Stress Conditions in Grooved Rails – Stress Determination

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The study investigates challenges posed by narrow tram track curves, causing slippage and increased wear. Numerical simulations assist in evaluating wear-reducing measures, requiring research on wheel-rail behavior. Findings from stress and tilting behavior measurements inform calibration, emphasizing the need for further models to predict wear and analyze contact behavior.

Introduction

To counter the challenges of increased contact forces and wear on wheels and rails, a combination of measurements and numerical simulations is developed to specifically aid in evaluating wear-reducing measures. The work aims to generate insights by establishing a measuring point in the Wiener Linien tram network, measuring stresses during tram crossings, and obtaining calibration data for finite element method (FEM). Findings from stress and tilting behavior measurements inform the calibration, with simulation results closely aligning with actual measurements.

Measurement

A corresponding measurement area was found in Vienna, which has a newly covered superstructure and a radius of 49.6 m. The selected curve has no superelevation and has a rail profile 60R1 with a rail quality of R 290 GHT. Further characteristics of the track are the continuous bearing and a track gauge of 1435 mm (standard gauge).[1] Depending on the type of vehicle used, a maximum speed of 30 km/h is possible.

In total 56 permanent strain gauges and 18 temporary laser sensors are used to record the wear behavior and the behavior during passes. A total of three measurement cross-sections are defined in order to be able to track the stress behavior of the grooved rail in the curve. The first measurement cross-section is located at the beginning of the curve the second measurement cross-section is located in the middle of the curve and the third measurement cross-section is located at the end of the curve. Figure 1 shows an overview of the positioning of the measuring cross-sections.

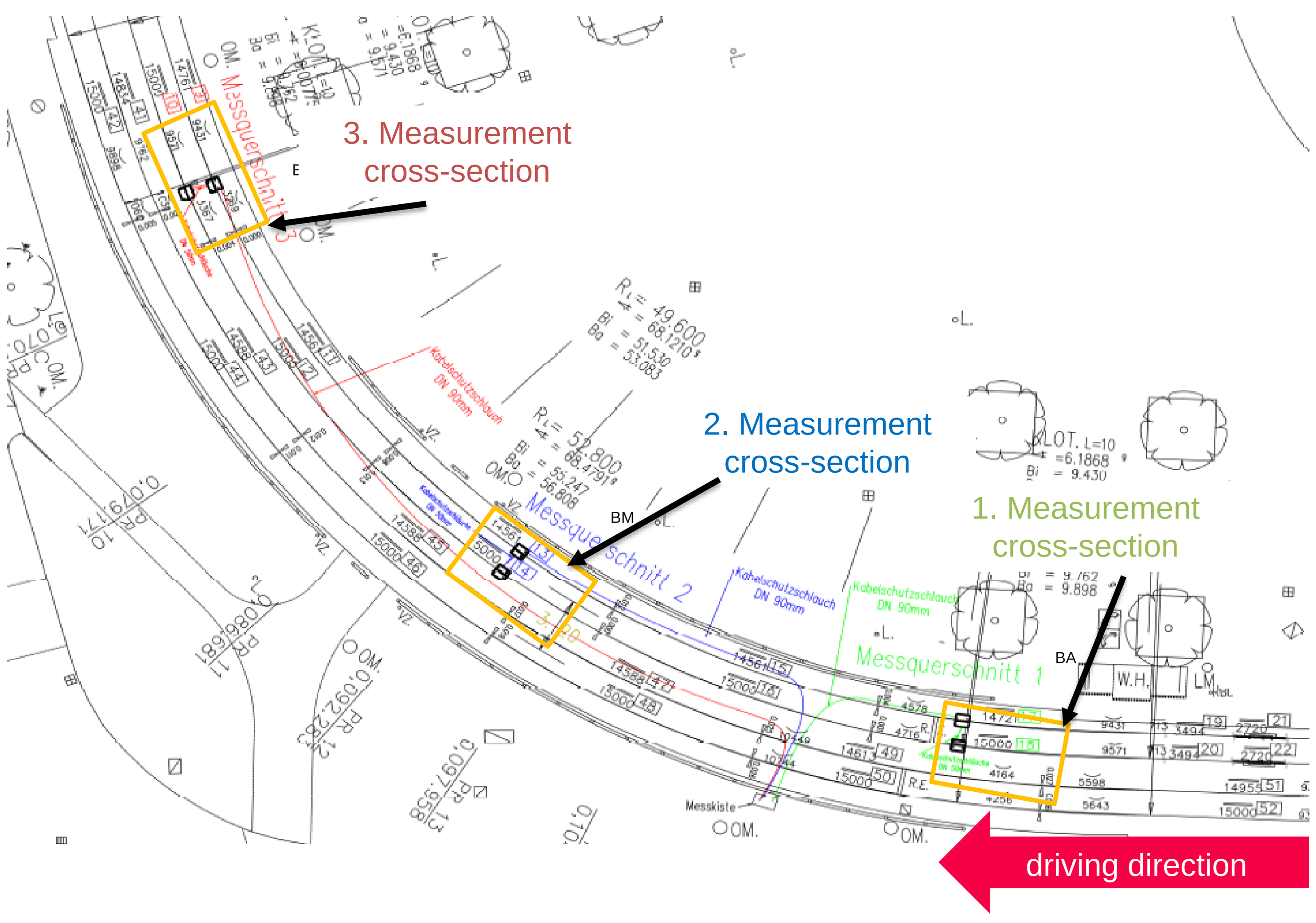

Fig.1: Overview of the positioning of the measuring cross-sections[1]

The findings on the stress and tilting behavior of the grooved rail during normal operation are obtained in the course of a first measurement on the track. In a second measurement, static and speed-dependent measurements are carried out using a specific vehicle type. The static measurements are mainly used for the calibration of the FEM simulation.

The first and second measurements indicate lower stresses in the middle of the arch compared to the start and end, possibly due to uncertain contact point knowledge. The second measurement, focusing on speed, reveals stress variations along the rail positions and deflection patterns with increasing speed.

Simulation

When setting up the simulation, a precise contact analysis between wheel and rail is initially assumed using a simplified single-point contact. In addition, only the static measurements are used for the first calibrations with the simulation system, as too many influencing variables are involved in a dynamic comparison and this requires further calculation methods. Due to the static approach, only an idealized straight track is modelled for the comparison. Results of the simulation model can be seen in Figure 2.

The first runs of the simulation were carried out with two single-point contacts on the running surface and on the head corner rounding in order to gain a general understanding of the stress distribution within the grooved rail. It was then possible to draw conclusions about possible contact between the wheel and the rail in order to calibrate the data with the first and third measurement cross-sections. The comparison showed that an average deviation of 20 % could be achieved with the first measurement cross-section. For the third measurement cross-section, the values for the inner rail matched well with an average deviation of 33 %, but a two-point contact was assumed for the outer rail, as the stress values represent a possible combination of contact between the running surface and the head corner rounding.

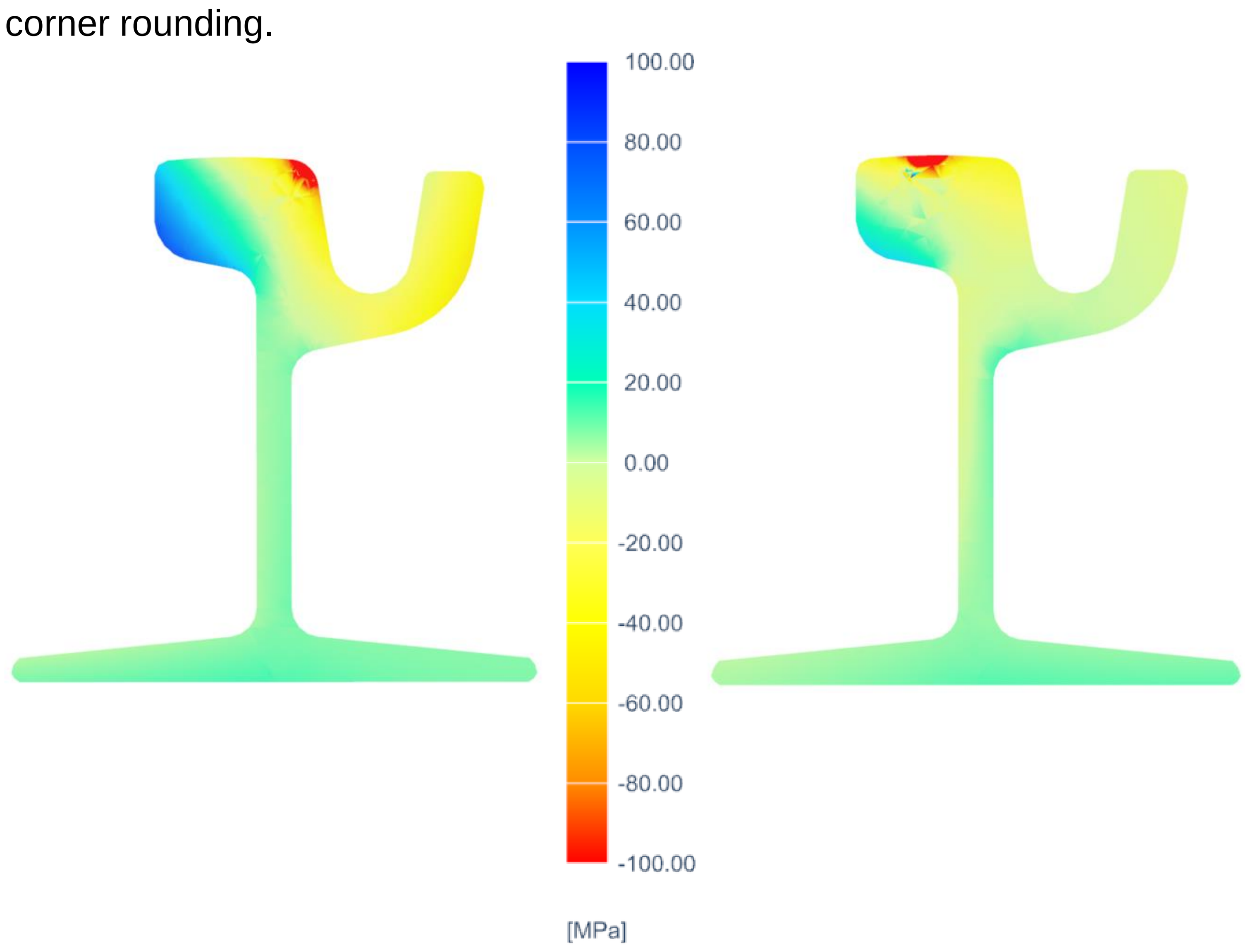

Fig.2: Normal stresses in the rail axis with a load on the running head area (left) and a load on the head corner rounding (right)

Conclusion

In general, the behavior of the grooved rail in the track curve can be reproduced via a simplified structure of the simulation. In order to obtain future wear predictions for suitable measures, further FE-models must be built, especially with regard to the contact analysis. The influence of single-point and two-point contact can be reflected in the stress behavior of the grooved rails and depends on the profiles of the wheel and the rail. An FE-model for the analysis of the contact, which depends on the wheel and rail profile, is necessary for further analyses on the contact behavior.

References

[1] Institut für Eisenbahnwesen Infrastrukturdesign, Vorprojekt - Verschleißgrenzen von Rillenschienen; Übersicht: Positionierung der Messquerschnitte, Rohrsystem; XI., Svetelskystraße-Etrichstraße. Datum: 16.09.2022; Plangrundlage: Wiener Linien GmbH & Co KG, Ausführungsplan, XI., Svetelskystraße-Etrichstraße, Datum: 10.05.2022.

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