

# Using non-smooth multi-domain dynamics to improve the safety on haul roads in surface mining

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## ABSTRACT

Safety berms are used on haul roads of surface mines to protect haul trucks from rolling over an edge and to avoid collisions. Their current design is based on rules of thumb. However, their behaviour is still poorly understood and accidents, where haul trucks collide or run over safety berms, are still happening on a regular basis. Hence, the industry is interested in a more rigorous design approach involving numerical modelling. An attempt to provide a deeper understanding of the problem using non-smooth multi-domain dynamics has been made within the presented research. Thereby the haul truck and the safety berm are modelled by means of a strongly coupled approach of non-smooth multi body dynamics and non-smooth discrete elements [1].

The numerical model of the truck is developed by combining rigid bodies with interconnected ideal joints. Starting from a CAD model of the truck, first so-called kinematic loops are established and then kinematic constraints describing the possible motion characteristics are introduced. The dynamics of the vehicle are described by the same equations of motion which are used to describe the dynamics of the material of the safety berm represented by rigid spherical particles using the non-smooth discrete element method (NDEM). The numerical model is first calibrated using full-scale data from experimental tests [2] and then applied to investigate the collision between the haul truck and safety berms of various safety berm geometries under different approach conditions. An extensive numerical analysis based on five representative scenarios is carried out. The scenarios include: a reversing truck at moderate velocity, head-on collision at high velocity, collision at shallow approach angle, collision at shallow approach angle on ramp and collision due to side-wise sliding. The results of the simulations allowed to provide design guidelines that assist the mining industry in providing safer haul roads.

## REFERENCES

- [1] Algoryx Simulation (2017). AgX Multiphysics. <http://algoryx.se>.
- [2] A. Giacomini and K. Thoeni, "Full-scale experimental testing of dump-point safety berms in surface mining", *Canadian Geotechnical Journal*, **52**(11), 1791–1810 (2015).