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Theory and Applications

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Preface

Dynamic interaction between train and track is increasingly intensive with the rapid development of high-speed railways, heavy-haul railways, and urban rail transits, causing more critical and complex vibration problems. Higher train running speed would result in severer train and track interaction, bringing more prominent problems in terms of running safety and stability of the train moving on elastic railway track structures. It must ensure that the train has a good ride comfort when running at a high speed without overturn or derailment. Additionally, the greater the wheel–axle load of a vehicle, the stronger the dynamic effect of the vehicle on track structures, inducing more serious dynamic damage to railway tracks. This requires mitigation of the dynamic interaction between heavy-haul train and track. Obviously, seeking solutions to the abovementioned sophisticated dynamic interaction problems of the large-scale system just from the vehicle system or the track system itself is no longer sufficient. It is necessary to conduct dedicated and in-depth research on the dynamic interaction between rolling stock and track systems. Only with a deep and comprehensive understanding of the mechanism of vehicle–track dynamic interaction is it possible to implement reasonable approaches to minimize the dynamic wheel–rail interaction, to obtain optimal integrated designs of modern rolling stocks and track structures, and eventually to ensure safe, smooth, and efficient train operations. Owing to the fast development of computation technologies, it is realistic today to study and simulate such coupled dynamics problems by considering the vehicle system and track system as a large integrated system with interaction and interdependence. This is the original intention of the vehicle–track coupled dynamics theory discussed in this book.

The author proposed the concept of *Vehicle–Track Coupled Dynamics* for the first time in the late 1980s. In 1991, the author completed his doctoral thesis entitled *Vertical Vehicle–Track Coupled Dynamics*. In 1993, a research paper for investigating the vertical interaction between vehicle and track based on the vehicle–track coupled dynamics was published at the 13th Symposium of the International Association for Vehicle System Dynamics (IAVSD), and then was included in a supplement of the IAVSD journal *Vehicle System Dynamics (VSD)* in 1994. With the continuous funding from the National Natural Science Foundation of China

(NSFC), the National Outstanding Young Scientist Foundation of China (received by the author in 1995), the Ministry of Science and Technology of China (MOST), the China Railway (former China Ministry of Railway), railway industry companies, and others, the research group (including graduate students) led by the author carried out many follow-up research tasks, and published the first academic monograph in this research field entitled *Vehicle–Track Coupled Dynamics* (First edition, in Chinese) in 1997. Afterward, the second, third, and fourth editions of the monograph (in Chinese) were published in 2002, 2007, and 2015 respectively, which became the most fundamental reference books in the field of railway system dynamics and design of rolling stocks and track structures in China, especially for high-speed railways.

In recent years, with the great-leap-forward development of modern railway transportation, especially for high-speed railways, the vehicle–track coupled dynamics theory needs to address more demanding engineering requirements and many new emerging open problems. Supported by the NSFC Major Project (Grand No. 11790280), the NSFC Key Project (Grand No. 51735012), the Program of Introducing Talents of Discipline to Universities (111 Project) (Grant No. B16041) from the China Ministry of Education (MOE), the author led his group to extend the vehicle–track coupled dynamics theory through more elaborate theoretical analysis and more extensive investigations of field problems uncovered in practice. Meanwhile, worldwide research on this topic has also been extremely active and achieved much progress recently. The first English monograph re-edited from the author's Chinese monographs is published when the relevant field is undergoing rapid development in terms of theoretical research and engineering practices.

The writing of this book would not be possible without the support from various individuals and organizations. First, the author is most grateful for the continuous support from the NSFC, the MOST, the China Railway, the MOE, etc. during the past decades. The author also owes much gratitude to those who have participated in the amendment of this English monograph. They are Dr. Shengyang Zhu, Dr. Liang Ling, and Dr. Zaigang Chen from the author's group; Dr. Yunshi Zhao, Dr. Xiaoyun Liu, and Dr. Ilaria Grossoni from University of Huddersfield (UK), Dr. Guoying Tian from Xihua University (China). The author would like to thank the following scholars with special gratitude: Dr. Qing Wu and Dr. Tim Mcsweeney from Central Queensland University (Australia), Prof. Zili Li from Delft University of Technology (the Netherlands), Prof. Kelvin C. P. Wang from Oklahoma State University (USA), and Prof. Manicka Dhanasekar from Queensland University of Technology (Australia), for their extreme enthusiasm in proofreading this book. Some calculation examples performed by Dr. Liang Ling are also gratefully acknowledged. Finally, the author wants to thank his Ph.D. students, Mr. Yu Sun, Ms. Yu Guo, Mr. Jun Luo, Mr. Tao Zhang, and Ms. Mei Chen, for their assistance in carefully editing and supplying photographs, diagrams, and relevant information.

The author believes the publication of this English monograph on *Vehicle–Track Coupled Dynamics* will be conducive to both the investigation of railway engineering dynamics and the development of modern railway industry.

Chengdu, China Wanming Zhai
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