Effect of extreme climate on wheel-rail interaction over rail squats

Sakdirat Kaewunruen[1], PhD; Andris Freimanis[2]; Makoto Ishida[3], PhD

[1]Senior Lecturer in Railway and Civil Engineering, School of Engineering, the University of Birmingham, Birmingham, B152TT UK, s.kaewunruen@bham.ac.uk.
[2]PhD Student, Department of Civil Engineering, Riga Technical University, andris.freimanis_1@rtu.lv.
[3] Chief Track Engineer, Railway Engineering Department, Nippon Koei Ltd, Tokyo, Japan.

ABSTRACT:

Globally, modern ballasted railway tracks have become the most efficient and effective infrastructure for railway industry operating below 250 km/h of train speed for over centuries. The ballasted tracks have been tailored and optimised over and over; and they are often used in light rail tracks, metro networks, suburban rail network and intercity rail lines since they are relatively inexpensive and quite superior in terms of maintainability and constructability. Rail squats are defined by the growth of any cracks that have grown longitudinally through the rail subsurface and some of the cracks propagating to the bottom of rails transversely have branched from initial longitudinal cracks with a depression of rail surface. The rail defects are commonly referred to as 'squats' when they were initiated from damage caused by rolling contact fatigue, and as 'studs' when they were associated with white etching layer caused by the transform from pearlitic steel due to friction heat generated by wheel sliding or excessive traction. Such rail surface defect induces wheel/rail impact and large amplitude vibration of track structure and poor ride quality. In Australia, Europe and Japan, rail squats/studs have occasionally turned into broken rails. The root cause and preventive solution to this defect are still under investigation from the fracture mechanical and material scientific point of view.

The dynamic interactions between vehicle and track impose vibrations and acoustic radiations and become moving vibro-acoustic sources along the railway corridor. Especially when there is imperfection of either wheel or rail, the dynamic amplification of loading conditions and reflected vibration effects on infrastructure and rolling stocks is significantly higher. In practice, imperfection of rail tracks can be classified into short wave length and long wave length defects. The short wavelength defects include high-frequency related rail surface defects such as dipped joint rails, rail squats, rolling contact fatigues (RCFs), rail gabs and crossing nose. The long wavelength defects are those associated with low frequency vibrations such as differential track settlement, mud pumping, bridge ends, stiffness transition zone, etc. Most previous studies into vehicle-track interactions are concerned only to a revenue service in an idealised condition. This study is the world first to evaluate the coupling dynamic vehicle-track interactions over rail squat defects considering the effect of extreme temperatures. The vehicle model has adopted multi degrees of freedom coupling with a discrete supported track model using Herzian contact theory. This paper highlights the dynamic impact load factors experienced by railway track components due to wheel/rail contacts. The insight into the dynamic amplification will enable predictive track maintenance and risk-based track inspection planning to enhance public safety and reduce unplanned maintenance costs.