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Grain-resolving simulations of submerged cohesive granular collapse

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We investigate the submerged collapse of weakly polydisperse, loosely packed cohesive granular columns, as a function of aspect ratio and cohesive force strength, via grain-resolving direct numerical simulations. The cohesive forces act to prevent the detachment of individual particles from the main body of the collapsing column, reduce its front velocity, and yield a shorter and thicker final deposit. All of these effects can be accurately captured across a broad range of parameters by piecewise power-law relationships. The cohesive forces significantly reduce the amount of available potential energy released by the particles. For shallow columns, the particle and fluid kinetic energy decreases for stronger cohesion. For tall columns, on the other hand, moderate cohesive forces increase the maximum particle kinetic energy, since they accelerate the initial free-fall of the upper column section. Only for larger cohesive forces do the peak kinetic energy of the particles decrease. Computational particle tracking indicates that the cohesive forces reduce the mixing of particles within the collapsing column, and it identifies the regions of origin of those particles that travel the farthest. The simulations demonstrate that cohesion promotes aggregation and the formation of aggregates. They furthermore provide complete information on the temporally and spatially evolving network of cohesive and direct contact force bonds. While the normal contact forces are primarily aligned in the vertical direction, the cohesive bonds adjust their preferred spatial orientation throughout the collapse. They result in a net macroscopic stress that counteracts deformation and slows the spreading of the advancing particle front.