Dynamic responses of asymmetrical turnout bearers to coupling vertical and lateral forces in railway switches and crossings

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ABSTRACT:

Railway infrastructure is naturally a complex system. Its behaviours, geometry and alignment, wheel-rail forces and operational parameters such as tractive efforts are often found to be nonlinear and asymmetrical. Railway urban turnout is a special track system used to divert a train from a particular direction or a particular track onto other directions or other tracks. It is a structural grillage system that consists of steel rails, points (or called ‘switches’), crossings (special track components), steel plates, rubber pads, insulators, fasteners, screw spikes, beam bearers (either timber, polymer, steel or concrete), ballast and formation. It is often found that most train-turnout interaction induces dynamic transient loading on the track components. Also, ballast damage can cause differential settlement and aggravates the impact forces acting on partial and unsupported sleepers and bearers. Importantly, the localised ballast breakages underneath any railseat increase the likelihood of centre-bound cracks in railway sleepers and bearers due to the unbalanced support. In many case, trains divert from one tangent track to another curved turnout road. Not only does the complex train-track interaction generate vertical impact loading, but the curving behavior of the train body also induce dynamic lateral force acting on the rail.

This paper presents a numerical simulation of a standard-gauge concrete bearer at crossing panel, taking into account the tensionless nature of ballast support. The finite element model was calibrated using static and dynamic responses using past experiments. Previous extensive studies established that the two-dimensional Timoshenko beam model is the most suitable option for modeling concrete sleepers under vertical loads. In this investigation, the finite element model of asymmetric concrete bearers at a v-crossing has been previously developed and calibrated against the numerical and experimental modal parameters. The influences of topologic asymmetry on coupling dynamic behaviours of crossing bearers are firstly investigated. In addition, it is the first to demonstrate the effects of material damping on the dynamic spectra of turnout bearers in the v-crossing panel. The outcome of this study will improve the railway turnout construction and maintenance criteria in order to improve train-turnout interaction and ride comfort.