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NUMERICAL ANALYSIS OF CRACK PROPAGATION IN A PULL-OUT TEST

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The authors of this paper performed series of computer analyses of a pull-out test in which a pre-set self-undercut anchor is pulled out of a material surface. Those analyzes were performed in Abaqus program. It was modeled in 2D stress state as an axially symmetrical task. To simulate the crack the meshless X-FEM method was used [1].

The main goal was to obtain the critical force, that divides the model into two separate elements, where one is a pulled-out cone. The other goal was to obtain the crack path. These analyzes are intended to create a method, that allows to predict the critical force for any brittle material and for any length and shape of anchor. The first attempt to solve this problem was described in previous author's work [2]. The authors decided to use different sandstone types initially. Mechanical parameters for this material were obtained from laboratory tests. The sandstone material was modeled as linear-elastic with Young modulus $E = 9.287$ GPa, Poisson ratio $v = 0.415$, tensile strength $f_t = 2.35$ MPa and critical strain energy release rate for mode I $G_{Ic} = 0.0921$ N/mm. Tensile strength is the stress that initiates the crack ("Maxps" criterion). The crack tip model is a cohesive zone model, with a stabilizing viscosity coefficient that does not allow the crack to wide open in the tip zone.
The damage evolution softening is linear, with mode-independent behavior. It is interesting that the force grows all the time of described simulation, not decrease after the appearance of the crack. In all simulations the angle between the model outer surface and the crack path was ca. 25°. This means that the pulled-out cone is quite wide. Near the top surface of the model the crack runs almost parallel to the surface, but in some simulations the crack returns deep into the model area, and in other cases it breaks vertically. In all simulations the force started to decrease here.

The accuracy of computer methods of calculating critical force in pull-out test will be improved in the future researches.

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