3D-DEM Simulation of Ballasted Layer Deformation

Akiko KONO
Senior Researcher, Track Dynamics, Railway Dynamics Division

1. Introduction

Ballasted tracks have “weak areas” where there is differential settlement or ballast flow. These issues hinder maintenance cost reduction efforts.

Identifying influential factors through experiments is necessary to fully understand such local deterioration phenomena. However, there are limits to the external force conditions that can be simulated by using experimental equipment. Additionally, detailed observation of the behaviour of constituent particles that induce plastic deformations of ballasted layers is difficult with the current measurement technologies. RTRI have begun numerical study by using ‘DEMCS’, a Discrete Element Method (hereinafter “DEM”) code developed by University of Tsukuba (1).

2. Studying the ballasted layer using a Discrete Ballasted Track Model

Figure 1 shows the “Discrete Ballasted Track Model around Rail Joint” simulating a general layout of sleepers around the rail joints of narrow gauge tracks in Japan. If an external force, including high-frequency components that occur when a train passes through a rail joint is input into the elements of the sleepers arranged here, the deformation of a ballasted layer under these complex external force conditions can be simulated.

Figure 2 shows the distribution of inter particle contact forces in a ballasted layer at the moment when the front axle passes immediately above the joint. The upper chart shows the distribution when no countermeasures are taken, and the lower one shows the results after applying a resilient rail pad and a rubber mat as countermeasures. It was verified that these actions led to a significant decrease of inter particle contact forces immediately below the rail joint.

Figure 3 shows the movement of ballast particles before and after the passage of one bogie. The upper chart shows the movements in the case where no countermeasures are taken, and the lower one shows the results after taking the countermeasures mentioned above. The countermeasures caused the behaviour of ballast particles immediately below the joints to be restrained, although the movements of ballast particles are slightly increased under the adjacent sleepers.

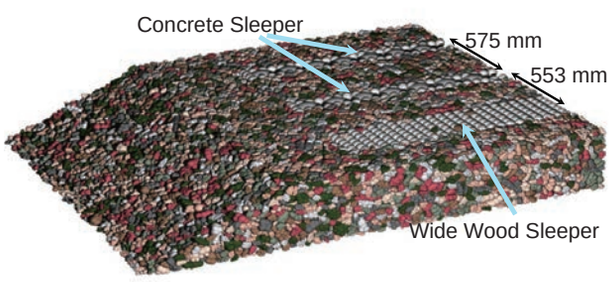

Fig. 1 Discrete Ballasted Track “Model around Joint”

3. Future application

DEM simulation enables researchers to focus on the inter particle contact forces responsible for degradation and on the movements of ballast particles which are responsible for ballast settlement. We would like to validate the mechanism causing complex local deteriorations of ballasted tracks by complementing the results of our experiments with this simulation.

(1) T. Matsushima & H. Saomoto . 2002 . Discrete Element Modelling for Irregularly-Shaped Sand grains, Proc. of Numerical Methods in Geotechnical Engineering, pp. 239-246

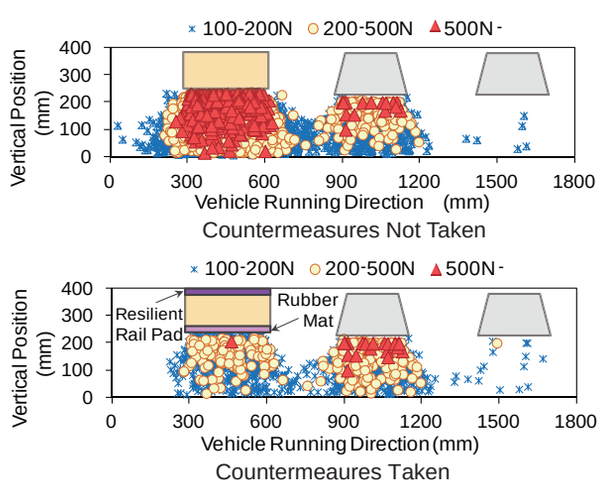

Fig. 2 Change of Contact Forces Distributions in Ballasted Layer

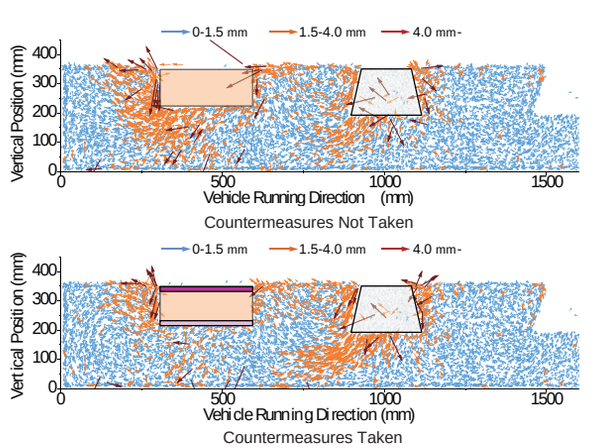

Fig. 3 Change of Particle Movements in Ballasted Layer