

Thank you for carefully addressing my comments and improving the text.

However, I disagree with the statements about the necessary dependence of the overall process on Δx . Moreover, I think this statement actually makes the DEM approach questionable unless fixed.

The author says in Section 3.1 (30): “It is also worth stressing that — as in all DEM models — the macroscopic properties of the modeled material (its strength, elastic modulus, and so on) depend not only on the microscopic properties of grains and bonds, but also on the grain size (e.g., Potyondy and Cundall, 2004; Koyama and Jing, 2007).”

I do not think this statement is true. Potyondy and Cundall say, for example, that the local properties like cement modulus are dependent on grain size in their model to actually achieve the macro properties that are independent on size. Sure, this means that the local coefficients must be selected properly to achieve the overall convergence when the grain size changing but it shows their effort to keep the macro properties controlled. I actually think even this approach is not well justified as physical laws should be formulated such that coefficients are size independent.

For example, [Kumar et al., 2016] prefer not to use normal or tangential stiffnesses as parameters for local models but talk about material (contact) parameters as they introduce:

$$\Sigma_N = K_N/2R^*, \quad \Sigma_T = K_T/2R^*,$$

in their laws making the contact laws independent on block size. Where the normal and tangential stiffnesses K_N and K_T are size dependent as necessary, and R^* is the effective radius at the contact point.

Different authors use different approaches to ensure that the global parameters do not change with discretization which is essentially are ice blocks in author’s model. For example, [Leclerc, 2017] carefully calibrate the beam model in their DEM approach to match macro properties by running their model for the large range of local parameters. They ensure that the DEM model accurately reproduce elastic behavior of the material comparing the results with finite elements analysis.

I am familiar with the same approach to match adhesion local properties such as surface energy γ to achieve the correct bulk material adhesive strength. For example, [Kulchitsky et al., 2016] also use both theoretical consideration and extensive calibration on known engineering tests to connect local contact properties with macro parameters before they use DEM to do the quantitative comparisons.

The grain size distribution is also important in some processes as you say but it does not mean that the mean value has to be exactly the same as in the actual material to achieve the right physical results. I prefer to say that *the grain size is a resolution of the model and hence the macro physics must not depend on it* unless you actually work with the grains that exactly match the grains in your physical process. If the resolution becomes “a free model parameter”, there is something wrong with such a model.

Overall, I think it is very fruitful to think about DEM with bonds models solving actual classical elastic or other continuous problems until finite deformation occur. As it can be seen in [Leclerc, 2017] or [Jin et al., 2011], DEM actually reproduce elastic behavior before the bonds are broken if the macro parameters are well calibrated with the local contact properties or even better local laws are correctly chosen.

For the ice model the ice blocks have very regular cuboid shapes. In this case the local contact laws should contain the dimension explicitly and can be formulated using coefficients that are

independent on the block size. For example, the stiffness coefficient can be related to the contact area between the blocks somehow.

Minor 2.2.4 reply: That is the only thing I asked if $l_{b,i} = h_{b,i}$ in the actual computations. Apparently, that is the case. Actually, I noticed this because often it is very useful to make test computations with two bond dimensions being not equal to each other to see if there are any problems in the algorithm implementation or dependence on their ratio.

References

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