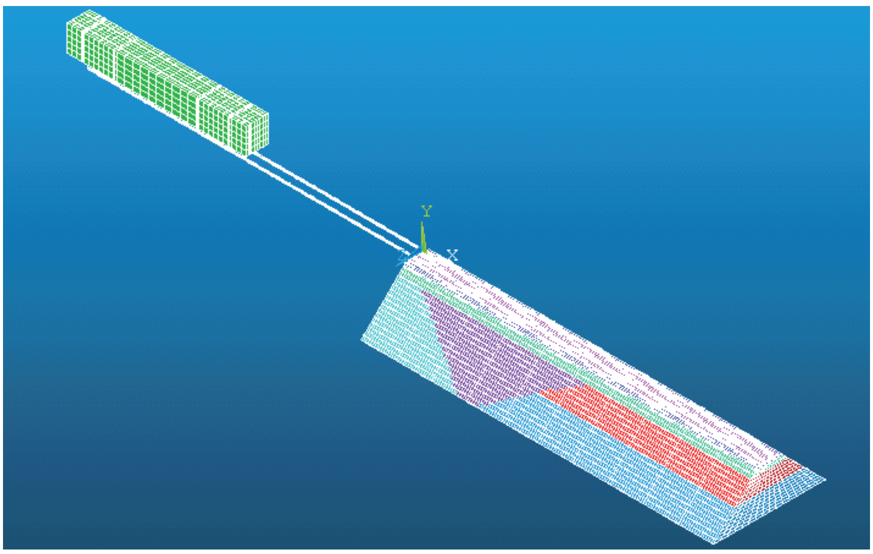
VERÖFFENTLICHUNGEN

des Grundbauinstitutes
der Technischen Universität Berlin
Herausgegeben von S.A. Savidis

HEFT 61

Numerical Investigation of Dynamic Railway Vehicle-Track-Subgrade Interaction



Shan, Yao

Berlin 2013

Bibliographic information published by the Deutsche Nationalbibliothek
The Deutsche Nationalbibliothek lists this publication in the Deutsche Nationalbibliografie; detailed bibliographic data are available in the internet at http://dnb.d-nb.de.

Zugl.: Berlin, Techn. Univ., Diss., 2013

Adresse des Instituts:

Fachgebiet Grundbau und Bodenmechanik - Degebo
Technische Universität Berlin
Sekr. TIB1-B7
Gustav-Meyer-Allee 25
13355 Berlin

Telefon: (030) 314-72341
Telefax: (030) 314-72343
E-Mail: info@grundbau.tu-berlin.de
Internet: http://www.grundbau.tu-berlin.de

Printed in Germany.

ISBN 978-3-8440-2294-0
ISSN 0342-3905

Shaker Verlag GmbH • P.O. BOX 101818 • D-52018 Aachen
Phone: 0049/2407/9596-0 • Telefax: 0049/2407/9596-9
Internet: www.shaker.de • e-mail: info@shaker.de

Preface by the Editor

The variation of the track stiffness directly influences the vehicle-track dynamics and the effect increases with the train speed. With the development of the high speed railway track, it is important to know how the dynamic response of the vehicle-track system changes with track stiffness.

It is acknowledged that the most abrupt change of the track stiffness usually occurs in the transition zone, e. g. bridge-embankment or tunnel-embankment transition zone. Consequently, the design of the transition zone configuration has significant effect on the track stiffness transition. The problem is to find a transition configuration for the best track performance. In this study, the author presents some interesting findings regarding this issue based on three dimensional dynamic numerical simulations by the finite element method. It is worth to note that some conclusions related to the influence of the rail support stiffness on the dynamic response of the vehicle-track system have never been reported in literature.

For the studies on the vehicle-track-subgrade system dynamics, the complete system is usually divided into the vehicle-track system and the track-subgrade system in traditional numerical simulations. For the vehicle-track system the ballast and subgrade are usually simulated as layers of springs and lumped masses. In this way the wave propagation in the continuous medium (e. g. subgrade) cannot be simulated. For the track-subgrade system the vehicle loads are usually simulated as moving load and the wheel-rail interactions cannot be considered. This method is used for static or quasi-static problems. The author employed a complete vehicle-track-subgrade model to investigate the influence of the rail support stiffness on the dynamic response of the system. Furthermore, the transition performances of two different transition configurations employed in China are evaluated and compared.

In order to investigate the influence of the rail support stiffness and the excitation frequencies on the dynamic response of a vehicle system, the author developed two types of analysis and the low excitation frequencies (0~40Hz) are simulated. A very important finding is that for each excitation frequency the dynamic response of the vehicle is only sensitive to a certain range of the rail support stiffness. A “stiffness sensitive zone” is for the first time defined by the author. This finding has significant practical importance for the construction of the high speed railway track. The author indicated that the stiffness sensitive zones of low excitation frequencies (0~40Hz) can be avoided by controlling the rail support stiffness.

In my opinion, this study presents a number of interesting findings regarding vehicle-track-subgrade dynamics by the finite element method.

Berlin, August 2013

S. A. Savidis

Numerical Investigation of Dynamic Railway Vehicle-Track-Subgrade Interaction

vorgelegt von
Master of Science
Yao Shan
aus Shandong, China

von der Fakultät VI - Planen Bauen Umwelt
der Technischen Universität Berlin
zur Erlangung des akademischen Grades

Doktor der Ingenieurwissenschaften

(Dr.-Ing.)

genehmigte Dissertation

Promotionsausschuss:

Vorsitzender:	Prof. Dr.-Ing Y. Petryna
Berichter:	Prof. Dr.-Ing S. Savidis
Berichter:	Prof. Dr.-Ing W. Rücker
Berichterin:	Dr.-Ing. habil. B. Albers

Tag der Wissenschaftlichen Aussprache: 10. April 2013

Berlin 2013

D83

Abstract

Since a railway track is a long infrastructure constructed on complex foundations, the rail support stiffness is changed along the railway line. A sudden change of the rail support stiffness leads to an abrupt variation of the wheel-rail contact force. As a result the ride comfort of passengers is influenced as well as the dynamic response of the track and the subgrade.

In order to investigate the influence of a variation of the rail support stiffness on the dynamic response of the vehicle-track-subgrade system, a parameter study with a simple wheel-rail-substructure model has been carried out for a first qualitative analysis in the time zone. The influence of the support stiffness, the running direction of the wheel, the geometry irregularity of the rail and the excitation frequency are investigated. The results show that a larger track stiffness difference leads to a larger dynamic response of the complete system especially in the vicinity of the interface between the high stiffness zone and the low stiffness zone. The wheel running direction has limited influence on the dynamic response of the complete system.

Taking into account a sinusoidal track irregularity and the vehicle velocity, different wheel excitation frequencies (0~40Hz) are simulated. For each of these frequencies the dynamic response of the wheel is only sensitive to a certain range of the support stiffness. A higher excitation frequency leads to a larger range of the sensitive stiffness. In order to insure the ride comfort of passengers, excitation frequencies for which the support stiffness changes in the stiffness sensitive zone should be avoided by improved construction and maintenance methods.

After the parameter study on the influence of the rail support stiffness and the excitation frequency on the dynamic response of the wheel-rail-substructure system, a complete vehicle-track-subgrade model is employed to compare the performance of different transition zones. Two types of configurations that have been suggested in the Chinese design code for high speed railways on slab tracks are simulated.

Neglecting the geometric irregularity of the rail the dynamic response of the two-part transition section is smaller than that of the inverted trapezoid transition section. For each excitation frequency a stiffness sensitive zone appears, in which the change of the overall support stiffness has obvious influence on the dynamic response of the vehicle system. The larger the excitation frequency is, the wider is the sensitive zone. For overall support stiffnesses of the rail higher than 20kN/mm, the stiffness sensitive zones of low excitation frequencies (0~40Hz) can be avoided. In the same geometric irregularity condition the transition performance of the two-part transition section is better than that of the inverted trapezoid transition section.

Key Words: vehicle-track-subgrade system, excitation frequency, support stiffness of the rail, stiffness sensitive zone, finite element method, dynamic response, transition zone

Table of Contents