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Extended Abstract

Peridynamics Modelling of Rail Surface Defects in Urban Railway and Metro Systems [†]

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Rail squats and studs, which are one of critical rail surface defects, are typically classified as the propagation of any cracks that have grown longitudinally through the subsurface. Some of the cracks could propagate to the bottom of rails transversely, which have branched from the initial longitudinal cracks with a depression of rail surface. The rail defects are commonly referred to as 'squats' when they were initiated from damage layer 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 above-mentioned rail defects have been often observed in railway tracks catered for either light passenger or heavy freight traffics and for low, medium or high speed trains all over the world for over 60 years except some places such as sharp curves where large wear takes place under severe friction between wheel flange and rail gauge face. It becomes a much-more significant issue when the crack grows and sometimes flakes off the rail (by itself or by insufficient rail grinding), resulting in a rail surface irregularity. 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 [1–12].

This study is the word first to establish and demonstrate a novel state-based peridynamics modelling technique that is able to define and predict crack propagation from rail surface defects commonly found in urban railway and metro systems. The root cause and preventive solution to this defect are still under investigation from the fracture mechanics and material sciences point of view. Some patterns of squat/stud development related to both of curve and tangent track geometries have been observed, and squat growth has also been monitored for individual squats using ultrasonic mapping techniques. This paper highlights peridynamics modeling of squat/stud distribution and its growth [13–17]. Squat/stud growth has been measured in the field using the ultrasonic measurement device on a grid applied to the rail surface. The depths of crack paths at each grid node form a three dimensional contour of rail squat crack. The crack propagation of squats/studs is modelled using peridynamics. The modeling and field data is compared to evaluate the effectiveness of peridynamics in modelling rail squats as shown in Figure 1.
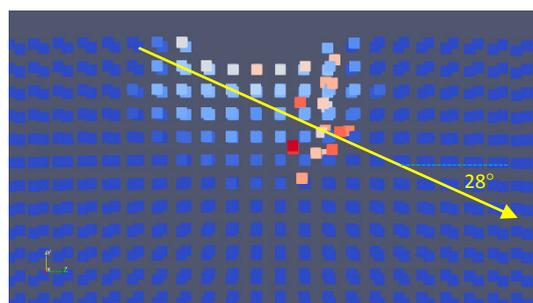
Figure 1. Peridynamics crack propagation of rolling contact fatigue defect.

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