3D Laser scanning technique coupled with DEM GPU simulations for railway ballasts

Patrick Pizette*, Nicolin Govender†,*, Benjamin Gobé*,$, Daniel N. Wilke‡ and Nor-Edine Abriak*

* IMT Lille Douai, Univ. Lille, EA 4515 - LGCgE – Laboratoire de Génie Civil et géoEnvironnement, département Génie Civil & Environnemental, F-59000 Lille, France
e-mail: patrick.pizette@imt-lille-douai.fr, web page: http://www.lgcge.fr/

† Research Center Pharmaceutical Engineering, GmbH, Graz , Austria
e-mail: govender.nicolin@gmail.com, web page: http://www.rcpe.at

$COLASRAIL, Maisons-Laffitte, France, web page: http://www.colasrail.com

‡Centre of Asset and Integrity Management, University of Pretoria, South Africa
e-mail: wilkedn@gmail.com, web page: http://www.up.ac.za/centre-for-asset-integrity-management

ABSTRACT

One of the key parameters that fundamentally influences the performance of track ballast is particle shape. Particularly settling of the railway on the track ballast depends strongly on the shape, surface roughness and wear characteristics of the ballast. As a consequence railway industries have imposed standards to fix quality requirements regarding ballasts.

In parallel, researchers are developing simulation methodologies to tackle the problematic settling of ballasts as freight is hauled within an infrastructure. In particular, the discrete element method (DEM) is classically used to better understand the settling of ballasts under repeated cyclic loading. The computational demands of DEM often limits these studies to 2D simulations or at most 3D simulations using only simplistic spherical shapes to construct lumped particles [1]. Unfortunately, a critical geometric aspect of ballast is particle angularity which is poorly represented using lumped particle representation [1]. This study investigates the potential of a DEM code to model i) realistic particle shape, ii) a large number of particles in a 3D ballast simulation and iii) the potential of GPU based simulations to be used in ballast applications. The simulations are to be validated experimentally using accurate and realistic particle representations.

The graphics processing unit (GPU) with its highly parallelized hardware architecture is essential towards achieving ii) as millions of particles are being regularly simulated within reasonable computing times on GPU platforms [2-4], while the specific DEM environment BlazeDEM-3DGPU [2] is crucial for i) as polyhedral shaped convex and non-convex particles can be modelled efficiently allowing for angularity of the ballast to be resolved accurately. Towards capturing the ballast shapes a laser scanning technique is applied to obtain digitized ballast representations of actual track ballast for use in DEM simulations. The detail of the digitized ballast can be controlled by controlling the effective number of faces used in presenting the ballast samples. A benefit is that the critical geometric features could be investigated by conducting DEM simulations using varying detailed ballast samples. In addition, simplified ballast samples allows in particular for large numbers of angular particles to be simulated during loading and unloading investigations of ballast.

This study demonstrates that a laser scanning strategy is effective, efficient and practical to quantify the shape properties of the ballasts towards constructing digitized ballast samples for use in DEM simulations. Secondly, this study shows that GPU-enabled DEM can efficiently model the cycling loading on a compression box representative of a typical laboratory ballast experiment.

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