Numerical modelling of flying ballast phenomena on high speed lines. Part B: Analysis of the stability of the ballast layer by means of a DEM model

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The projection of ballast particles due to the aerodynamic field generated by the passing of a train (a phenomenon known as flying ballast) is an issue of major concern for high speed line managers, since it may lead to severe safety and maintenance problems [1]. Hence, a significant research effort has been done in the recent years in order to better understand the processes involved as well as to propose solutions to reduce the incidence of such phenomenon.

In this sense, the present research project is aimed to develop a new type of ballast made out of modified concrete and high-density recycled materials. Therefore, numerical and physical modelling has been performed in order to test the behaviour of the new material under flying ballast conditions, as well as to determine the most convenient design parameters. Regarding the numerical modelling, it has been divided in two different segments: i) the aerodynamic interaction between the track and the vehicle, which determines the initiation of motion of the ballast particles and is described in detail in [2]; and ii) the mechanical behaviour of the ballast (accounting for its nature as a discrete medium) under the vibrational and aerodynamic excitation induced by the train.

This paper delves into the second segment and thus describes in detail the modelling of the ballast particles under certain aerodynamic loading conditions by means of a DEM (discrete element method) model developed within YADE-DEM commercial software. Such technique is based on the discretization of the material in a group of independent elements, which allows to accurately reproduce the discontinuous and heterogeneous nature of ballast.

Moreover, once the model has been defined, a sensitivity analysis is performed regarding several key parameters:

i) Geometry of the modelled particles (*i.e.*, radius and number of the spherical elements conforming each ballast particle)

ii) Settlement of the particles after placement (*i.e.*, if only gravity is considered or additional compaction forces are applied)

iii) Size and length of the model (*i.e.*, number of ballast particles, thickness of the ballast layer and model dimensions).

The conclusions drawn from the sensitivity analysis are of utmost importance for the optimization of the numerical modelling of the entire phenomenon, which is later performed to determine the optimal characteristics of the new material. In this concern, 9 ballast layer configurations with different particle weights (100 g, 150 g and 200 g) and shapes (traditional, cubic and spherical) are modelled.

References

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