Vertical Natural Modes of Gravel Aggregate in Ballasted Railway Track

Akira Aikawa*

* PhD, Senior Researcher, Railway Dynamics Division,
Railway Technical Research Institute (RTRI)
Hikari-cho, Kokubunji, Tokyo, 185-8540 Japan
E-mail: aikawa.akira.11@rtri.or.jp, web page: http://www.rtri.or.jp/

ABSTRACT

The ballasted track is characterized by its structure with a ballast layer sandwiched in between sleepers and a roadbed, which significantly reduces the impact loads by running trains. The dynamic loads of trains generate the vertical natural motions in the ballast layer which trigger minute wears or plastic deformation among the blocks. The accumulation of such minute gaps will gradually cause the looseness and subsidence of the ballast layer. Therefore, the ballast requires periodic maintenance, which is an important subject of technical research. The dynamic loads are transmitted to the ballasted layer as a wave through the inside of gravel, consequently inducing the natural vibration mode specific to the ballast layer. Although the ballast layer is a discontinuous structure, it is considered to have natural vibration modes specific to ballast track. However, the dynamic characteristics of ballast layers in relation to repeated dynamic loads have not yet been sufficiently elucidated. This research investigates the natural vibration characteristics of the ballast layer and their transmission characteristics for dynamic loads by using field measurement, full-scale vibration tests, large-scale parallel finite element transient response analysis on HPC, and elastic discrete element analysis on GPGPU. The results indicate that the rigid body vibration mode of the ballast layer belongs to the low-frequency domain below 100 Hz, and that the low-frequency components of the dynamic loads exerted by passing trains are hard to damp. Furthermore, it is also found that the elastic vibration mode of the ballast layer falls within the broad frequency domain ranging between 400 and 800 Hz. The stress acting on an angularity part is inferred to be about 1100 times greater than the average stress on the ballast surface. Natural vibration modes such as the rigid-body and elastic vibration modes of the ballast layers play a role in the deterioration of ballast, as it wears and flows.

Keywords: ballasted track, measurement, spectral analysis, natural frequency, large-scale parallel finite element analysis, elastic discrete element method

REFERENCES

[1] H. Sakai and A. Aikawa, "Three-Dimensional Finite Element Analysis of Sleeper Vibration with the Influence of Ballast", *Proceedings of the First International Conference on Railway Technology: Research, Development and Maintenance*, Civil-Comp Press, UK, (2012).

[2] A. Aikawa, "Determination of the Natural Modes of a Ballast Layer", *Proceedings of the Ninth International Conference on Engineering Computational Technology*, Civil-Comp Press, UK, Paper 19, (2014).

[3] H. Okuda, "Structural Analysis for Large Scale Assembly: Research and Development of Innovative Simulation Software", http://www.ciss.iis.utokyo.ac.jp/riss/english/project/structure/.