during wedge-splitting tests on cementitious composites and resulting in overestimation of the values of the determined fracture-mechanical characteristics of the tested materials is investigated in this paper via numerical simulations performed using a commercial finite element method tool with an implemented cohesive crack model. The rather broad range of cohesive behaviour of the studied materials was simulated through adjustments made to the corresponding characteristic length of the composite. The parasitic amount of energy is dissipated in fracture processes around the corners of the groove for the insertion of the loading platens. This amount was extracted from simulated load-displacement curves; it is observed that the amount considerably depends on the specimen proportions and only slightly on the level of material brittleness.*

Keywords: ***wedge-splitting test, concrete fracture, specimen proportions, energy dissipation, numerical simulation***

1. Introduction, motivation, problem description

The wedge splitting test (WST, Linsbauer & Tschegg, 1986) can be conveniently used for measuring the fracture-mechanical parameters of quasi-brittle building materials, particularly cement-based composites. The desirable failure propagation in the area of the ligament of the test specimen, i.e. starting at the specimen's notch tip and propagating towards the opposite surface of the specimen (Fig. 1a left), can be accompanied by parasitic failure around the other considerable stress concentrator(s) – the corner(s) of the groove for inserting the loading platens (Fig. 1a right). The amount of energy released in such failures is not being separated from the energy consumed in the desired fracture process within ordinary testing and evaluation procedures. Therefore, noticeable errors in the values of fracture parameters may arise in some cases depending on the specimen's proportions and the test configuration. The paper presents the results of a numerical study conducted in order to develop and propose a solution applicable in the evaluation of classical fracture-mechanical parameters via the wedge-splitting test.

2. Numerical simulations, evaluation of the parasitic failure energy release

The amount of mechanical energy dissipated in the undesirable failure processes around the groove corners can be quantified based on the difference between the work of fracture in the desirable and undesirable failure mode cases. Therefore, two variants of the model were prepared: *i)* a reference variant with the constitutive model for quasi-brittle material used throughout the entire specimen volume (marked as *V1*), and *ii)* an artificial variant with elastic material around the groove corners (*V2*). The differences between the two models are indicated in Fig. 1b. The subtraction of the areas under the load–displacement curves corresponding to the reference and alternative model gives an estimation of the amount of energy dissipated in the failure around the groove corners, see Fig. 1c.

The numerical study was conducted using a commercial finite element (FE) tool with an implemented cohesive crack model governing the tensile failure – ATENA 2D software (Červenka et

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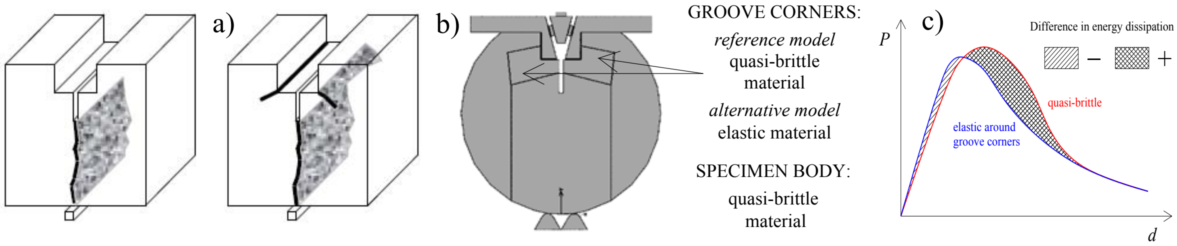

Figure 1: a) Desirable (left) and undesirable (right) types of failure of the WST specimen, b) illustration of both the reference and alternative geometric model, c) sketch of the evaluation of energy dissipated in failure around the groove corners

al., 2005). For modelling of the cementitious composite material of the specimen a fracture-plastic material model was used. Several material sets were created in order to simulate cementitious composites of a relative wide range of material (quasi-)brittleness, i.e. ranging from rather ductile softening composites (for instance those reinforced with fibres) to nearly brittle ones (for instance cement pastes). The model was created also in variants with different relative notch lengths α to investigate the effect of the notch length on the parasitic energy dissipation. Further details on both geometrical and material model are given in the full-length paper and Holušová (2012).

3. Discussion, conclusions

The work of fracture values were calculated from the load−displacement diagrams simulated for the *V1* and *V2* model variants. The difference between the two were expressed also in relative values (with respect to the entire value of work of fracture of the specimen). The absolute (see Fig. 2) and relative quantities representing the energy release around the corners of the groove for inserting the loading platens into the WST specimen are in detail presented and discussed in the full-length paper; Here we only note that their trends correspond to the graphical representations of the simulated failure.

The main conclusions from the study on the particular case of the size and shape of the WST specimen can be summarized in the following points: *i)* The amount of energy dissipated additionally around the groove corners decreases with increasing notch length; for short notches (α less than 0.1) it can take a proportion of the entire dissipated energy ranging from 3 to 10 %. For notches with a relative length greater than approx. 0.25 the effect becomes negligible. *ii)* An increase in the absolute amount and a slight decrease in the relative amount of parasitic energy dissipation with increasing characteristic length are observed. Verification of these results via another simulation method as well as experimental validation of the basic conclusions of this study is planned for future research.

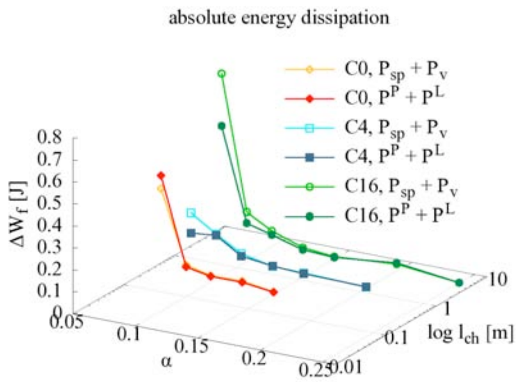

Fig. 2: The amount of absolute energy dissipation around groove corners as a function of the relative notch length and the characteristic length of the composite

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