Task 2.4: Life extension for plain line through preventing corrugation

To provide a better understanding of corrugation and what can be done to prevent it.

- Experimental tests conducted in the Turkish railways include: 1) a catalogue of corrugation and track parameters, and 2) experiments on corrugated rail making use of three fastening systems available from the industry.

- A further analysis of the 3D FE modelling approach and new insights about short pitch corrugation. The global explanation of the dynamic conditions and the resulting corrugation damage are described. The modelling approach is not able yet to develop corrugation from smooth rail condition.
Corrugation catalogue

Corrugation Section:
- Wavelength, Amplitude
- Type of Corrugation

Track parameters:
- Type of Rail, Rail Grade, Sleepers, Fastening Rail Pad
- Curvature (Straight / Curve), Lubrication Condition, Date of Renewal/ Reparation

Traffic
- Type of Traffic, Single/ Double Traffic Direction
- Axle Load of Passenger Trains, Freight Trains
- Speed Limit for Passenger Trains, Freight Trains
- Vehicle Velocity, Vehicle in Acceleration, Vehicle in Deceleration
- Number of Daily Passenger Trains, Number of Freight Trains, Gross Ton (Annually)
Experimental test

Eskişehir- Afyon- Kütahya Line

W14  W21  HH
Modelling part:

• Background
• Model and method
• Conclusions and further research
• Questions
1 Background

Uniform corrugation

- amplitude
- wavelength

Corrugation variations in wavelength and amplitude

Corrugation variation in amplitude and corrugation induced squats
2 Model and methods

Schematic diagram of the model
Parameters from typical Dutch network

FE model in 3D
2 Model and methods

Field measurement of corrugation (~30 mm)

Illustration of the applied corrugation (corrugation 2 with P2 at 0.6 m, only 3 complete waves are plotted).

4 positions to be investigated
3 Contact solutions

Contact pressure, shear stress, contact patch, adhesion-slip distributions and vector graphs of micro-slips when $A = 20 \, \mu m$ (projection onto the $xOy$ plane; Border 1: contact patch border; Border 2: adhesion-slip distribution border).
3 Contact solutions

Summary:

With increases in the corrugation amplitude:

• The increases in the contact area, maximum pressure, shear stress and micro-slips at the corrugation crest are small, and some of them even decrease.

• Changes at the trough are large. The large micro-slip and the significantly reduced contact pressure at the trough are the major contributions to the differential wear, which causes corrugation initiation and growth.
4 Other results: differential wear

Differential wear in-phase with corrugation

Vertical track mode

Longitudinal track mode

Becoming dominant when corrugation is severe.

For corrugation initiation
4 Other results: contact forces

Contact forces are not in consistent with the corrugation.

Dynamic wheel-rail contact forces obtained for the corrugation
4 Other results: contact forces

1. The frequencies of the normal ($F_N$) and longitudinal ($F_L$) forces are different from the corrugation excitation frequency;
2. Their frequencies are varied with corrugation wavelength, at around 31 mm they converge to the same frequency;
3. The longitudinal contact frequency is less influenced by the corrugation than the vertical contact force.
5 Conclusions and further work

- In the presence of corrugation, contact patch, stresses and micro-slip distributions will be re-distributed.

- Wear, under an applied corrugation, is in-phase with the corrugation and the corrugation will not grow.

- Besides the generally accepted hypothesis that vertical vibration for corrugation, longitudinal modes are more important for the initiation of corrugation.
5 Conclusions and further work

• The frequencies of the vertical and longitudinal vibration modes and contact forces as well as the resulting wear are different.

• Therefore, they should be consistent with the corrugation for initiation and growth.

• The results explain the occurrence of rail squats induced by the corrugation.

• Further work: to investigate the track parameters and reproduce the consistent corrugation initiation and growth.
Questions

Thank you for your attention!