

## Supplementary material

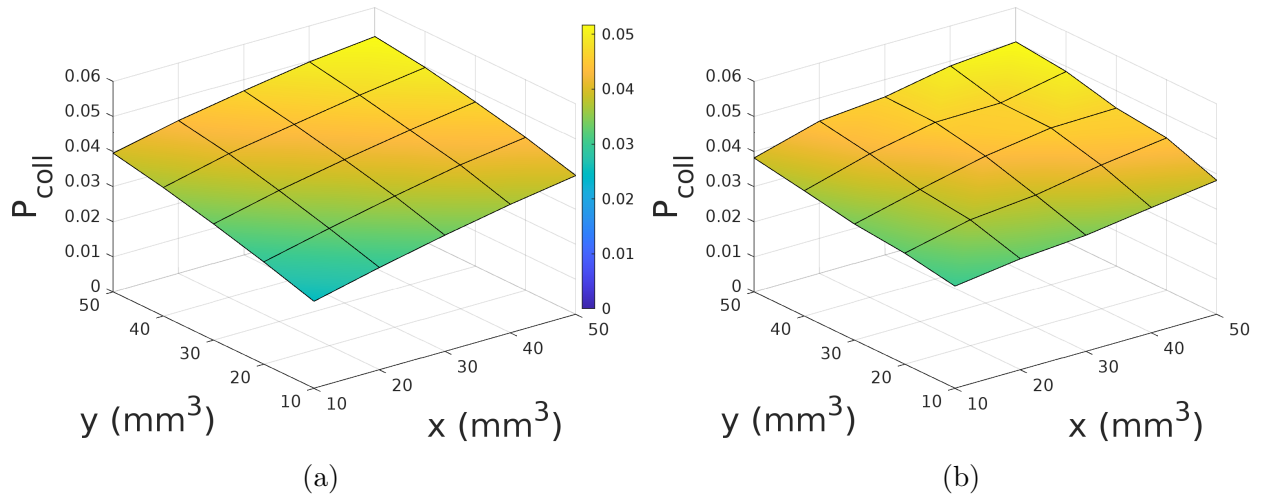


Figure S1: Test case 1 - Comparison of the probability of collisions between particle classes obtained from (a) DEM simulation, and (b) developed formulation (4), for resolved system with *uniformly* distributed particles.

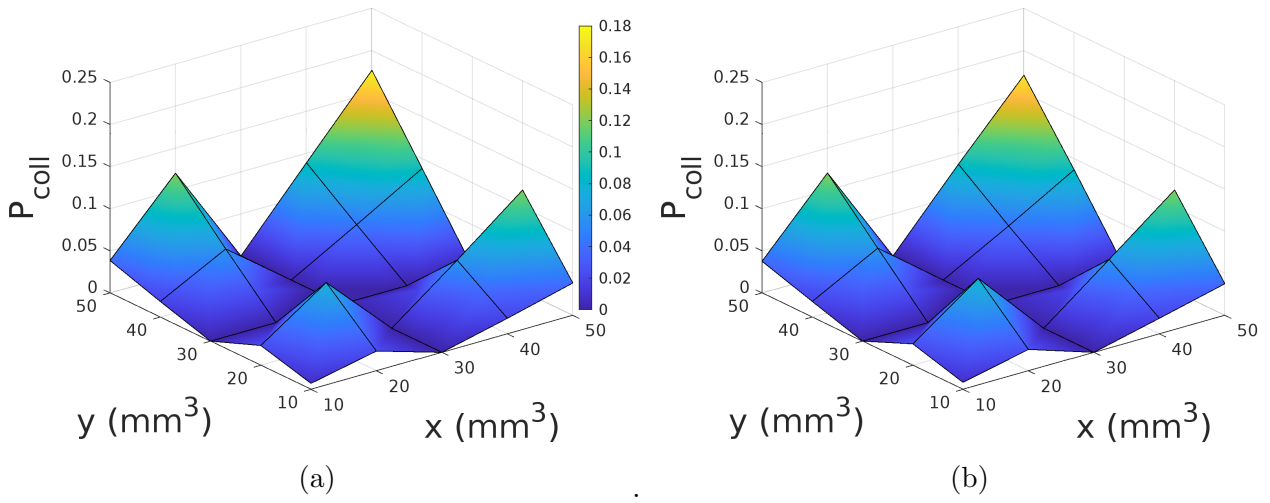


Figure S2: Test case 1 - Comparison of the probability of collisions between particle classes obtained from (a) DEM simulation, and (b) developed formulation (4), for resolved system with *erratically* distributed particles.

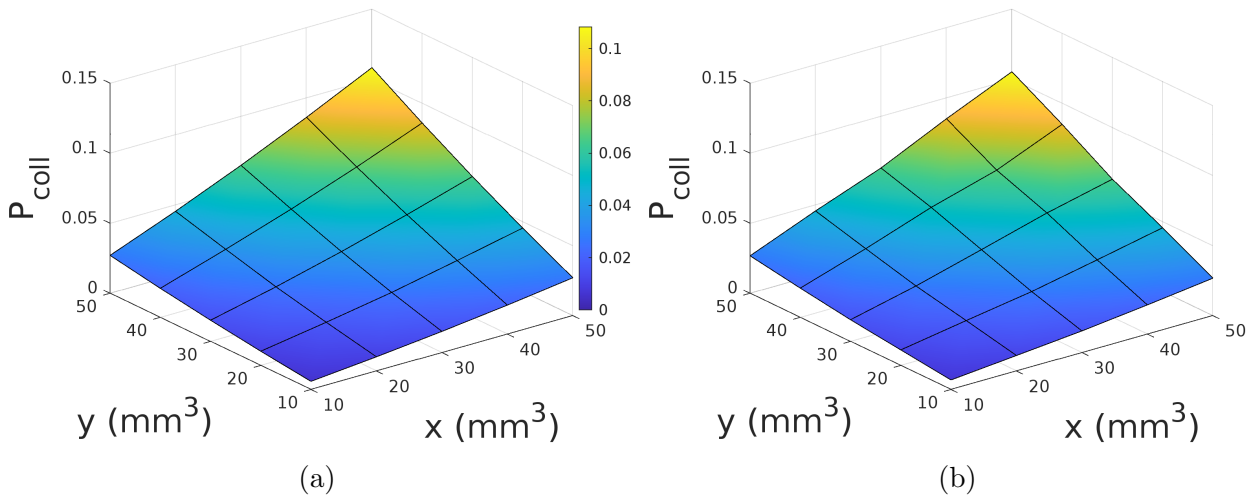


Figure S3: Test case 1 - Comparison of the probability of collisions between particle classes obtained from (a) DEM simulation, and (b) developed formulation (4), for resolved system with particles distributed in *ascending* order.

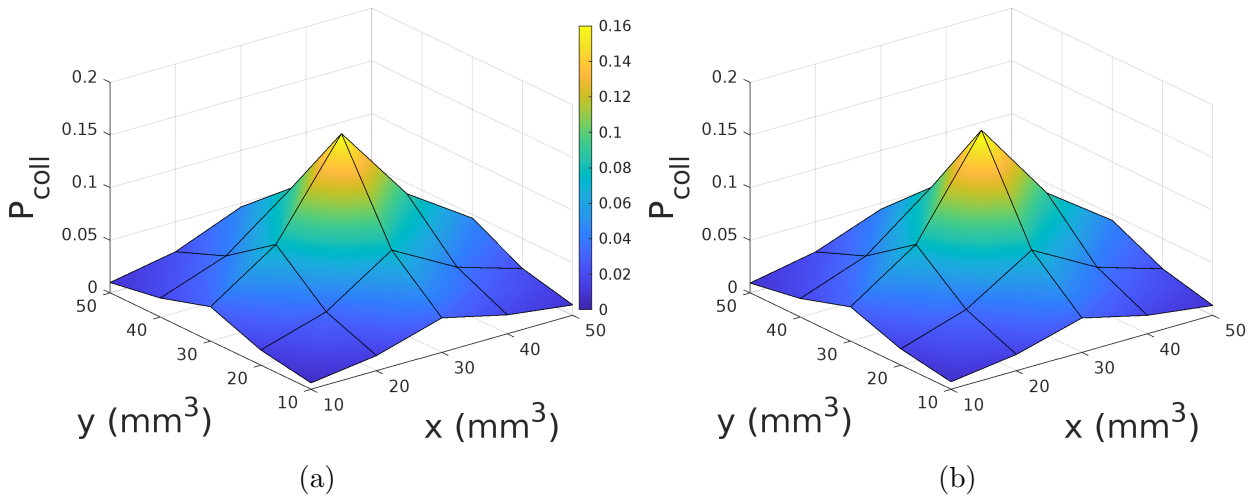


Figure S4: Test case 1 - Comparison of the probability of collisions between particle classes obtained from (a) DEM simulation, and (b) developed formulation (4), for resolved system with *normally* distributed particles.

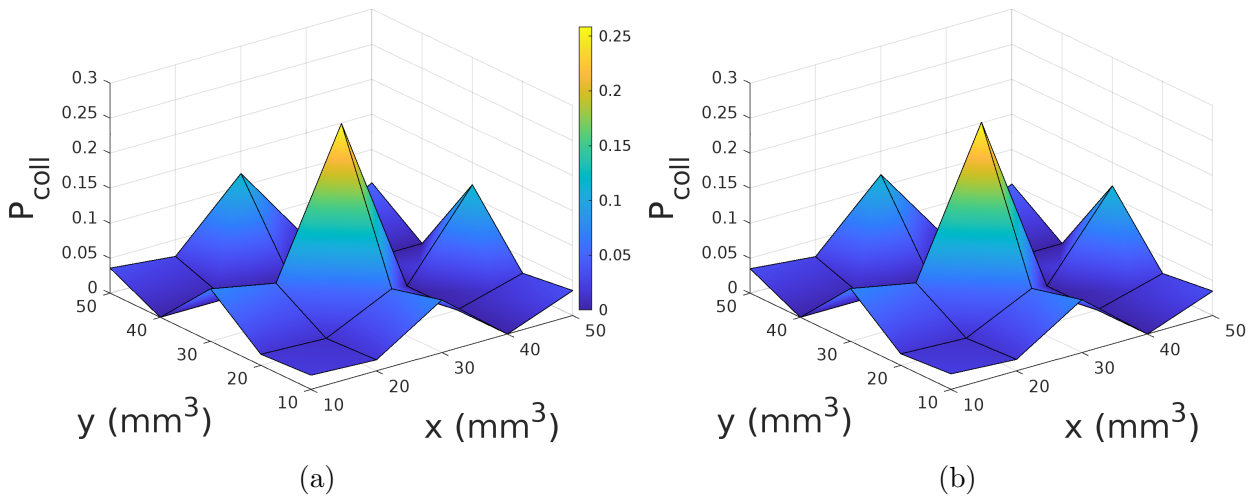


Figure S5: Test case 2 - Comparison of the probability of collisions between particle classes obtained from (a) DEM simulation, and (b) developed formulation (4), for resolved system following D1 distribution.

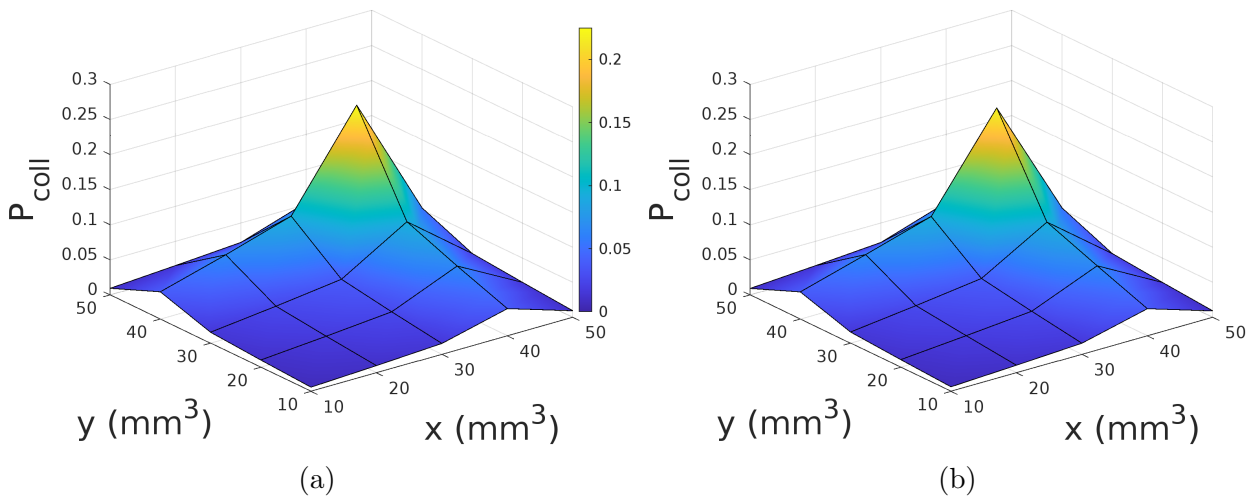


Figure S6: Test case 2 - Comparison of the probability of collisions between particle classes obtained from (a) DEM simulation, and (b) developed formulation (4), for resolved system following D2 distribution.