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SIMULATION OF GROUND EXCAVATION PROCESSES WITH THE PARTICLE FINITE ELEMENT METHOD (PFEM)

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ABSTRACT

We present a new application of the Particle Finite Element Method (PFEM) [1–4] for the modeling of excavation problems.

Lagrangian descriptions of motion of the continuum medium are the natural way of describing motion in solid mechanics. Particle finite element methods are based in these solid mechanics settings that can treat large material deformations and rapidly changing boundaries. These capabilities are very suitable for modelling fluid motions and moving free surfaces.That is the reason that the most of the research and applications of PFEM can be found up-to-date in the context of computational fluid dynamics (CFD) instead of solid mechanics. The good results in modelling fluid-structure interaction problem have been the motivation to use the PFEM in dynamic solid mechanics.

The simulation of an excavation process is a non-linear dynamic problem. It includes geometrical, material and contact non-linearities. Modelling the contact process can be seen as the main difficulty. The simulation faces the problems of: detection of a changing geometry, detection of contact between several solid domains, estimation of correct interacting forces, computation of the wear related to this contact forces and removal of the material that has been excavated from the model.

The method have its fundamentals in classical non linear finite element analysis. The formulation is based on the updated lagrangian formulation for solids. The dynamic problem is integrated using an implicit scheme. Remeshing strategies are employed in order to identify the boundary surfaces. A remeshing of the domain is introduced for the detection of rapidly changing boundaries. The extended Delaunay Tessellation and the Alpha Shape concept together, are used as a methodology for contact detection between domains [1–4]. An interface mesh is created for contact recognition. This interface mesh is used for the contact treatment. A particular constitutive contact law has been developed for capturing contact normal and frictional forces. By means of an Archard-type law, the excavation and damage caused in the ground is quantified. The erosion and wear parameters of the ground under study govern the excavation processes that is effectively modelled with the PFEM.

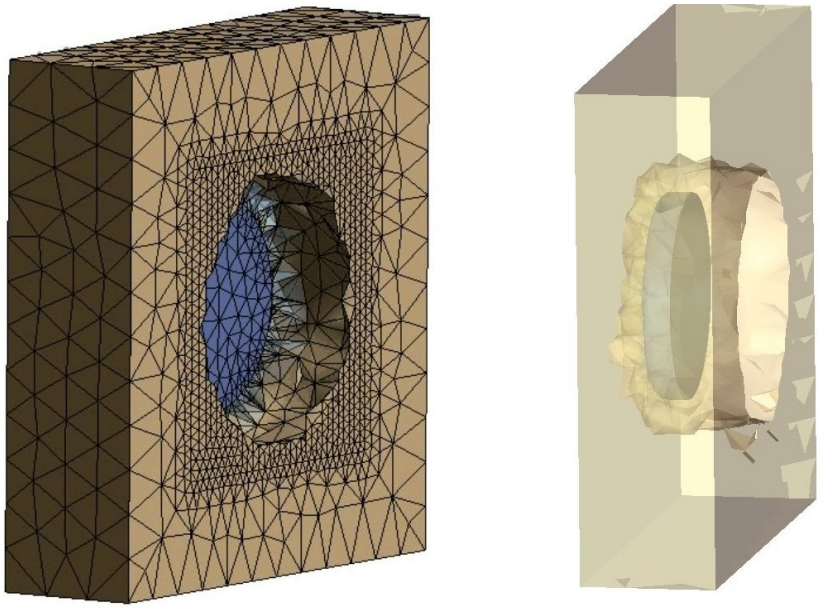

Figure 1: Simulation of an excavation with a TBM using the PFEM

Preliminary results obtained show that PFEM is as a very suitable tool for the analysis and simulation of excavation problem. The method also allows to model the wear of the rock cutting tools in a simple and economical way. The computational cost of the method is cheap compared with other methods, such as the DEM (Discrete Element Method), typically employed for this type of problems. A good characterization of the ground mechanical property is however needed. Examples of application of the PFEM to a number of 2D and 3D excavation and rock cutting processes are presented showing the efficiency of the PFEM for this type of problems.

REFERENCES

[1] Idelsohn, S.R., Oñate, E., Calvo, N. and del Pin, F., "A lagrangian meshless finite element method applied to fluid-structure interaction problems". *Computer and Structures*, Vol. **81**, 655–671, 2003.

[2] Oñate, E., Idelsohn, S.R., Del Pin, F. and Aubry, F., "The particle finite element method. An overview. *Int. J. Comput. Methods*, Vol. **1**(2), 267–307, 2004.

[3] Idelsohn, S.R., Oñate, E. and Del Pin, F., "The particle finite element method a powerful tool to solve incompressible flows with free-surfaces and breaking waves". *Int. J. Num. Meth. Engng*., Vol. **61**, 964–989, 2004.

[4] Oñate, E., Celigueta, Miguel A. and Idelsohn. "Modeling bed erosion in free surface flows by the particle finite element method", *Acta Geotecnica*, Vol. **1**(4), 237–252, 2006.

[5] Peter Wriggers, *Computational Contact Mechanics*. Ed.Springer, second edition. 2006.