11th World Congress on Computational Mechanics (WCCM XI)
5th European Conference on Computational Mechanics (ECCM V)
6th European Conference on Computational Fluid Dynamics (ECFD VI)
July 20 - 25, 2014, Barcelona, Spain

A NOVEL ITERATIVE METHOD FOR HEAVY HAUL RAILWAY VEHICLE/TRACK SYSTEM WITH DIFFERENT GAP OF UNSUPPORTED SLEEPERS

Ying-Jie Wang [1], and Jong-Dar Yau [2]

[1] School of Civil Engineering, Beijing Jiaotong University, Beijing 100044, China. Email: wyj_bjtu@126.com
[2] Department of Architecture, Tamkang University, New Taipei City 251, Taiwan. Email: jdyau@mail.tku.edu.tw

Key Words: *Heavy haul railway, Vehicle/track system, Unsupported sleepers, Hertzian spring, Iterative solution, Different gap.*

Abstract: Nowadays, heavy haul trains up to several kilometres long, are widely used to transport coals in China[1]. Due to repeat loadings of moving railway vehicles, the settlement of ballast or subgrade may result in hanging sleepers being no longer supported by the ballast. When a vehicle moves over the railway track with unsupported sleepers, the variations of track stiffness will induce significant variations for the wheel/rail contact forces, which may accelerate track degradation, such as increased wear, fatigue, and so on.

During the past decades, the interaction between moving loads and railway infrastructures with unsupported sleepers have been paid much more attentions by railway researchers and engineers. Grassie et al studied the dynamic response of railway track with a section of unsupported sleepers using dynamic model and brought out that the sleepers were likely to crack in the absence of ballast support[2]. Zhu et al built a coupled vehicle/track model with unsupported sleepers which were verified by a 1:5 scale model wheel/rail test rig. They found that the wheel/rail interaction force increased remarkably due to discontinuity of the track support with hanging sleepers[3]. Shi et al. developed a heavy haul railway vehicle/track/subgrade FEM model using ABAQUS software and studied the effect of unsupported sleepers on track vibration, safety and potential subgrade failure[4]. In the above research works, the sleeper is assumed totally unsupported by the ballast. However, for most cases of the sleepers there exists a gap between the sleeper and the underneath ballast, which means if the deformation of the sleeper is larger than a certain gap then the sleeper would be supported by the ballast again.

In this paper, the dynamic responses of a heavy haul railway vehicle traversing over ballast track with different gap of unsupported sleepers are investigated. In this model, the vehicle is modelled as a multi-body system, and the ballast track is developed by finite element method with a 3-layer model of rail, sleepers, and ballast masses. In the track model, the rail is regarded as an Euler-Bernoulli beam resting on discrete sleepers, and each sleeper is regarded as a lumped mass. To simulate the gap between the unsupported sleeper and the ballast, a

nonlinear spring and dashpot system is adopted. The wheel/rail contact force is modelled by the Hertzian spring. To solve the nonlinear vehicle/track system with different gap of unsupported sleepers, a novel iterative method with two iterative procedures is put forward. The first iterative procedure is to calculate the wheel/rail contact force, and the second is to determine if the sleeper is supported or unsupported by the ballast. The influence of unsupported sleepers on the dynamic responses of the vehicle and track components is investigated as well. The present study indicates that the wheel/rail contact force varies abruptly when the vehicle passing over the unsupported track zone, which may result in track deterioration.

Acknowledgment
The research reported herein is partly supported by the Fundamental Research Funds for the Central Universities (grants No. 2014JMB096). This support is gratefully acknowledged.

REFERENCES

[1] X. Lu, T.W. Makowsky, D.T. Eadie, K. Oldknow, J.L. Xue, J.Z. Jia, G.B. Li, X.H. Meng, Y.D. Xu and Y. Zhou, Friction Management On a Chinese Heavy Haul Coal Line. *Proc. Inst. Mech. Eng. Part F-J. Rail Rapid Transit*, Vol. 226, Issue 6, pp. 630-640, 2012.

[2] S.L. Grassie and S.J. Cox, The Dynamic Response of Railway Track with Unsupported Sleepers. *Proc. Inst. Mech. Eng. Part D-J. Automob. Eng.*, Vol. 199, Issue 2, pp. 123-136, 1985.

[3] J.Y. Zhu, D.J. Thompson and C. Jones, On the Effect of Unsupported Sleepers on the Dynamic Behaviour of a Railway Track. *Vehicle Syst Dyn*, Vol. 49, Issue 9, pp. 1389-1408, 2011.

[4] J. Shi, A.H. Chan and M.P. Burrow, Influence of Unsupported Sleepers on the Dynamic Response of a Heavy Haul Railway Embankment. *Proc. Inst. Mech. Eng. Part F-J. Rail Rapid Transit*, Vol. 227, Issue 6, pp. 657-667, 2013.