Finite element based estimation of lateral forces in heavy haul railway switch combined with strain gauges measurements

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Introduction

Switches (turnouts) are critical parts in a railway system. While more continuous conditions are achieved along an undivided track, many discontinuous events take place when the train passes a switch. When a train runs on the diverting track of a switch, the wheels on the outer rail will pass the gap in the crossing plate (the frog). During this, the guiding of the axles will be done by the check rail (guard rail). The components are shown in figure 1 and 2.

In heavy haul tracks, large lateral forces F_{lat} are imposed on the check rail, that is supported by cast or welded steel brackets attached to the sleepers. The check rail system is heavily loaded and subjected to fatigue.

NORUT has developed a method to assess the forces on the check rail without costly and inconvenient in situ test arrangements.

Method. Experimental work and simulation

In this work the most loaded brackets were monitored with strain gauges. The calculation of the forces was done by comparing the measured strains with calculated strains in an advanced ANSYS [1] FE-model of the loaded rail components. The FE-model contains several types of nonlinearities to provide the most realistic model of the strain distribution.

The support brackets are shown in figure 2 and 3. The brackets in the current work are manufactured in steel grade S355. The parts are joined by fillet welds.

In a complex geometry most of the surface is not suited for strain gauges due to large strain gradients. By means the FE-model of the assembly, it was found that on the back side of the support plates there were large enough areas with relatively constant strain, as shown on the strain plot on figure 3.

To capture the torsion in the brackets, strain gauges were placed on the back side on both support plates on four of the most loaded brackets. The strain gauges were used in a Wheatstone quarter bridge setup. With a Campbell Scientific logger, they can be logged with a frequency up to 200 Hz. The data reading is trigged automatically by trains, and the data are transferred to a web server.

Results

The measured strain peaks were found to be in the range -200 – -900 microstrains [µstr]. In the simulation model, an applied force of 60 kN would give -644 µstr in the area where the brackets had their strain gauges attached, giving a scale factor -0.093 kN/µstr.

It was found that the scattering among the forces from the axles along the trains was high. The third bracket, that is situated opposed to the crossing, was subjected to the highest average force. Results from 9 iron ore trains are shown in figure 4.

The trains passed with velocities varying between 10 and 40 km/hr. However, no correlation between the velocity and the magnitude of the forces was found in this velocity range.

Conclusions

By means of an advanced and elaborated FE-model, it is possible to correlate calculated strains with measured strains, and hence to assess the forces acting on a structure.

The lateral forces on the check rail is highly stochastic with large scatter.

The work is still going on. One of the main goals is to check the effect of heavier trains, when the axle load from the iron ore wagons is increased from 30 tonnes axle load to 32.5 tonnes.

References

[1] ANSYS Mechanical ® Release 2019, Computer Program, Ansys Inc.

Acknowledgments

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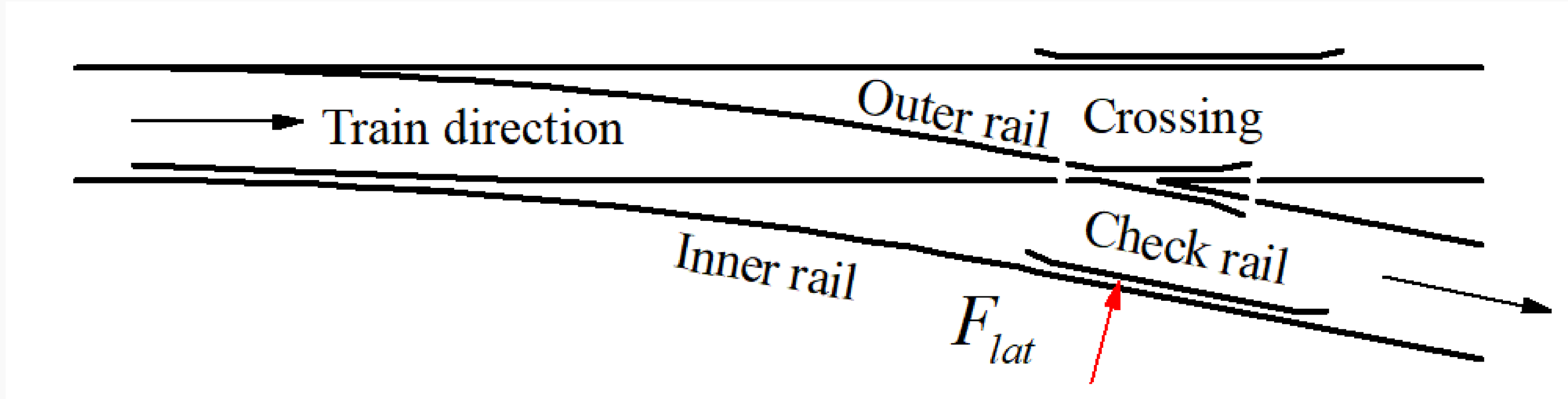

Figure 1. Some components in a railway switch. Peak forces are estimated in the supports of the shown check rail

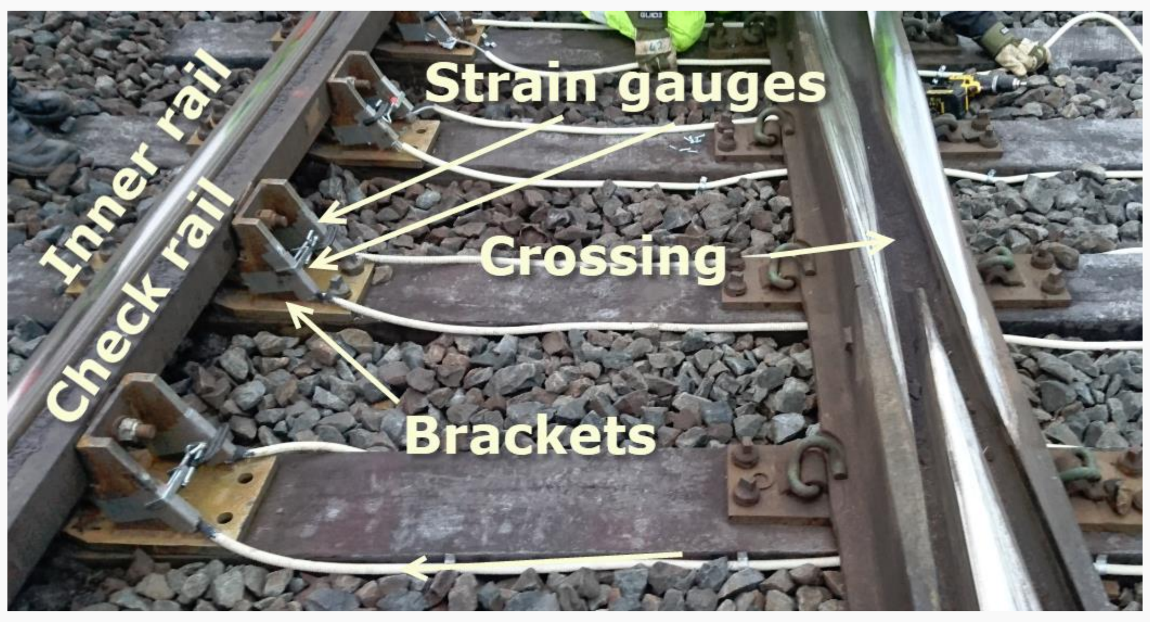

Figure 2. The four most loaded brackets were instrumented with strain gauges on both of the support plates

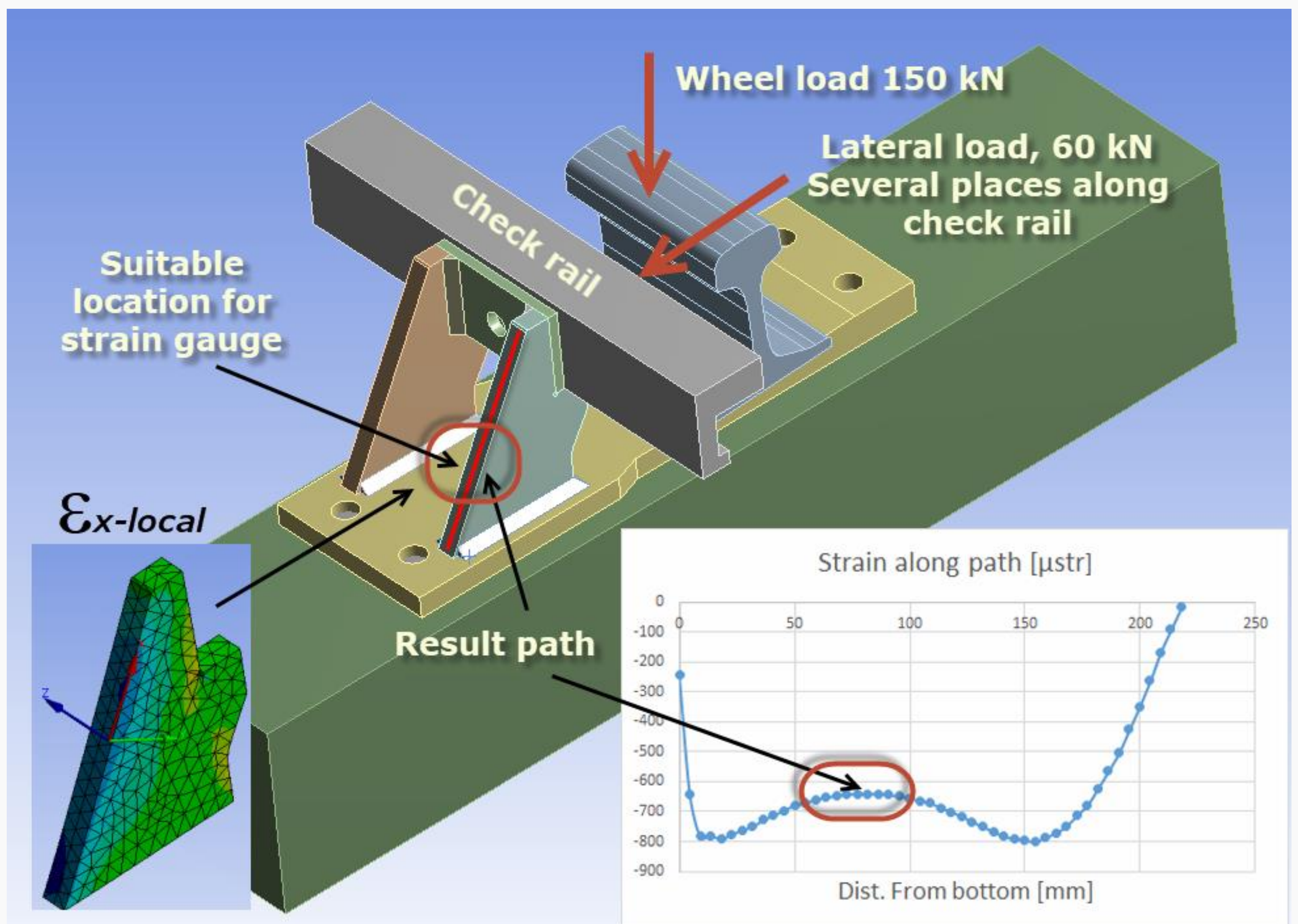

Figure 3: Geometry and FE-model. Location for the strain gauges

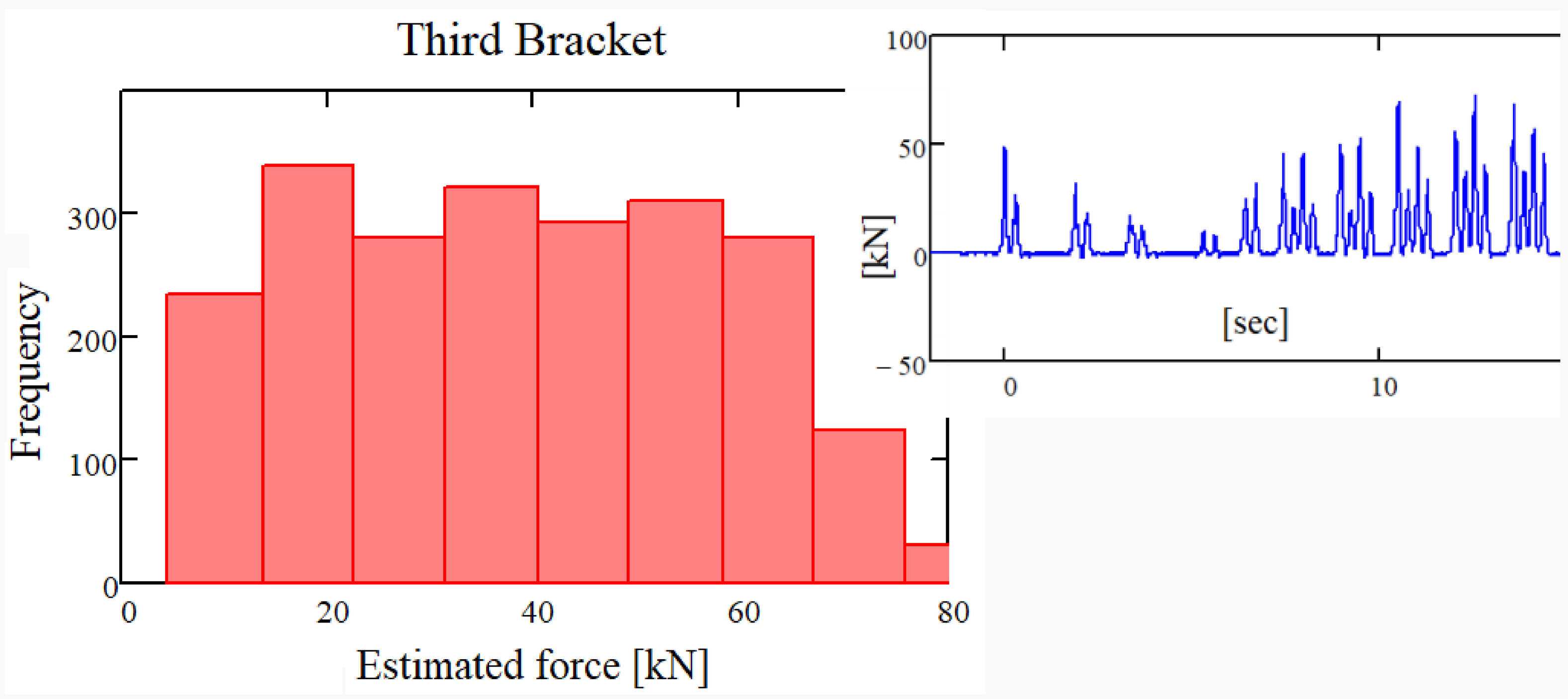

Figure 4: Histogram showing the scatter in peak forces on the third bracket. N = 2016, mean = 38.9 kN, st.dev. = 19.3 kN, max = 84.8 kN

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