NeTIRail

Needs Tailored Interoperable Railway Infrastructure

Corrugation

NeTIRail-INFRA final conference

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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)

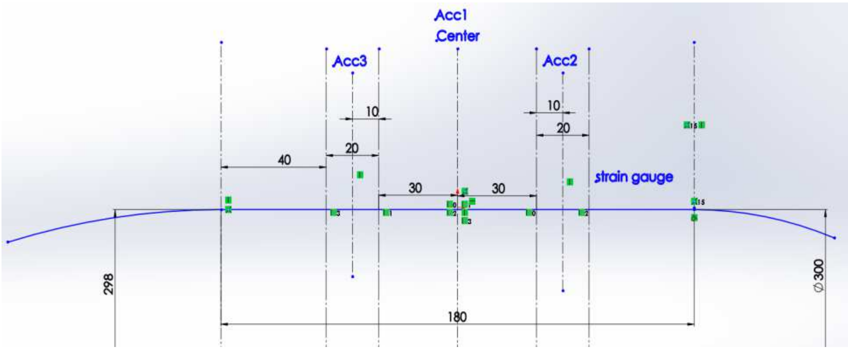
TYPE OF CORRUGATION:

CORRUGATION	
Wavelength	100-300mm
Amplitude	25µm
Type of Corrugation	Medium Pitch
TRACK PARAMETERS	
Type of Rail	UIC 60 E
Rail Grade	900
Type of Sleepers	B70 Concrete
Type of Fastening System	Skl 14
Type of Rail Pad	RP 700
Curvature (Straight/Curve)	Straight
Lubrication Condition	Unavailable
Date of Renewal/ Reparation	2008

TRAFFIC	
Type of Traffic	Mixed Traffic
Single/ Double Traffic Direction	Double Traffic Condition
Axle Load of Passenger Trains	12 tonnes
Axle Load of Freight Trains	22.5 tonnes
Speed Limit for Passenger Trains	100 km/h
Speed Limit for Freight Trains	70 km/h
Vehicle Velocity	120 km/h
Vehicle in Acceleration	35 km/h
Vehicle in Deceleration	30 km/h
Number of Daily Passenger Trains	6 Passenger Trains
Number of Freight Trains	8 Freight Trains
Gross Ton (Annually)	4.450.000 gtn

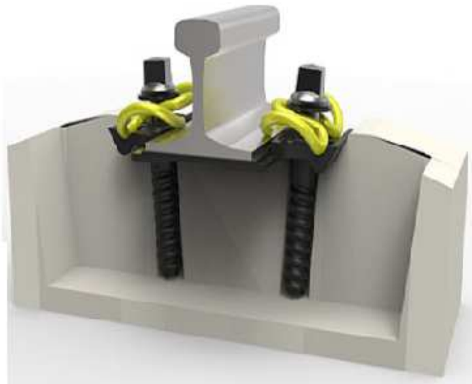
Experimental test

Eskişehir- Afyon- Kütahya Line



W14

W21



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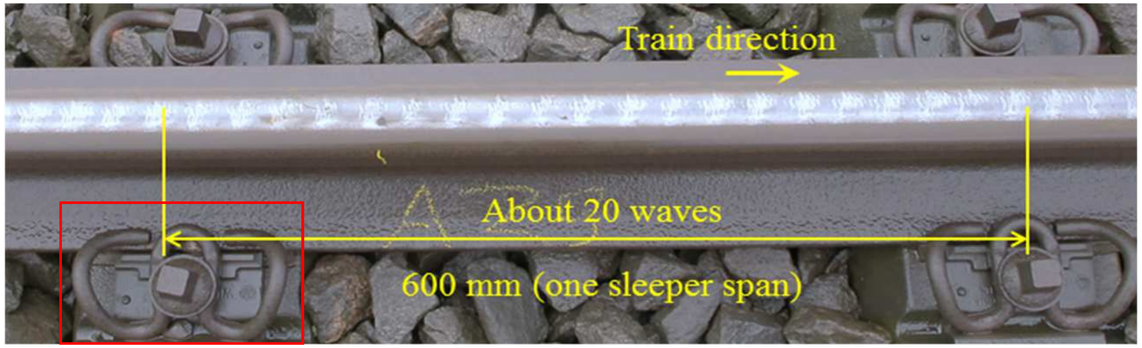
Modelling part:

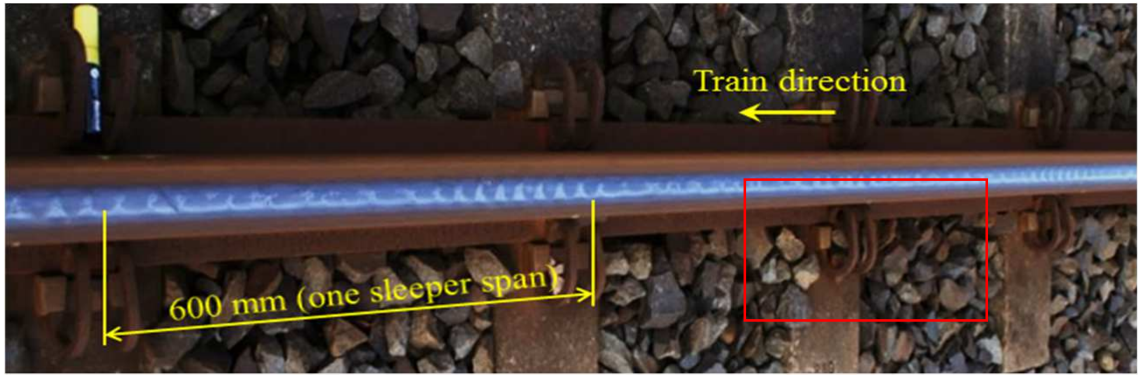
- Background
- Model and method
- Conclusions and further research
- Questions

1 Background

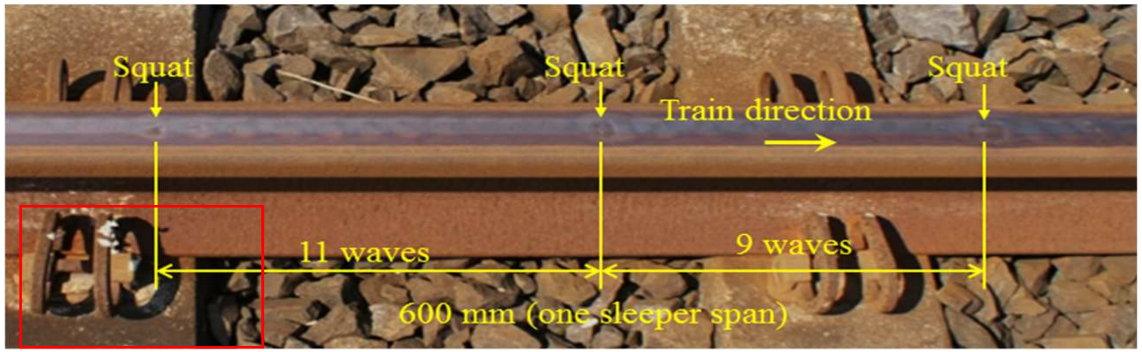


Uniform corrugation

- amplitude
- wavelength

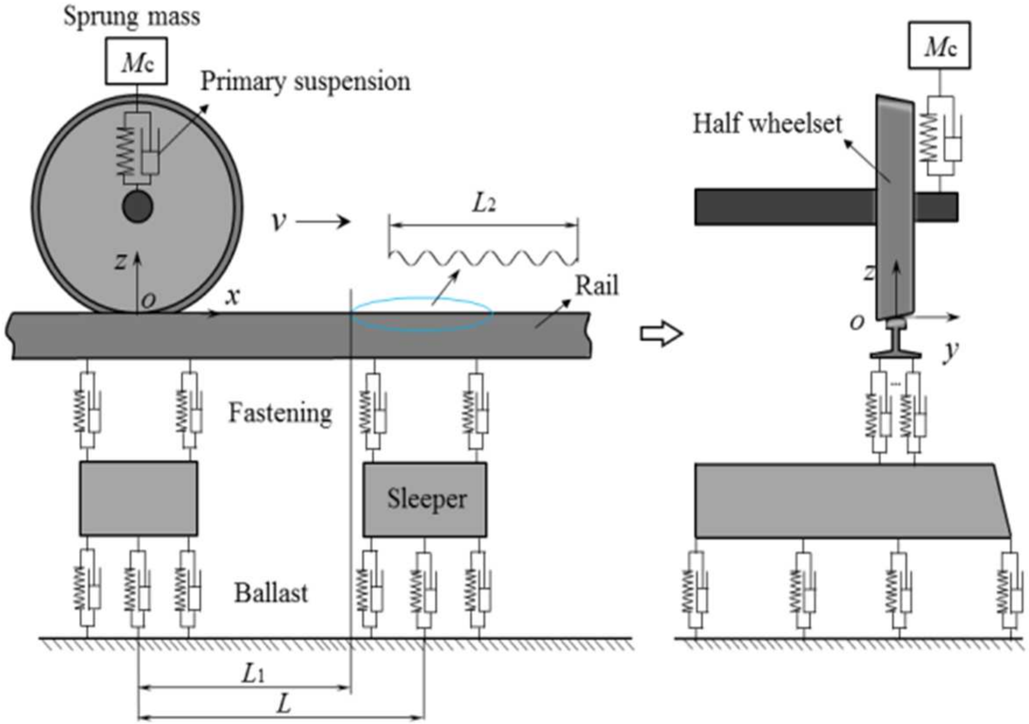


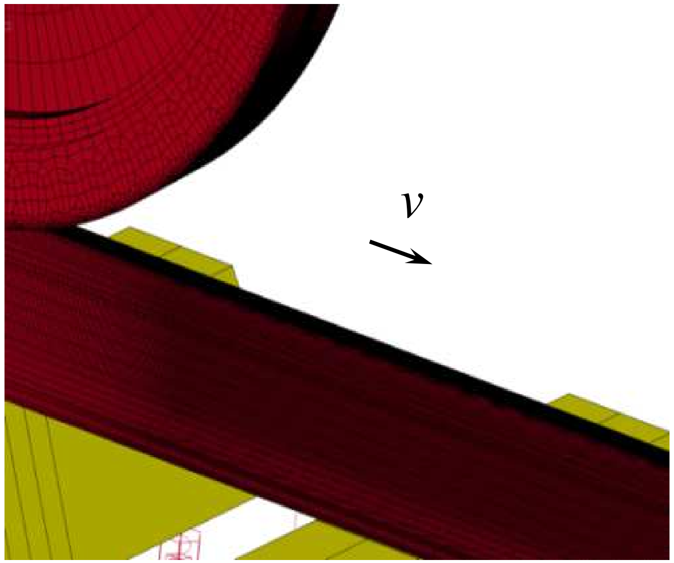
Corrugation variations in wavelength and amplitude



Corrugation variation in amplitude and corrugation induced squats

2 Model and methods

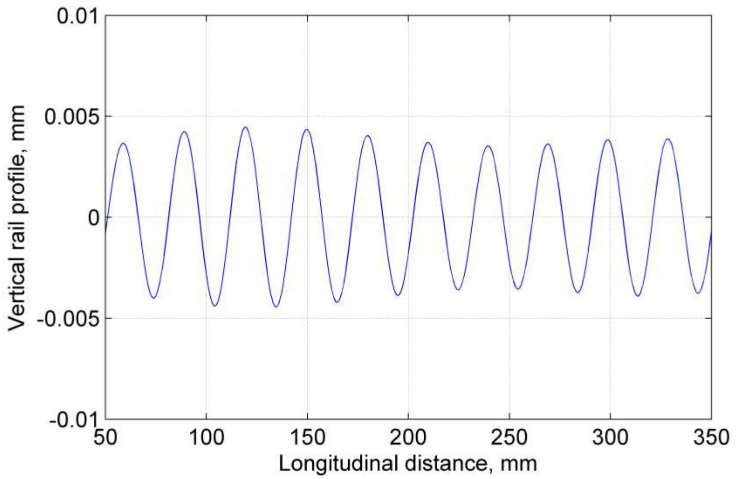




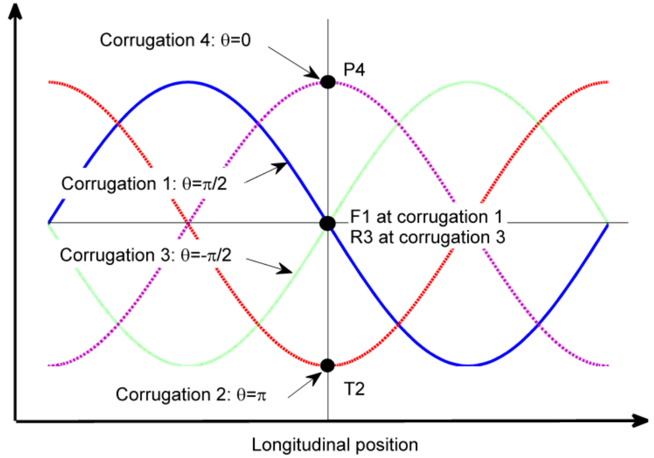
Schematic diagram of the model
Parameters from typical Dutch network

FE model in 3D

2 Model and methods



Field measurement of corrugation (~30 mm)



4 positions to be investigated

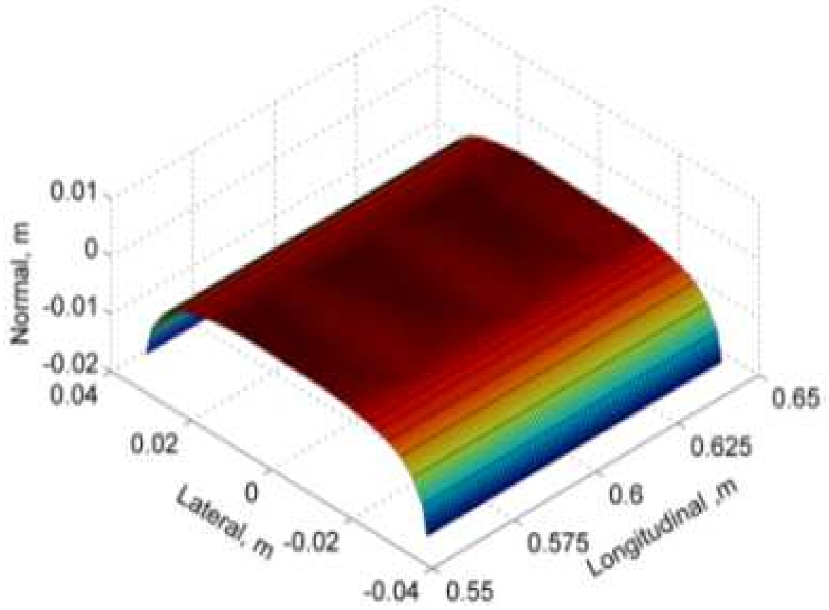
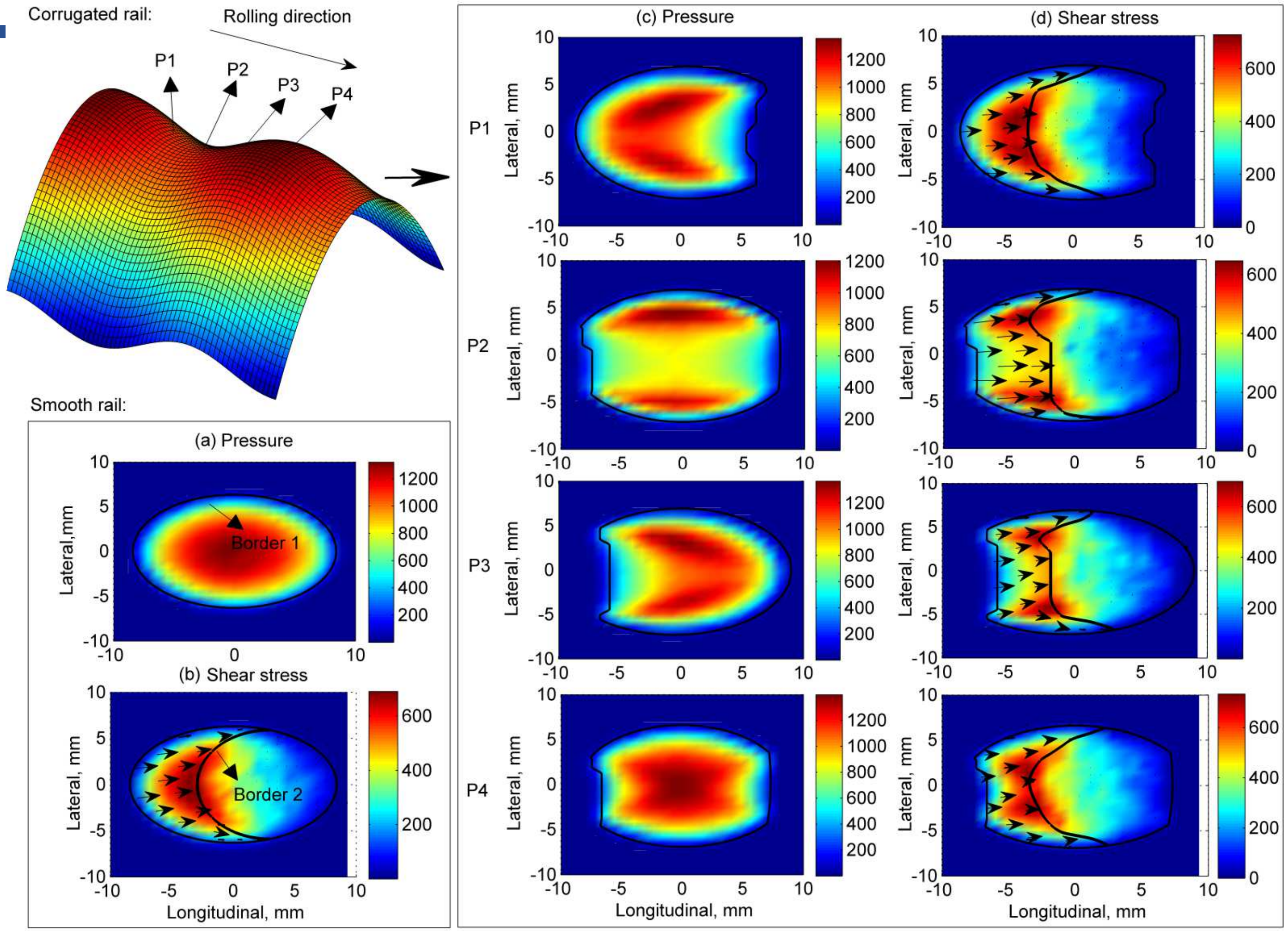


Illustration of the applied corrugation (corrugation 2 with P2 at 0.6 m, only 3 complete waves are plotted).

3 Contact solutions



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

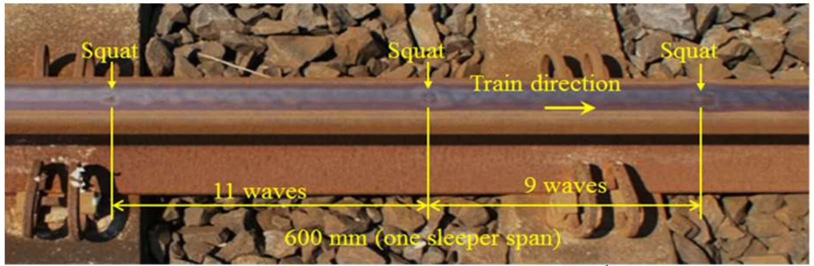
3 Contact solutions

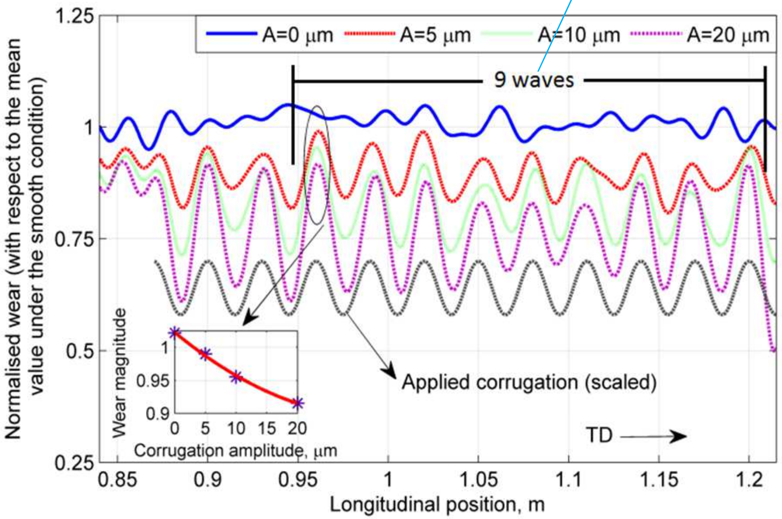
Summary:

With increases in the corrugation amplitude:

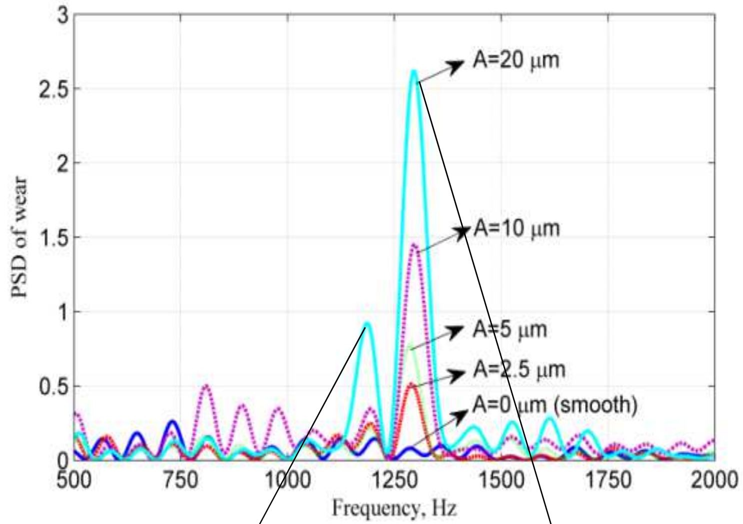
- The increases in the contact area, maximum pressure, shear stress and micro-slips at the corrugation crest are small, and some of them even decrease.
- Changes at the trough are large. The large micro-slip and the significantly reduced contact pressure at the trough are the major contributions to the differential wear, which causes corrugation initiation and growth.

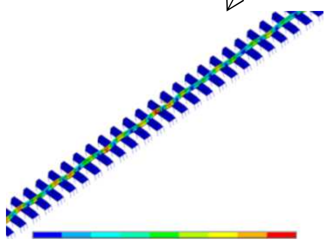
4 Other results: differential wear



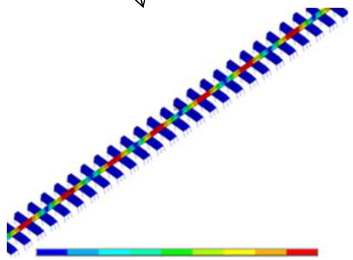


Differential wear in-phase with corrugation





Vertical track mode

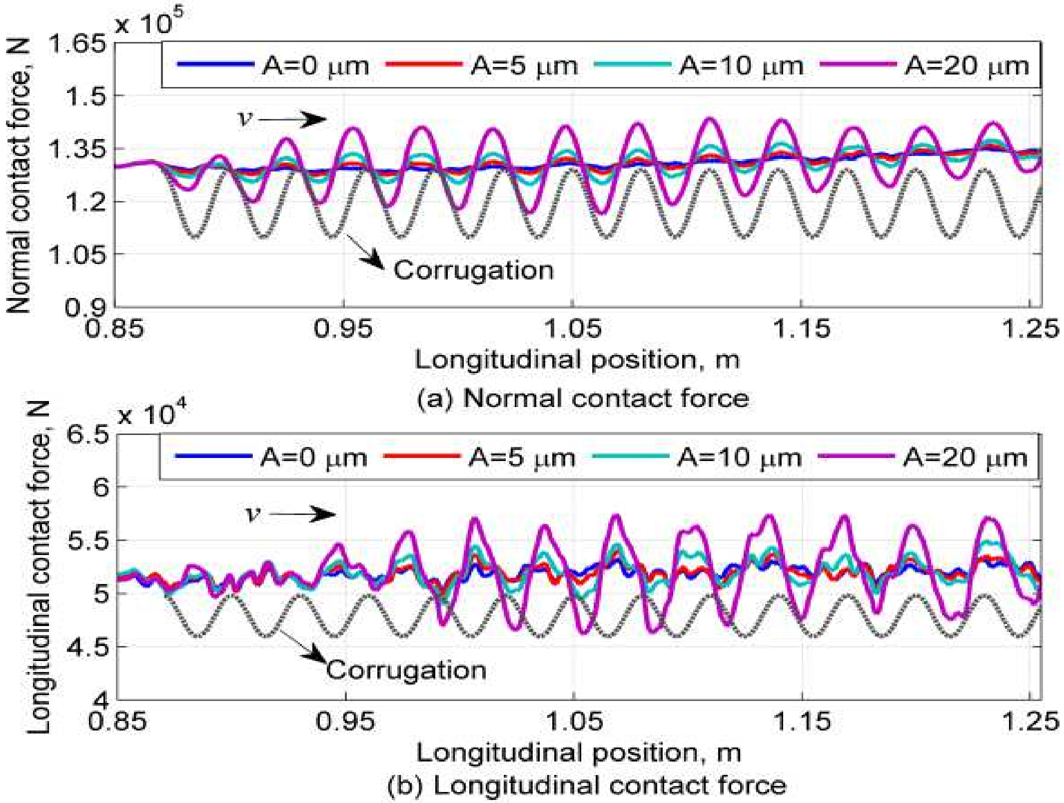


Longitudinal track mode

Becoming dominant when corrugation is severe.

For corrugation initiation

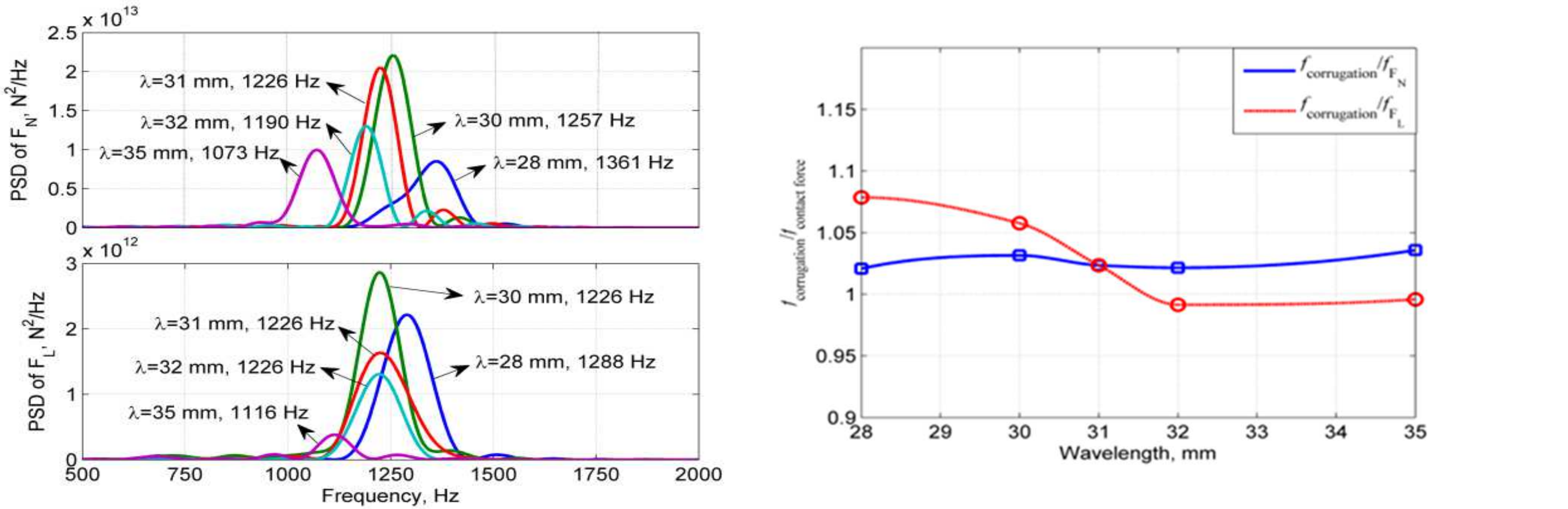
4 Other results: contact forces



Dynamic wheel-rail contact forces obtained for the corrugation

Contact forces are not in consistent with the corrugation.

4 Other results: contact forces



(a) PSD of F_N (upper) and F_L (lower) (b) Ratio of corrugation over contact force frequency

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 !