Representation of Bulk and Surface Crushing Phenomenon in DEM Model of Railway Ballast

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ABSTRACT

In simulation of railway ballast behaviour using Discrete Element Method (DEM), it seems to be necessary to take into account the crushing and the abrasion of grains. Nowadays, two approaches have been used in discrete modelling. The first approach represents each grain as an assembly of smaller units with cohesive contacts between them [1, 2]. The crushing and abrasion occur as the cohesive contacts between particles within the grain are uncoupled. This approach is universal, but it demands extreme computational resources from the beginning of the simulation, it is therefore convenient only for simulation with small amounts of grains. The second approach does not suffer from such computational complexity, but it is more phenomenological and approximate [3, 4]. This approach is content of our study. At the beginning, every ballast grain is modelled as one rigid body (sphere in our case) but it may break into smaller particles (crushing) or decrease its radius (abrasion). In paper [5] it was found that the surface fracture (abrasion) rather than bulk fracture (crushing) may dominate, therefore it is desirable to consider the abrasion too.

The crushing occurs when some equivalent stress in the grain, here determined as von Mises stress computed from fabric stress tensor, exceeds the size depending material strength. The grain is then replaced by several smaller bodies, pieces. All these pieces must have the spherical shape since we limited ourselves to only spherical bodies to save computational time. Therefore their assembly cannot form the exact shape as the original grain. The effects of number of pieces and other internal properties on the ballast system are studied.

The abrasion occurs when the surface pressure, here taken as the maximum Hertzian pressure [6], exceeds the material strength. Again, the abraded grains have to be spherical too. Therefore, the grain radius is decreased. The effect of ratio between radii of the abraded and original grains is studied as well as effects of other internal parameters of the abrasion model.

All the studies are performed using simulation of oedometric test performed by Lim [7].

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