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FINITE ELEMENT CONTACT-IMPACT ALGORITHM IN EXPLICIT TRANSIENT ANALYSIS

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Abstract: *This work addresses three issues in computational modelling of contact-impact problems: i) overviews a contact algorithm proposed by these authors, ii) local search treatment based on the modification of the Nelder-Mead simplex method, iii) discusses an algorithmic aspects of contact algorithm in conjunction with the explicit time integration scheme. The talk closes with the presentation of several numerical examples including the longitudinal impact of two thick plates, for which analytical solution is available.*

Keywords: ***FEM, contact-impact, explicit dynamics, local contact search***

In the context of the finite element method, a frictionless three-dimensional contact-impact algorithm using pre-discretization penalty formulation was proposed (Gabriel et al., 2004). The key feature of this algorithm is that the local search and the penalty constraint enforcement are performed on the Gausspoint level of linear/quadratic serendipity elements rather than the nodal level of a finite element mesh. The method is shown to be consistent with the variational formulation of a continuum problem, which enables incorporation of higher-order elements with midside nodes to the analysis. Owing to a careful description of kinematics of contacting bodies when the non-linearized definition of penetration has been introduced, the displacement increments in the course of one load step are permitted to be large. Thus, the extension to geometrically nonlinear problems is straightforward. The algorithm proves to be robust, accurate and symmetry preserving—no master/slave surfaces have been introduced.

In proposed algorithm the local search represents measuring penetration of a Gauss point through the counterpart's object surface. It is necessary first to define the outward normal and then to compute its intersection with a curved surface, establishing distance. Although appearing trivial at first glance the numerical solution process is far from being easy, especially when dealing with severely distorted surfaces. In Ref. (Gabriel et al., 2010) several methods for the solution of non-linear algebraic systems were thoroughly tested: the Newton-Raphson method, the least square projection, the steepest descent method, Broyden's method, BFGS method and the simplex method. The effectiveness of these methods was performed by means of the benchmark configuration of distorted contact segment from static solution of bending of two rectangular plates over a cylinder (Gabriel et al., 2004). The most fitting method turned out the modification of the Nelder-Mead simplex method (Nelder and Mead, 1965), which belongs to very popular and simple direct search technique that has been widely used in unconstrained optimization problems. It is represented by the move of triangular simplex (2D) in space based on the values of minimized functions at the vertices of the triangle using several parameters: reflection, contraction, and simplex size. It is shown that the proposed local search procedure strongly improves the robustness, accuracy and computational cost of the transient dynamic analysis.

The algorithm is fully compatible with the explicit time integration scheme. Its dynamic behaviour is tested by means of a contact-impact problem of two thick colliding plates (Brepta and Valeš, 1987). Although the penalty method usually suffers from the well-known undesirable oscillations the algoritm performs well. It should be pointed out that the proclaimed symmetry is also perfectly preserved. Apart from this, the influence of numerical dispersion is taken into account (Plešek et al., 2010).

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