Discrete element modelling of the shrinkage-induced fragmentation of a thin brittle layer

Zoltán Halász*† and Ferenc Kun*†

*Institute for Nuclear Research, Hungarian Academy of Sciences (Atomki), P.O. Box 51, H-4001 Debrecen, Hungary
e-mail: fiser@atomki.mta.hu

†Department of Theoretical Physics, University of Debrecen, P.O. Box 5, H-4010 Debrecen, Hungary
Email: ferenc.kun@science.unideb.hu - Web page: http://dtp.atomki.hu/~feri

ABSTRACT

Layers of heterogeneous materials attached to a substrate often undergo sequential cracking due to shrinkage stresses caused by desiccation, mismatch of thermal expansion co-efficients, or by stretching or compression of the substrate. From the spectacular crack patterns of dried out lake beds through the polygonal ground patterns of permafrost regions to the formation of columnar joints in cooling volcanic lava,shrinkage-induced cracking is responsible for a large variety of complex crack structures in nature [1].

We investigate the effect of the amount of disorder on the shrinkage-induced cracking of a thin brittle layer attached to a substrate. Based on a discrete element model we study how the dynamics of cracking and the size of fragments evolve when the amount of disorder is varied. In the model a thin layer is discretized on a random lattice of Voronoi polygons attached to a substrate. Two sources of disorder are considered: structural disorder captured by the local variation of the stiffness and strength disorder represented by the random strength of cohesive elements between polygons. Increasing the amount of strength disorder, our calculations reveal a transition from a cellular crack pattern, generated by the sequential branching and merging of cracks, to a disordered ensemble of cracks where the merging of randomly nucleated micro-cracks dominate. In the limit of low disorder, the statistics of fragment size is described by a log-normal distribution; however, in the limit of high disorder, a power-law distribution is obtained [2].

REFERENCES

[1] L. Goehring, A. Nakahara, T. Dutta, S. Kitsunezaki, and S.Tarafdar, “Desiccation Cracks and Their Patterns: Formationand Modelling in Science and Nature”, (John Wiley & Sons, NewYork, 2015).

[2] Z. Halász, A. Nakahara, S. Kitsunezaki, and F. Kun, “*Effect of disorder on shrinkage induced fragmentation of a thin brittle layer*”, Phys. Rev. *E, Vol. 96*, 033006, (2017).