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THE NONLINEAR NUMERICAL ANALYSIS OF SOLID MECHANICS PROBLEMS USING MESHLESS METHODS

Jorge Belinha[1], Lucia Simas Dinis[2], António Augusto Fernandes[1,2] and Renato Natal Jorge[1,2]

[1] Institute of Mechanical Engineering (IDMEC-FEUP). Rua Dr. Roberto Frias S/N, 4200-465 Porto, Portugal. jorge.belinha@fe.up.pt

[2] Faculty of Engineering of University of Porto (FEUP). Department of Mechanical Engineering. Rua Dr. Roberto Frias, 4200-465 Porto, Portugal. ldinis@fe.up.pt; aaf@fe.up.pt; rnatal@fe.up.pt

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This work shows the potential and efficiency of meshless methods in the numerical analysis of highly demanding nonlinear solid mechanics problems. Two meshless methods are used in this work: the Element Free Galerkin Method (EFGM) [1] and the Natural Neighbour Radial Point Interpolation Method (NNRPIM) [2].

Within the EFGM the nodal connectivity is imposed using the concept of influence-domains and the background integration mesh is obtained using a Gauss-Legendre quadrature scheme, very similar with the Finite Element (FEM) procedure. The shape functions are constructed using the Moving Least Square (MLS) approximants technique, which leads to shape functions lacking the delta Kronecker property. The most important disadvantage of the MLS approximation shape functions is that the essential and the natural boundary conditions cannot be directly imposed as in the FEM. Therefore, in order to impose the essential boundary conditions the penalty method is used in this work.

The NNRPIM is a truly meshless method capable to enforce organically the nodal connectivity using the influence-cell concept, which is obtained from the Voronoï diagram mathematical construction. In addition, the Voronoï diagram allows to construct a node-depending background integration mesh, required in the numerical integration of the integro-differential equations ruling the studied physical phenomenon. The NNRPIM interpolation functions, which are constructed using the Radial Point Interpolators (RPI), possess the delta Kronecker property, simplifying the imposition of the natural and essential boundary conditions.

In the nonlinear elastoplastic analysis it is adopted a constitutive model considering classical metal plasticity, assuming the von Mises yield criteria and incompressibility in the plastic regime. In this comparison study only isotropic elastoplastic bilinear materials and small deformations are assumed. The used non-linear solution algorithm is the Newton-Raphson initial stiffness method and the efficient "forward-Euler" procedure is used in order to return the stress to the yield surface [3]. In order to demonstrate the effectiveness of the method, elastoplastic benchmark examples are analysed. In addition, the meshless methods efficiency is shown with other demanding nonlinear analyses, such as the study of benchmark examples considering large deformations assumptions, the prediction of the crack propagation path in brittle materials and the enforcement of contact.

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