NONLINEAR INTERACTIONS BETWEEN SLIDING BLOCKS ON AN INCLINED SURFACE

K.T. Chau*, X.X. Wei†, L.L. Zheng†, and R.C.K. Wong&

*Department of Civil & Structural Engineering, The Hong Kong Polytechnic University, Kowloon, Hong Kong, China
cektchau@polyu.edu.hk

† Department of Applied Mechanics, School of Science & Technology, Beijing Institute of Technology, Beijing, China

& Department of Civil Engineering, University of Calgary, Calgary, Alberta, Canada

Motivated by its application to progressive process of landslides, a nonlinear multi-sliding block model is developed. The interaction force between adjacent blocks and base friction are both modeled as nonlinear functions, allowing for yielding and the development of residual shear stress respectively. Simulations were conducted for 1 to 50 blocks sliding on a slope angle of 30 degrees. It was found that linear stability analysis of the system of coupled differential equations does not yield good prediction of the equilibrium state due to the highly nonlinear nature of the sliding law and the inter-block interactions. Perturbations in terms of initial velocity was imposed separately to the top block, top two blocks, top three blocks,… and so on in different simulations. The magnitude of the initial perturbations, as expected, affects the overall sliding instability from the top block to the lowest block (i.e. whether all blocks eventually sliding down-slope with an ever increasing speed or not). It was found that a very complicated mechanism exists in the evolution of the sliding process. For example, if the top 30 blocks of a 50 blocks model are pushed initially, the interaction force between blocks propagates upward from the 20^{th} block (note that the 1^{st} block is at the base and the 50^{th} block is at the top of the slope) as a function of time. The interaction force develops because the inertia of the initially non-stationary lowest 20 blocks resists the sliding of upper blocks. When the compressional wave of interactions propagate to the 50^{th} block, another reflection of "relaxation wave" was observed. It was found that sliding velocity at block 41 does not drops to a constant value after the resistance wave passes by, but instead it increases again. This difference in sliding velocity between blocks 40 and 39 gradually increases such that there is no more wave reflections in the upper 9 blocks. However, there is a very complex resistance wave developed in the interaction force between block 41 to block 29 in subsequent times. But the relative displacement for block 29 to block 1 is found not large enough to generate wave reflection patterns in the lower blocks. Therefore, in this case these blocks are overall stable. The exact wave pattern however very much depends on the nonlinear parameters of the model. This pattern also affects whether the subsequent sliding is stable or not (i.e. whether unstable sliding of blocks occur that simulate landslides).

The present model opens up a whole new opportunity in investigating the nonlinear interactions between multi-sliding-blocks.