

Rolling contact at rail top geometry defects: reality and simulation

Z. Li and X. Zhao
Delft University of Technology, the Netherlands

R. Dollevoet
ProRail, the Netherlands

Keywords: Wheel-rail rolling contact, friction, plasticity, dynamic contact, finite element method

1 DESCRIPTION OF THE PROBLEM

Some geometry defects on the top of rail may cause larger wheel/rail interaction force and grow into squats, a type of local plastic deformation accumulated over many wheel passages (Figure 1). The impact force at squats is very detrimental to both the tracks and the rolling stock. The cracks accompanying them may cause catastrophic accidents. The questions are how such defects initiate and grow and what the root causes are.

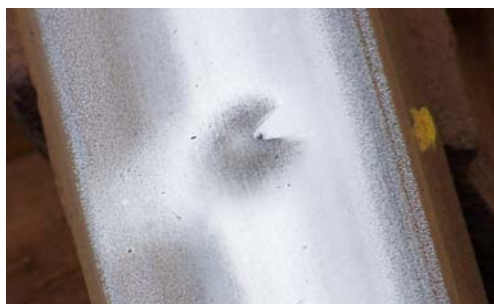
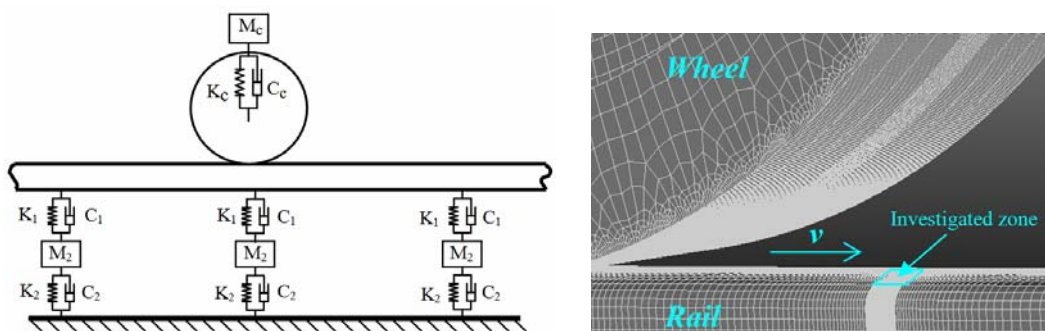


Figure 1. A typical squat.

2 MODELING METHOD

Correlation analyses show that squat occurrence is related to friction, plasticity and dynamics of the coupled vehicle-track interaction system. Some parameters of the track structure have strong influence on the dynamics. Finite element (FE) models are therefore developed (Figure 2). The wheel and rail are modeled with solid elements for detailed contact solution, while the rail pads, sleepers, ballast and the primary suspension and sprung mass of the vehicle are modeled as masses, springs and dampers.



(a) Schematic diagram of the model

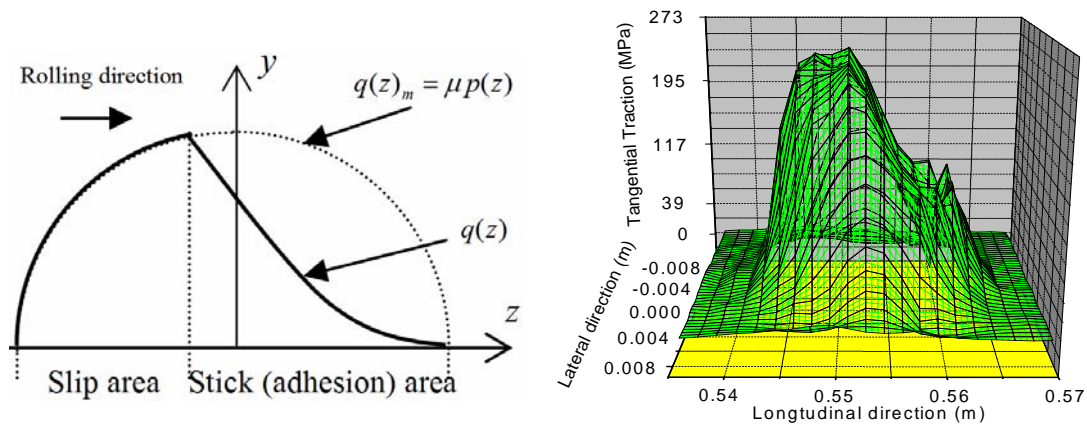
(b) Zoom-in of the wheel-rail contact

Figure 2. FE model of the coupled vehicle-track interaction system.

3 RESULTS AND VALIDATION

3D frictional dynamic rolling contacts at rail top geometry defects are solved in elasto-plasticity (Figure 3). The process of squats growth has been revealed [1] and validated by field monitoring. It is found that

- a. Squats may initiate from differential wear and differential plastic deformation [2].
- b. Track short wave defects can cause such wear and deformation [2].
- c. The relevant frequency of squats can be up to 2000 - 3000Hz. Such frequency component has been found in numerical simulations and is confirmed by measurements [1].
- d. Squat growth is influenced by certain eigen characteristics of the vehicle-track system [1].
- e. Squats bear some similarities with short pitch corrugation [1].



(a) Typical static tangential traction in 2D

(b) A calculated dynamic tangential traction in 3D

Figure 3. Comparison of tangential traction. For the static case it is presented in 2D for convenience of illustration. It can be seen that the dynamic contact follows basically the same pattern of slip (where $q(z) = q(z)_m$) and stick (where $q(z) < q(z)_m$), but high frequency components of the stress can be seen.

4 APPLICATIONS

The model and results are being applied to the identification of the root causes of squats initiation and growth, and to the establishment of criteria for optimal track maintenance and design.

5 REFERENCES

- [1] Z. Li, X. Zhao, C. Esveld, R. Dollevoet and M. Molodova, *An Investigation into the Causes of Squats – Correlation Analysis and Numerical Modeling*. Wear 265 (2008) 1349– 1355, DOI:10.1016/j.wear.2008.02.037
- [2] Z. Li, X. Zhao, R. Dollevoet and M. Molodova, *Differential Wear and Plastic Deformation as a Cause of Squat at Track Local Stiffness Change Combined with Other Track Short Defects*, Vehicle System Dynamics (2008), DOI: 10.1080/00423110801935855.
- [3] X. Zhao, Z. Li, C. Esveld and R. Dollevoet R, *The Dynamic Stress State of the Wheel-Rail Contact*. WSEAS Transactions on Applied and Theoretical Mechanics, Issue 2, Volume 2, February 2007, ISSN: 1991-8747 pp 52 – 59.