

Abstract

Vehicle dynamics and road dynamics are two separate subjects. In vehicle dynamics, road surface roughness is generally regarded as random excitation to the vehicle, while at the same time handling stability, ride comfort, and vehicle safety are all investigated. In road dynamics, the vehicle is generally regarded as a moving load acting on the pavement, while at the same time the response and lifetime of the pavement and foundation are all studied. This book suggests a new research concept to couple the vehicle and the road together with a three dimensional (3D) tire model. The dynamics of the vehicle, road, and the vehicle–road coupled system were investigated by a theoretical analysis, numerical simulations, and field tests.

Chap 1 gives the state of research in vehicle dynamics, road dynamics and tire dynamics, and proposes the research scheme of vehicle-road coupled system dynamics.

In Chap. 2, the lumped parameter models of two-axle and three-axle vehicle systems are established and the dynamic responses are analyzed.

In Chap. 3, the nonlinear virtual prototype model of a heavy vehicle is set up, and an orthogonal optimization program for the virtual heavy vehicle model is presented to analyze the effect of vehicle parameters on riding comfort and road friendliness according to the design of experiment (DOE) method.

In Chap. 4, the road models of a finite and infinite beam on a nonlinear foundation with viscous damping are established. Based on the Galerkin method and the integral transform method, the numerical and analytical solutions are derived for the dynamic response of the pavement structure subjected to a moving load. Moreover, the vibration characteristics of the pavement structure under a moving load are discussed through some examples. Furthermore, the coupled nonlinear vibration of the vehicle–pavement system is studied based on a finite Timoshenko beam on the foundation subjected to a spring–mass–damper oscillator.

Chap 5 establishes the road model as an infinite double-layer plate on a Kelvin foundation and an elastic half-space. An analytical approach is developed to investigate the dynamic response of the road subjected to moving vehicle loads. The analytical solutions of the dynamic responses in time domain are then derived by integrating the generalized Duhamel integral over the Green's function of the

double-layer plate under the unit impulse load. The vibration characteristics of the road under a moving constant and harmonic load are then analyzed.

In Chap. 6, a 3D finite element model of the road system is established and the time-dependent deflection, stress, and strain of the road are obtained by linking together the road surface roughness, a moving heavy duty vehicle, and a multilayered road system. The road fatigue life is calculated by taking the tensile strain at the bottom of the asphalt surface as the evaluation index.

In Chap. 7, a 2D and 3D vehicle–road coupled systems are built and coupled system responses are simulated with the methods of mode superposition, Galerkin’s method, and numerical integration. The differences between the coupled system and the traditional systems are also investigated.

By using the theory of vehicle–pavement coupled system proposed in Chap. 7, effects of system parameters on dynamic characteristics of vehicle and pavement are simulated and analyzed in Chap. 8. Based on the simulation results, some low dynamic design measures are suggested for choosing system parameters, which may contribute to the ride comfort of heavy vehicle and the life of asphalt pavement.

Chapter 9 presents a nonlinear vehicle–road coupled model composed of a seven degree of freedom (DOF) vehicle and a simply supported double-layer rectangular thin plate on a nonlinear viscoelastic foundation. A numerical integration method for solving this coupled system is developed and the nonlinear dynamic behaviors of the system are analyzed. In addition, the simulation results of the nonlinear viscoelastic model are compared to those of the linear or elastic model. The effects of system parameters on vehicle riding comfort and road damage are investigated.

In Chap. 10, a vehicle–road field test section was built on a highway and the responses of a heavy vehicle and the road were measured. This book has constructed a cross-subject research framework referred to as “vehicle–road coupled system dynamics” and will be beneficial to vehicle optimization, road design, construction, and fatigue life prediction.

This book is suitable for university professors, graduate students, and engineers majoring in vehicles, mechanics, highway engineering, and other related areas.

Dynamics of Vehicle-Road Coupled System

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2015, XV, 327 p. 255 illus., 36 illus. in color., Hardcover

ISBN: 978-3-662-45956-0