Relation between the collapse of force-chains and grain loops evolution in granular materials

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Abstract:

This study focuses on the mesoscale mechanism of the two dimensional granular materials, involving 2 structures: the force-chains and the grain loops [3], as shown in figure 1. These two structures are the essential elements that contribute to the behavior of the specimen, sharing a very close relation. By using the discrete element method, a dense 2D specimen of a spherical particles assembly is investigated. The purpose is to point out the connection between the stability of the force-chains and the attached grain loops around the force-chains during their life span. On the other hand, the second order work [1][2] is also taken into account as an instability criterion. In this way, the evolution of the second order work of grain loops is tracked over the loading path, in order to point out a relation between force chains buckling and vanishing of second-order work.

It is shown that during the life span of force-chains, the grain loops of 3 particles (loop-3) and of 6 particles (loop-6) show a consistent trend: the number of attached loop-3 decreases over time, and on the contrary, the number of loop-6 increases. The evolution suggests that there is a transition phase from loop-3 to loop-6, from the moment the force chains are created, till the moment they collapse (figure 2).

Moreover, the evolution of the second-order works of attached loop-3 and loop-6 shows that, respecting to time, the second-order work of attached loop-3 is greater than the attached loop-6, as shown in figure 3. This result ensures that the loop-3 is more stable than the loop-6.

Key words: microstructure, DEM, force-chains, grain loops, second-order work, collapse, instability

Illustrations:

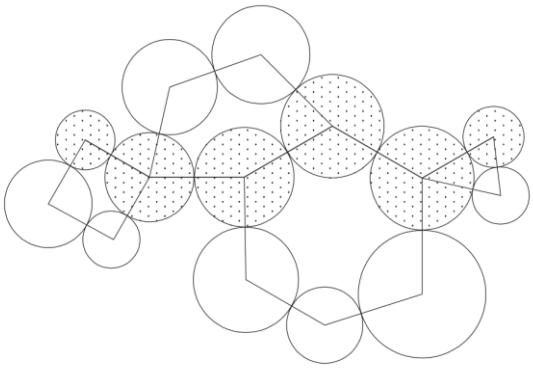

Figure 1. A force-chain and its attached grain loops

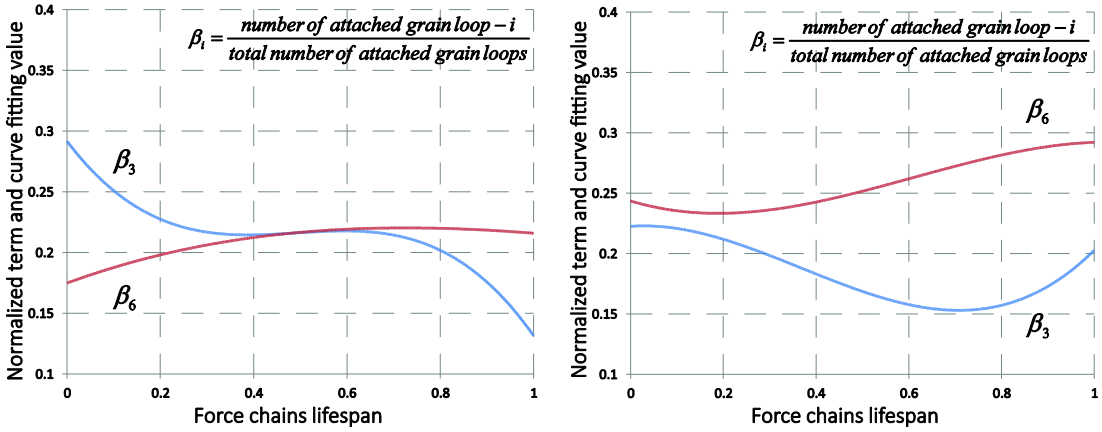

Figure 2. Variation of β in the hardening phase (left) and the softening phase (right)

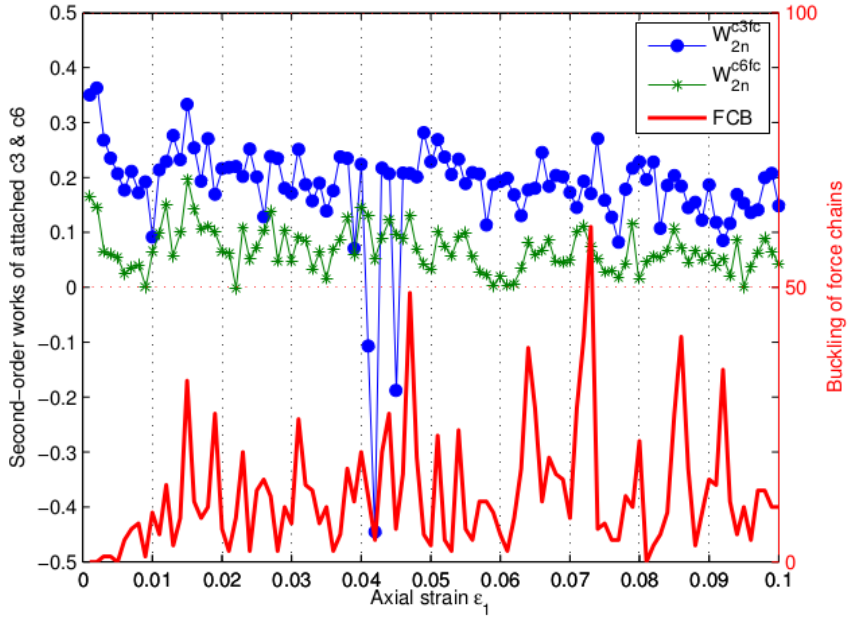

Figure 3. Evolution of the second-order work of the attached loop-3 and loop-6, compared with the buckling of force-chains

References

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