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On the Dynamic Response of Equant Rocks after a Rock-Tree Interaction

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Understanding rockfall dynamics and identifying in advance the best mitigation solution preventing the associated damages are key counter-measures to such landslides. In mountainous regions forest often acts as a natural barrier that impedes a potentially large influencing area coming along with falling blocks. A good management of forest in its risk-mitigating functionality calls for a thorough comprehension of rock-tree interactions on both micro- and macro-scales. For this sake Toe et al. (2017, 2018) have employed discrete element method (DEM) to model an impacting, spherical rock on a single tree stem and have further developed the so-called block propagation models accounting for the behaviour of a spherical rock after interacting with several trees on a slope. Their crucial findings point to the fact that the given rock's kinematics after impacting trees are mainly governed by the following parameters: the impact velocity, eccentricity, and the tree diameter. It is concequently a major concern whether their conclusions still hold for generally shaped rocks.

Hence this study implements the non-smooth mechanics coupled with hard contact laws following Leine et al. (2014) and Lu et al. (2018) to solve a non-spherical rock-(single) tree interaction problem. Firstly, we have investigated whether our modelling framework, i.e. modelling the tree stem as a rigid, non-deformable body, would produce the comparable observations for spherical rock-tree collisions as reported by Toe et al. (2017). Subsequently, rocks of the same mass have been altered into different shapes, i.e. a cubic shaped rock, an equant shaped rock (a standardized boulder shape regulated by the official European Technical Assessment Approval Guidelines), and several approximately equant shaped rocks obtained by constructing convex hulls using points randomly generated on a spherical surface. The aim of the corresponding rock-tree collisional simulations is to reveal how an equant rock's dynamic response changes with its surface 'blockiness' during the rock-tree frontal, lateral and scratch impacts. Here the surface blockiness of a rock is characterized using its surface area divided by that of the volume-equivalent sphere, e.g. sphere has a value 1 while cube has a value 1.24. Finally, the rock-tree interaction results obtained in this work have been extended to build macro-scale models linking the rock's surface blockiness quantity with its dynamic behaviour, i.e. energy dissipation and trajectory change after impacting with a single tree. This study lays a solid foundation for our next research, where achieving more insight into elongated and flattened rock-tree impacts is the focus.