Computational Study of the Effect of Draft Plates on the Solid Behavior in a Spout-fluid Bed

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Supplementary Information

1. Repose angle of the granular material
2. Effect of Young's modulus and Poisson ratio
3. Determination of steady-state in the absence and presence of draft plates
4. Comparison of three different drag force models
5. Grid sensitivity
6. Effect of discretization scheme

1. Repose angle of the granular material

To determine the repose angle of the granular material adopted in the current work, a packed bed with a total number of 241,525 particles and bed height of 0.217 m is initially formed in a cylindrical geometry (Figure S1a) with a radius of 0.09 m and height of 0.2 m. Specifically, the particles are monodisperse with particle diameters of 3 mm. The material properties are listed in Table 2. When the cylindrical wall is lifted slowly, a particle heap is formed, as shown in Figure S1b. The angle of repose for the current study is ascertained as 21.3°, which agrees with the numerical result of Goniva et al. [27].

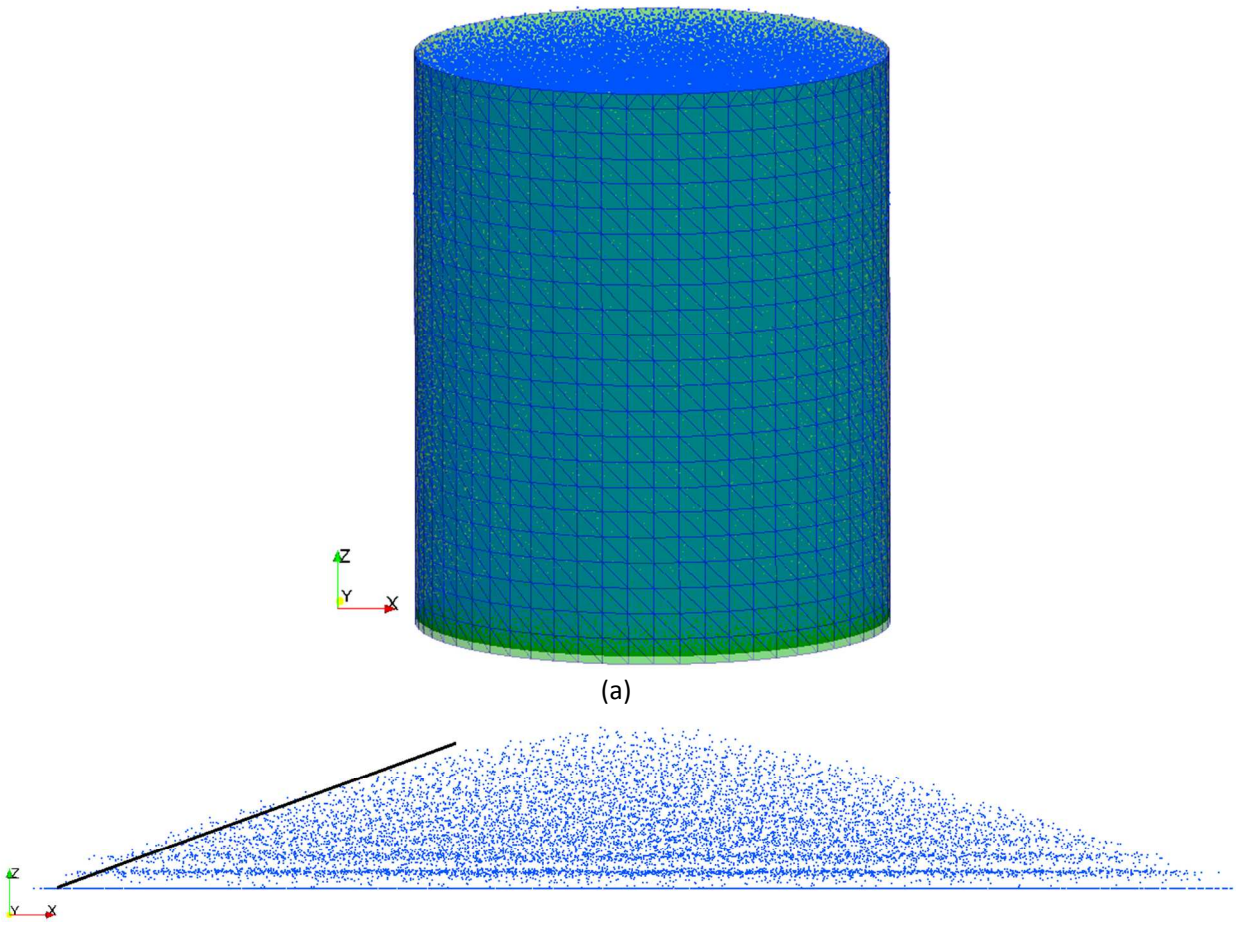

Figure S1. Granular system adopted to evaluate the repose angle of the granular material adopted in the current work: (a) initial configuration of the packed granular system; and (b) the formed heap after the simulation.

2. Effect of Young's modulus and Poisson ratio

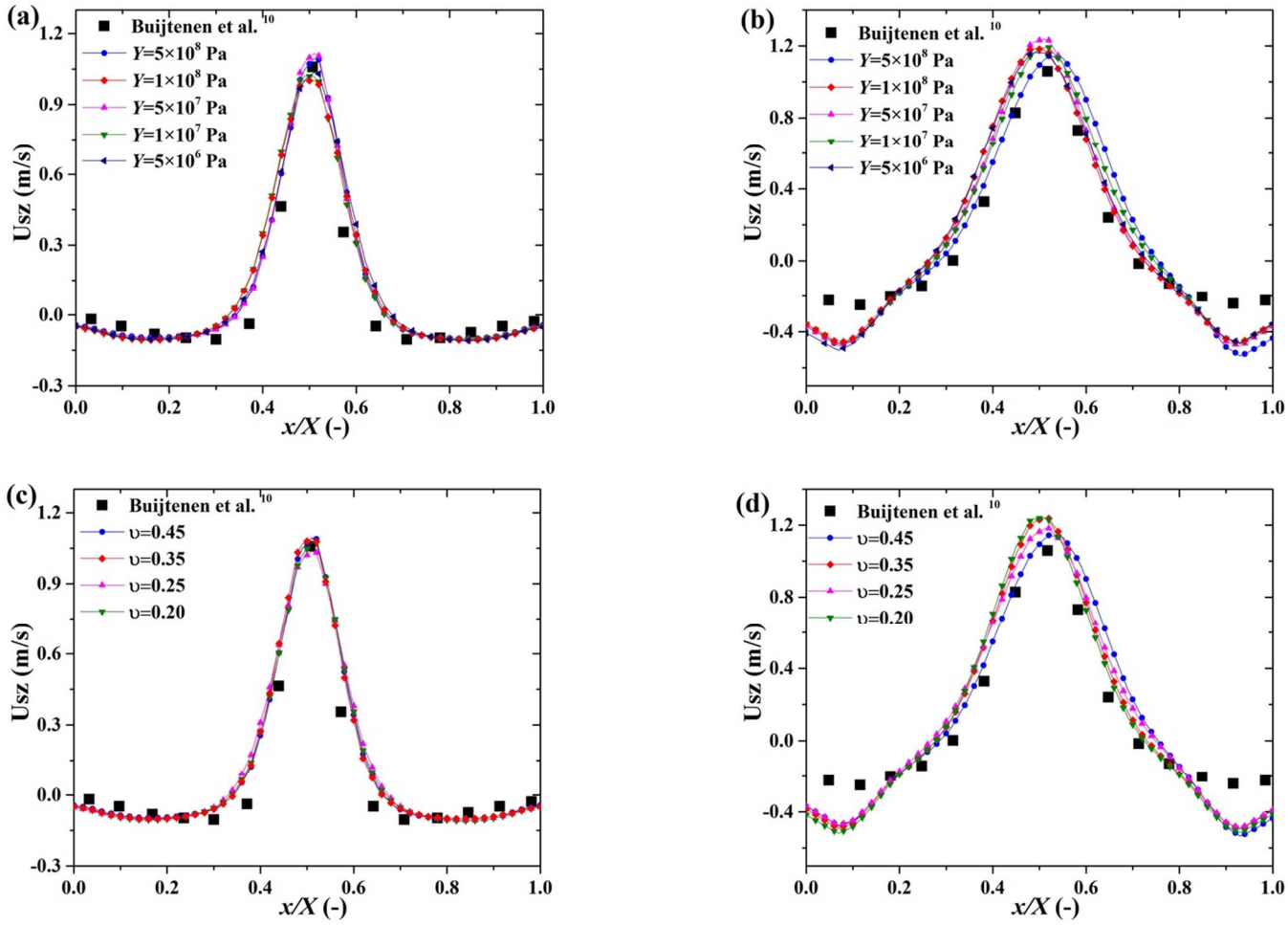

Figure S2. Effect of Young's modulus ((a) z/Z = 0.05 and (b) z/Z = 0.1) and Poisson ratio ((c) z/Z = 0.05 and (d) z/Z = 0.1) on the time-averaged vertical solid velocity (Usz) in the spout-fluid bed without draft plate.

3. Determination of steady-state in the absence and presence of draft plates

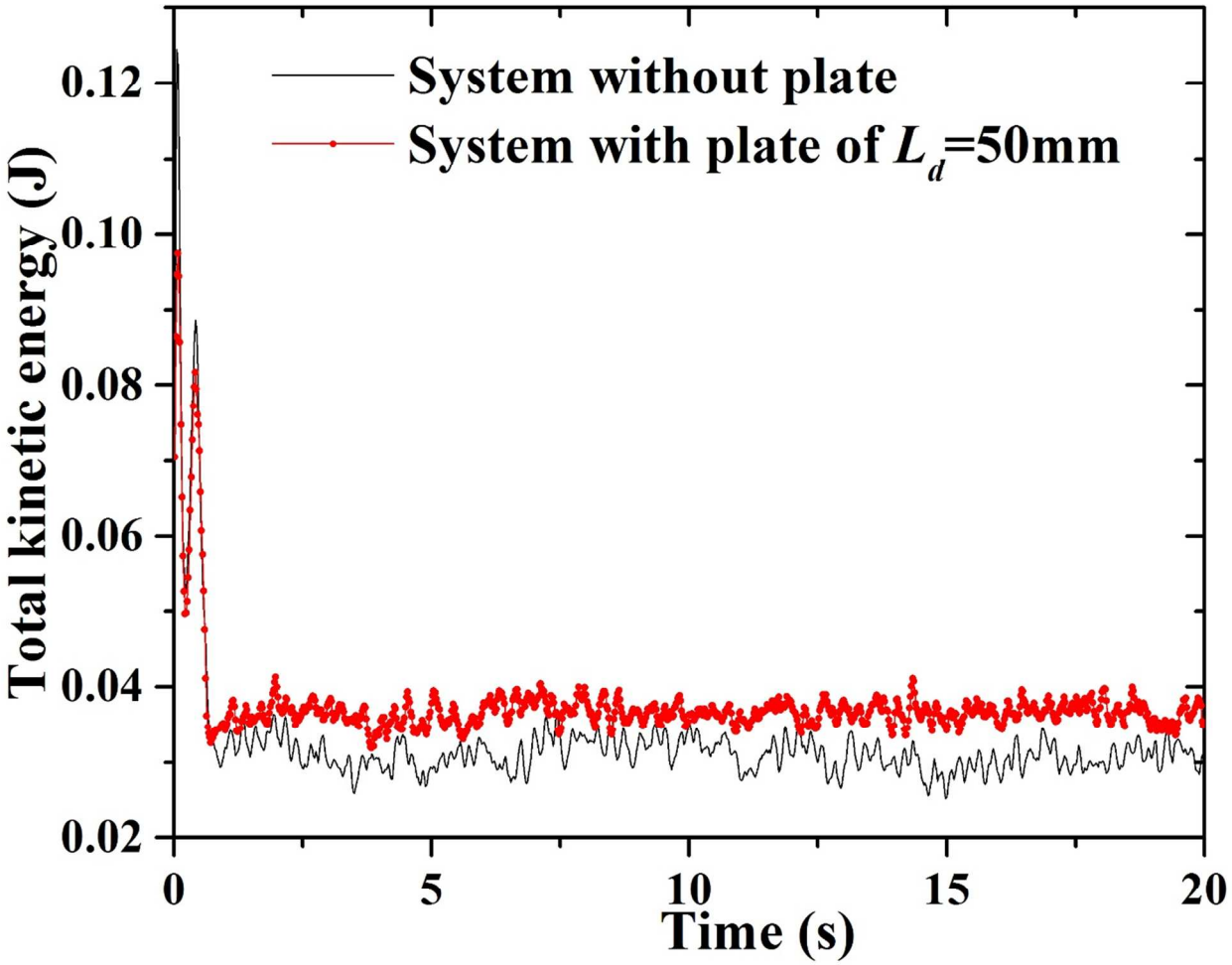

Figure S3. Evolution of the total kinetic energy of the solid phase in the spout-fluid bed in the absence and presence of draft plates (L_d = 50 mm).

4. Comparison of three different drag force models

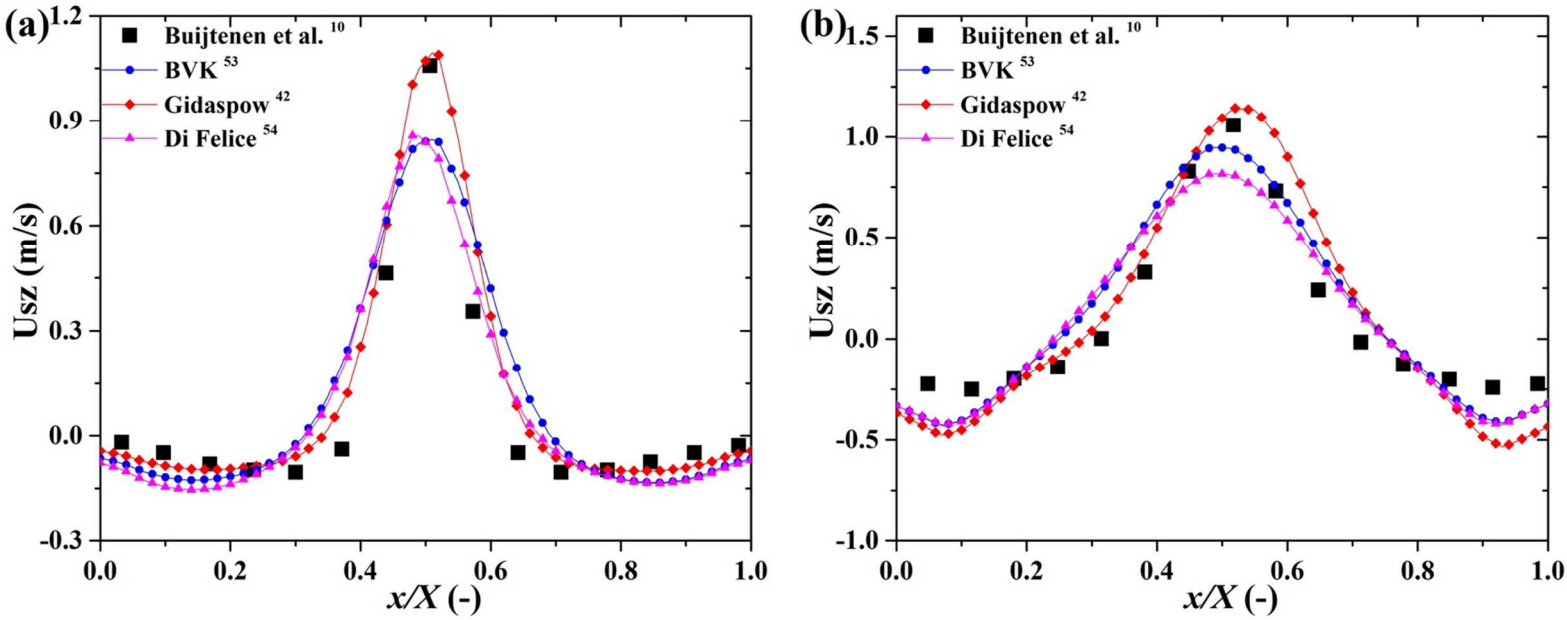

Figure S4. Effect of different drag force models on the time-averaged vertical solid velocity (Usz) in the spout-fluid bed without draft plate: (a) $z/Z = 0.05$; and (b) $z/Z = 0.1$.

5. Grid sensitivity

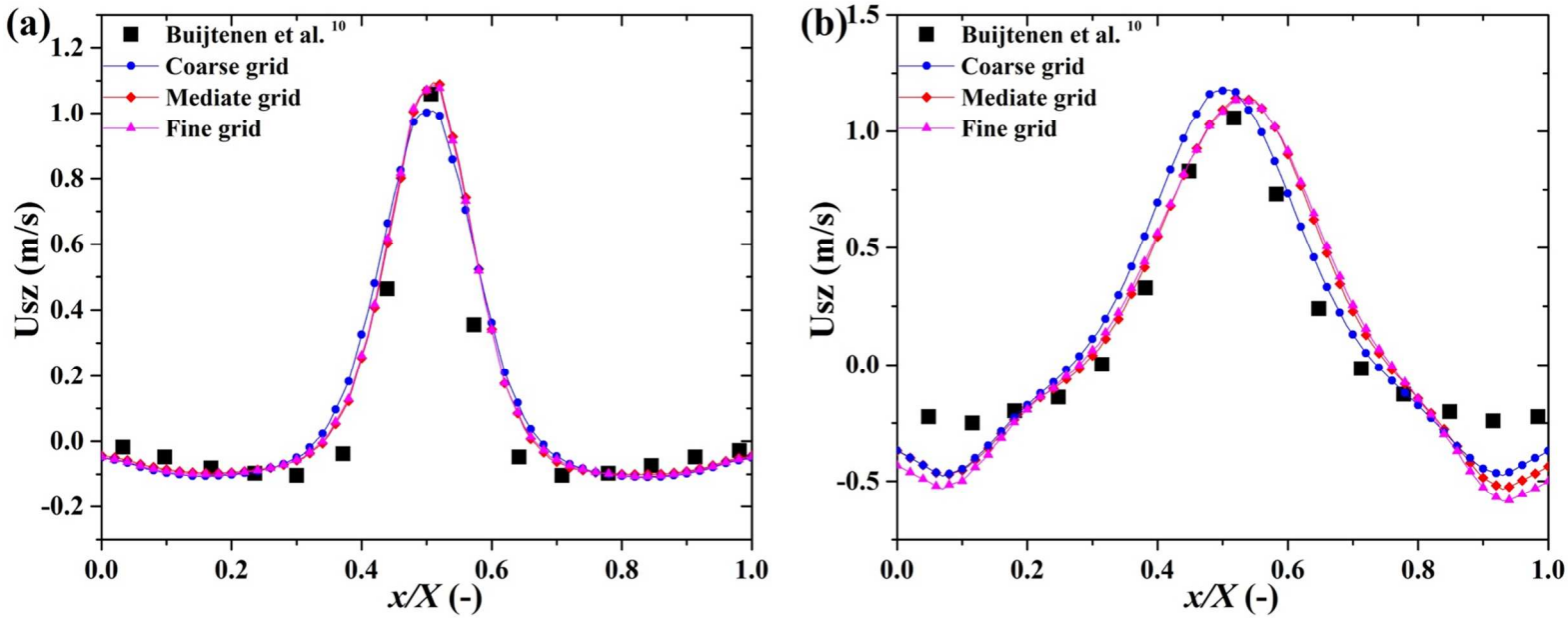

Figure S5. Effect of different grid resolutions (coarse grid: 15×2×100 ($x \times y \times z$); medium grid: 29×4×200, fine grid: 43×6×300) on the time-averaged vertical solid velocity (Usz) in the spout-fluid bed without draft plate: (a) $z/Z = 0.05$; and (b) $z/Z = 0.1$.

6. Effect of discretization scheme

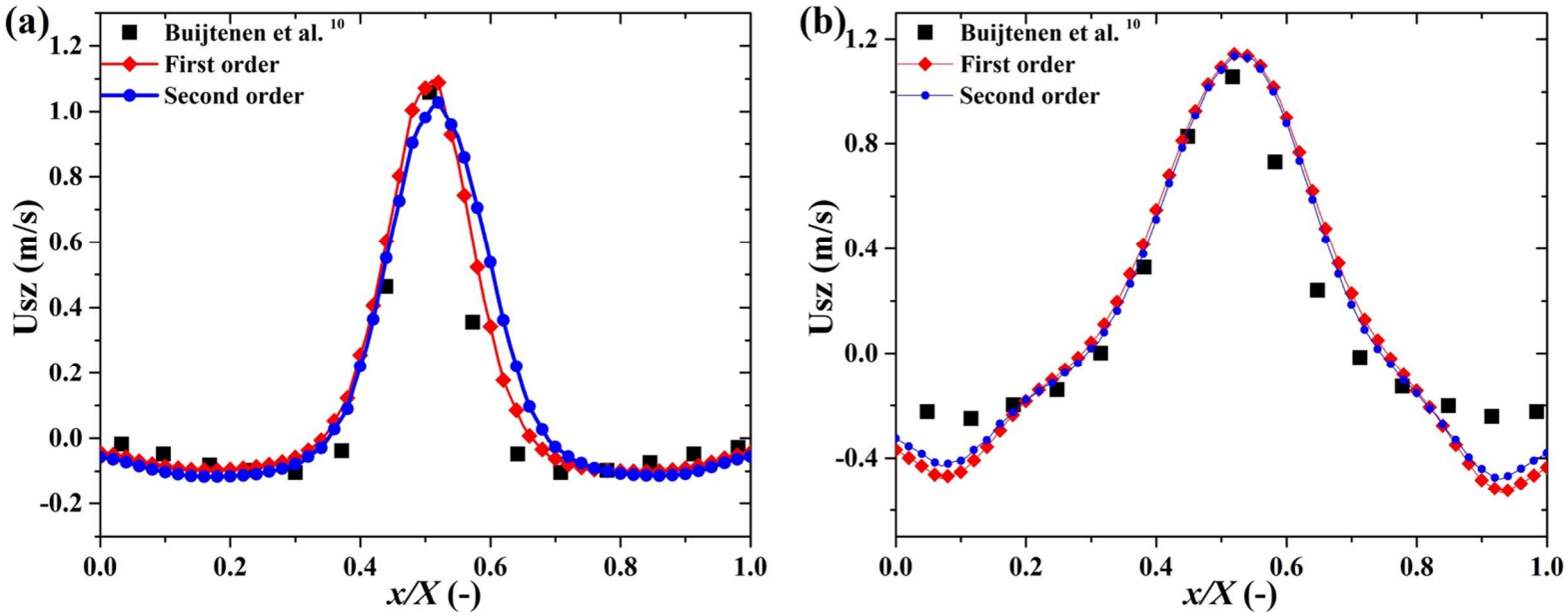

Figure S6. Effect of the discretization scheme adopted for the convective items in the governing equations for the gas phase on the time-averaged vertical solid velocity (Usz) in the spout-fluid bed without draft plate: (a) $z/Z = 0.05$; and (b) $z/Z = 0.1$.