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In this paper, a numerical model for studying the dynamics of landslides is presented. The modelling of landslides is performed with the aid of the generalized interpolation material point method (GIMP) [1]. The basic idea of the method is to combine a Lagrangian material description, in which the soil is divided into a set of material points, with a spatial grid for solving the equations of motion. Data is transferred between the two descriptions using GIMP interpolation functions. A self-contained overview of the GIMP method is included in the paper. The GIMP method provides several advantages. Notably, contact between different materials is automatically handled, constitutive behaviour is considered separately for each material point and problems associated with degeneration of a computational mesh are avoided.

The focus of the paper is to understand the evolution of slides by numerical simulation. Using an elasto-plastic material model, based on the Mohr-Coulomb yield criterion, the computational procedure for studying landslides is as follows

- Stresses are determined for a stable slope
- A landslide is triggered
- The dynamical evolution of the slide is modelled.

Landslides are studied for a simple slope, with a house at the top of the slope. The calculation of the initial stress distribution in the slope is based on a procedure in which the gravitation is applied in an incremental fashion. Analysis shows that this procedure yields stresses that are in almost exact agreement with commercial finite element software. The failure of the slope is triggered by reducing the strength of the soil, so that plastic material behaviour is encountered. By performing a dynamical time integration, the landslide is modelled from the triggering, during the landslide and until the soil has again reached a state of equilibrium.

Parameter studies have been performed by varying the soil properties and the number of material points, respectively. By simulating the landslide, for a cohesion-less soil using different angles of internal friction, the slide behaviour of different soil types has been investigated. The results show that the model can be applied to a variety of soil behaviour from slow, small deformation to rapid slides where an almost liquid-like behaviour of the soil is observed. A study using a varying number of material points shows that finely discretized models are necessary to capture the features of the landslides. A fine discretization is especially required to simulate parts of the soil leaving the bulk of material during the slide and to simulate the behaviour of the house during the landslide.

It is concluded that the GIMP method provides a promising tool for modeling rapid, large strain geotechnical problems. However, several limitations of the presented model need to be considered. Firstly, due to the complex nature of the problem, comparison between the model and physical data has not been performed. Secondly the application of an elasto-plastic material model is not realistic during the part of the landslide involving the most rapid displacements. The application and verification of more advanced material models is the target of future research.

References

1 S. Bardenhagen, "The Generalized Interpolation Material Point Method", Computer Methods in Engineering and Science, 5, 477-495, 2004.

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