Variability in breakage load of pebbles in gravels, or: Does shape really matter?

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In gravel, pebbles are subjected to a number of point loads from surrounding grains. Single pebble breakage in gravel occurs if these loads generate a critical stress that exceeds the strength of the pebble. Due to the natural ellipsoidal shape of pebbles, different geometric loading configurations on pebbles may appear in gravels and generate stress fields that differ in magnitude and size. This results in a variability in the breakage load of a single pebble. Thus, the loading configuration also represents a breakage controlling factor, apart from the magnitude of the load induced by the overburden.

In this study, the effects of different theoretical loading configurations (translation and rotation of the contact points, the combination of both, solution pitting and ellipticity) on pebble breakage were investigated. The configurations were studied using the finite element method in two dimensions, which is capable of investigating scenarios impractical for physical tests. The calculated stress distributions were used to predict the breakage load for the specific configuration by a maximum tensile stress based failure criterion. This allowed a comparison of the results with the physical breakage load distribution of fluvial pebbles obtained from point-load tests and an evaluation of the significance of the different configurations on single pebble breakage in gravel. The results of numerical modeling indicate that the most preferred fracture orientation is perpendicular to the longest pebble axis, and most of the investigated geometrical configuration effects lead to an increase in breakage load. These results coincide with the findings at an investigated gravel outcrop in a gravel pit south of St. Margarethen (Burgenland, Austria).