

# Preface

Since the world's first high-speed railway has been constructed and put into operation, the high-speed railway is highly competitive compared to other means of transportation for its distinct advantages in speed, convenience, safety, comfort, environment-friendly design, large capacity, low energy consumption, all-weather transportation, etc. According to the statistics from the International Union of railways (UIC), up to November 1, 2013, the total operation mileage of the high-speed railways of other countries and regions in the world is 11605 km. 4883-km high-speed railways are under construction, and 12570-km high-speed railways are planned to be constructed. The total operation mileage of high-speed railways in China are 11028 km, and 12000-km lines are under construction. The total operation mileage of Chinese high-speed railways accounts for half of that of the world's high-speed railways. China has become a country with the longest operation mileage and the largest scale construction in the world in high-speed railway. Meanwhile, 18 cities in China (including Hong Kong) possess urban rail transit with a total mileage of 2100 km, and 2700-km lines are under construction, ranking the first in the world. The high-speed railways and rail transit system have become the important engines to drive the socioeconomic development. The independent innovation of high-speed railway technology has become the major national strategic demand.

However, with the rising running speed of trains, the increased transportation density, and the increased transportation loads, the interaction between train and track has become intensified. To adapt to this change in railway development, the countries all over the world have strengthened the railway technological innovation and widely adopted new technologies, designs, materials, processes, and modern management methods in railway engineering. Hence, the concept of modern railway track has emerged. Modern railway track is developed with the advent of high-speed railway and heavy-haul railway, which must meet the fast and high-speed demand of passenger transport and the fast and heavy-haul demand of freight transport. Compared with the conventional railway track, the modern track has the following characteristics: ① high-standard subgrade; ② new subrail

foundation; ③ heavy and super-long continuous welded rail; ④ the scientific management of track maintenance; and ⑤ the organization of safe operations and coordination of railway and environment. Obviously, the traditional track mechanics and structural analysis methods cannot satisfy the needs of modern railway track analysis and design. Owing to the rapid development of computers and numerical methods in recent decades, new theories and methods are applied to the track mechanics and track engineering, making it possible to solve many problems which seemed impossibly hard to solve in the past and those complex problems emerging in the process of railway modernization.

This book is a systematic summary of the related theoretical and applied research findings on high-speed railway track dynamics made by the author and his research team over a decade. In the past decades, sponsored by many projects, such as the Natural Science Foundation of China (50268001, 50568002, 50978099, U1134107, 51478184), International Cooperation and Exchange Project (2010DFA82340), Natural Science Foundation of Jiangxi Province (0250034, 0450012), Sino-Austria, Sino-Japan, Sino-Britain, and Sino-America Scientific Cooperation Projects, “Sponsor Program for Key Teachers of Colleges and Universities” of the Ministry of Education (GG-823-10404-1001), Science and Technology Development Plan of China Railway Bureau (98G33A), Outstanding Science & Technology Innovation Team of Jiangxi Province (20133BCB24007), and the Training Program of the Leading Personnel of Key Disciplines and Technologies of Jiangxi Province (020001), the author and his research team have conducted the in-depth and systematic researches on high-speed railway track dynamics, environmental vibration and noise induced by railway traffic, and engineering applications of track dynamics and have achieved fruitful research findings, most of which belong to the frontier issues of the track dynamics theory. Participants in the research team are as follows: Xiaoyan Lei, Liu Linya, Feng Qingsong, Zhang Pengfei, Liu Qingjie, Luo Kun, Luo Wenjun, Fang Jian, Zhang Bin, Xu Bin, Wang Jian, Tu Qinming, Zeng Qine, Lai Jianfei, Wu Shenhua, Sun Maotang, and Xiong Chaohua.

The draft of this book has been used as the textbook for postgraduate students majoring in road and railway engineering in East China Jiaotong University for several years. The book falls into 15 Chapters: 1. Track Dynamics Research Contents and Related Standards; 2. Analytic Method for Dynamic Analysis of the Track Structure; 3. Fourier Transform Method for Dynamic Analysis of the Track Structure; 4. Analysis of Vibration Behavior of the Elevated Track Structure; 5. Track Irregularity Power Spectrum and Numerical Simulation; 6. Model for Vertical Dynamic Analysis of the Vehicle-Track Coupling System; 7. A Cross-Iteration Algorithm for Vehicle-Track Coupling Vibration Analysis; 8. Moving Element Model and Its Algorithm; 9. Model and Algorithm for Track Element and Vehicle Element; 10. Dynamic Analysis of the Vehicle-Track Coupling System with Finite Elements in a Moving Frame of Reference; 11. Model for Vertical Dynamic Analysis of the Vehicle-Track-Subgrade-Ground Coupling System; 12. Analysis of Dynamic Behavior of the Train-Ballast Track-Subgrade

Coupling System; 13. Analysis of Dynamic Behavior of the Train-Slab Track-Subgrade Coupling System; 14. Analysis of Dynamic Behavior of the Transition Section Between Ballast Track and Ballastless Track; and 15. Environmental Vibration Analysis Induced by Overlapping Subways.

Compared with similar studies, the contents of the five chapters, that is, the cross iteration algorithm for vehicle-track coupling vibration analysis, model and algorithm for track element and vehicle element, finite elements in a moving frame of reference for dynamic analysis of the vehicle-track coupling system, dynamic behavior analysis for the transition between ballast track and ballastless track, and environmental vibration analysis induced by overlapping subways, have distinct characteristics, which may be considered as the author's original findings.

With original concepts, systematic theories, and advanced algorithms, this book attempts at introducing to the readers the latest research findings and developments at home and abroad in high-speed railway track dynamics. It lays great emphasis on precision and completeness of its content. All the chapters are interrelated yet relatively independent, which makes it possible for the readers to browse through the book or just focus on special topics. It combines theories with practice to provide abundant information in the hope of enlightening and helping readers. Any comments and suggestions concerning the book are welcome and appreciated.

On the occasion of the publication of this book, I would like to express my sincere thanks to institutions and people that have been funding, supporting, and caring about my research work and the publication of this book! I would like to extend my special gratitude to Profs. Du Qinghua and Wang Mengshu, academicians of China Academy of Engineering, Mr. Guan Tianbao, senior engineer of Shanghai Railway Bureau, and Profs. Tong Daxun and Wang Wusheng from Tongji University, for their longtime care, guidance, and help. Particularly gratefully, academician Wang takes the trouble to write the foreword for this book. I am also deeply indebted to the translation team, Tang Bin, Lu Xiuying, Yang Zuhua, Liu Qingxue, Li Xing, and Huang Qunhui, from School of Foreign Languages in ECJTU for their translation work. Last but not least, my heartfelt thanks go to my colleagues, postgraduate students, and Mr. Wei Yingjie, editor of Science Press. The publication of this book is the result of their joint efforts.

Kongmu Lakeside  
2016

Xiaoyan Lei

High Speed Railway Track Dynamics  
Models, Algorithms and Applications

Lei, X.

2017, XXII, 414 p. 269 illus. in color., Hardcover

ISBN: 978-981-10-2037-7