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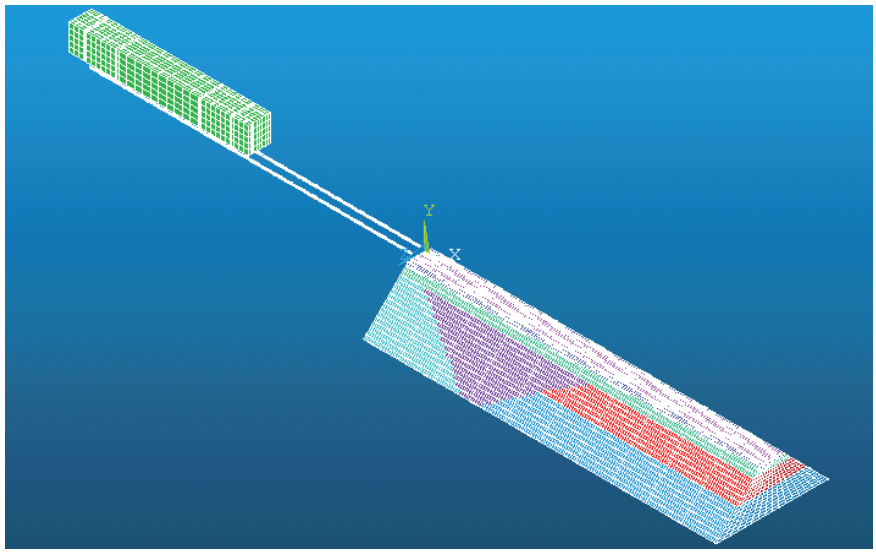
HEFT 61

Numerical Investigation of Dynamic Railway Vehicle-Track-Subgrade Interaction



Shan, Yao

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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

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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