CERIS Civil Engineering Research and Innovation for Sustainability

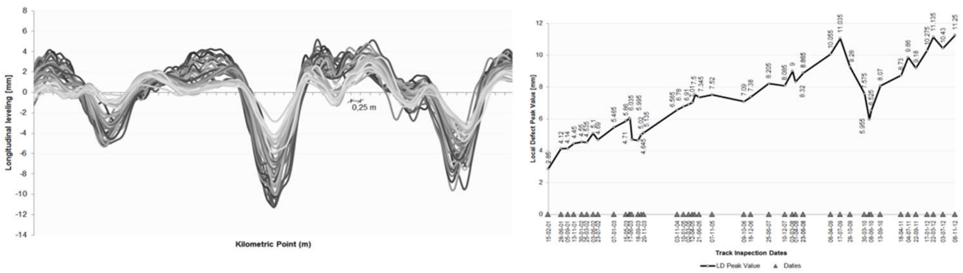
Development of degradation models to predict maintenance needs related to local defects of track geometry

Summary

The operation of railway systems leads to the inevitable degradation of track geometry. High-cost maintenance operations, therefore, have to be performed to ensure normal and safe operating conditions. Usually, such operations are limited both in time and space due to budget, time, equipment, and workforce constraints. For this reason, prioritizing its execution in track sections that need it most is of paramount importance. The forecast of preventive maintenance needs is usually carried out based on global track geometry quality indicators, often considering the standard deviation of longitudinal levelling (LL) in 200 m long sections as a key parameter. However, in many situations, the marked local evolution of local defects (LDs) is not properly anticipated by global quality indicators. In such cases, the mandatory values of the standards currently in force are often exceeded and corrective interventions have to be performed to restore normal circulation conditions, with consequent high direct and indirect costs resulting from the unavailability of the track. From this point of view, monitoring, modelling, and forecasting the evolution of LDs may make it possible to predict preventive maintenance needs related to track geometry with greater precision, thus enabling significant reductions in future costly corrective maintenance interventions. This thesis investigates the degradation of LDs using different regression models (linear, logarithmic, exponential, and power) which are applied to sets of measurements from different track inspections performed between consecutive tampings. Subsequently, an analysis of the most influential factors in the geometric degradation of both the track's substructure and superstructure is carried out, addressing aspects such as ballast type and age, the presence of singularities (switches, bridges, tunnels, viaducts, level crossings, culverts, underpasses, etc.), the existence of transition zones, type of rails, sleepers and fastenings, train speeds, state of renewal and geometric condition of the track, etc. Next, the influence of such factors on the efficiency of heavy and light tamping operations will also be analysed (work in progress) with the aim of developing models to predict the geometric recovery achieved by performing tampings and the impact of such interventions on the subsequent degradation rates of LDs. In broad terms, the results obtained so far show that the degradation of LDs is not always linear as is generally assumed in the literature (26 to 36% and 20 to 30% of the time the exponential and power models, respectively, are more suitable for modelling the data) and there are many situations in which the local degradation is much higher than its counterpart for the standard deviation in 200 m long track sections (up to 96 times higher). In fact, it is determined that even when the standard deviation limits recommended in current European standards are met, there is still a probability of up to 3% (or 7% for the Portuguese national case) that LDs above the immediate action limit (the most critical) emerge on the track. It is found that the existence of singularities and transition zones as well as the ballast type and age greatly affect both the probability of emergence of LDs and their degradation rates. Likewise, it is determined that train speeds and the geometric condition of the track also strongly impact its local geometry degradation rates. It is believed that monitoring, modelling, and predicting the degradation of LDs will greatly help to forecast future track renewal needs, as well as to anticipate currently unplanned maintenance needs and tackle unavailability costs.

Keywords

Track geometry degradation, local defects, degradation rates, track maintenance, tamping efficiency.



Signal overlapping for a LD of LL (on the left) and the evolution of its peak values over time (on the right).

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Period

2013-2024

Funding

FCT scholarship (PD/BD/52358/2013)