Chapter 4

Multiscale Modelling of Dry granular flows

4.1 Introduction

The dynamics of a homogeneous granular flow involve at least three distinct scales (see Figure 4.1): the *micro-scale*, *meso-scale*, and the *macro-scale*. At the microscopic or particle scale, the granular material is a discrete system whose physical properties are discontinuous with respect to the position and time. On the other hand, at the macroscopic or bulk scale, the granular material is a continuum system whose physical properties are continuous. Multi-scale simulations generally involve modelling the granular materials as an assembly of discrete-elements and as a continuum. The Discrete Element Modelling (DEM) involves describing the equilibrium conditions, the kinematic conditions, and the constitutive behaviour for each particle with respect to its neighbouring particles. Whereas, the continuum modelling involves defining those condition for an assembly of particles, using the continuum concept of stresses and strains.

4.2 Granular column collapse

The collapse of a granular column on a horizontal surface is a simple case of granular flow, however a proper model that describes the flow dynamics of this simple granular flow is still lacking. Lajeunesse et al. (2005) performed axis-symmetric and plane strain tests on granular column collapse. In the present study, multi-scale numerical modelling, i.e. discrete-element and continuum analyses, of the quasi-two dimensional collapse of granular columns are performed using the Discrete Element Method and the Material Point Method. Granular materials

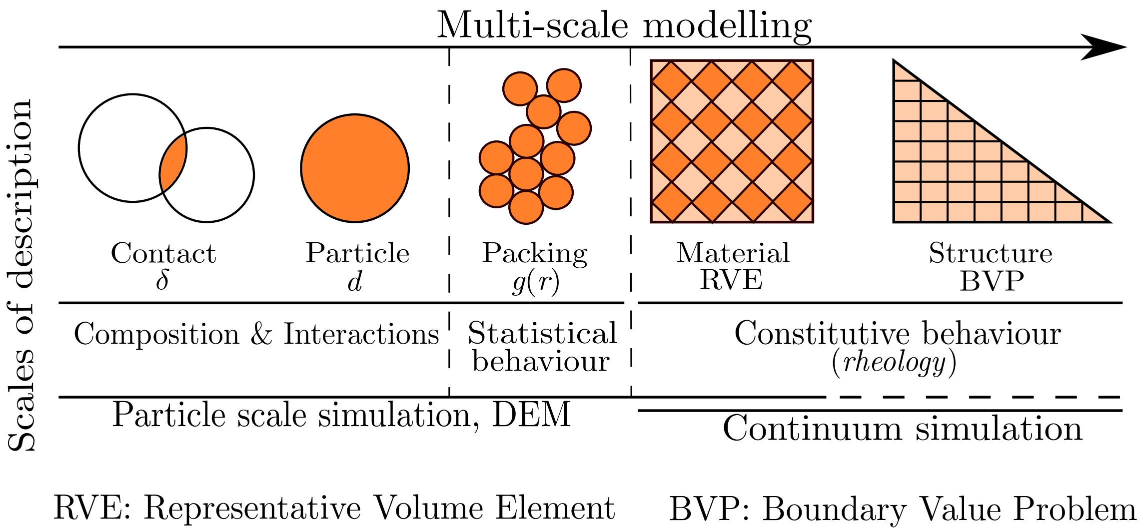

Figure 4.1 Multi-scale modelling of granular materials

when released suddenly on a horizontal surface exhibit transient flow. The mechanism of flow initiation, spreading dynamics and energy dissipation are studied. The experimental configuration used by Lajeunesse et al. (2005) is shown in Figure 4.2. Granular material of mass 'M' was poured into a container to form a rectangular heap of length 'L_i', height 'H_i' and thickness 'W'. The internal friction angle and the wall friction between the wall and the glass beads measured by Lajeunesse et al. (2005) are listed in Table 4.1. The mean packing density of the granular material was estimated to vary between 0.61 and 0.65. The gate was then quickly removed to release the granular mass that spreads in the horizontal channel until it comes to rest. The final run-out distance 'L_f' and the collapsed height 'H_f' were measured. The run-out distance and collapse height were found to exhibit power law relation with the initial aspect ratio 'a' $(= H_i/L_i)$ of the column.

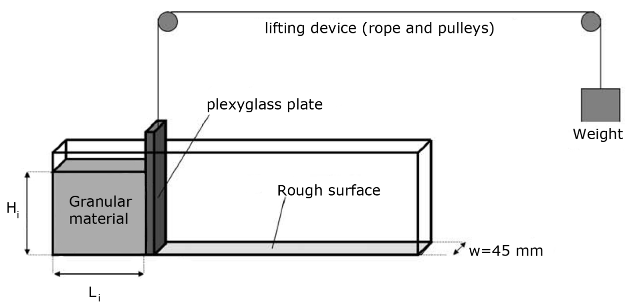

Figure 4.2 Schematic of experimental configuration for 2-D collapse in a rectangular channel, (Lajeunesse et al., 2005)

Table 4.1 Material properties, (Lajeunesse et al., 2005)

Parameter	**Value**
Material	Glass beads
Mean diameter of the glass beads	1.15 mm
Repose angle of glass beads	22 ± 0.5^o
Avalanche angle of glass beads	27.4 ± 0.5^o
Wall friction angle of glass beads	24.8 ± 0.2^o

References

Lajeunesse, E., Monnier, J. B., and Homsy, G. M. (2005). Granular slumping on a horizontal surface. *Physics of Fluids*, 17(10).