Investigating RCF damage mechanisms using the Kalker CONTACT add-on

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Railway track asset management

Hatfield rail crash, October 20, 2000:

Rails broke into pieces due to un-attended RCF cracks.
Railway track asset management

Different types of rolling contact fatigue:

**Head checks:**

**Squat:**
Railway track asset management

Rail grinding: remove cracks, restore design rail profile
Railway track asset management

Current track asset management focuses on:

- **When** to grind, **how much** material removal
  Towards preventive instead of corrective maintenance
- **Where** to grind
  Towards condition based instead of calendar based maintenance

Mainly looking back, existing damage!

3D laser scanned image of squat defect
Courtesy H.J. de Graaf, DGRI
Railway track asset management

Looking forward:
- Understand why damage occurs
- Prognose when and where damage will occur
- Optimize: reduce damage growth and track degradation.

Anti head check profile. Pictures: ProRail

RCF damage mechanisms – Kalker CONTACT add-on

October 9, 2014
Squats are found in the running band, isolated or in clusters. On tangent track and in large radius curves.
The rail material shows plastic flow in a top layer of $O(100 \, \mu m)$.
How do these stresses come about?

Simulation with the Kalker CONTACT add-on

System characteristics → Vehicle-track interaction → Damage model → Outputs: risk, economics
Simulation with the Kalker CONTACT add-on

System characteristics

VTI model

Dynamical model

Fast contact model

Damage model

Detailed contact model

Plastic strain accumulation

Crack initiation/growth

Outputs: risk, economics
Simulation with the Kalker CONTACT add-on

Basic vehicle on tangent track; constant velocity 25 m/s
Constant traction on 1st axle; standard w/r profiles; rail irregularities
Simulation with the Kalker CONTACT add-on

SIMPACK versus CONTACT: acceptable differences in total forces

![Diagram showing longitudinal and lateral forces over time](image-url)
Simulation with the Kalker CONTACT add-on

Large differences in maximum pressure and shear stress; CONTACT: fully non-Hertzian, Kalker’s “exact” rolling contact theory.
Simulation with the Kalker CONTACT add-on

Accumulated contact stress; magnitude and direction, integrated for 4 wheel passages
Simulation with the Kalker CONTACT add-on

Lateral irregularities

Vertical irregularities
Simulation with the Kalker CONTACT add-on

- Lateral irregularities
- Gauge irregularities
Simulation with the Kalker CONTACT add-on

Different wavelengths/amplitudes
Simulation with the Kalker CONTACT add-on

Contact stresses, 4 wheels

Position $x = 52$ m

Position $x = 57$ m
Typical direction of shear stress

- The accumulated stress can vary significantly over a distance of only several meters.
- This is mainly related to the lateral alignment of the track, lateral irregularities.
- Successive wheels move in the same way, all contribute similarly.

Further research should concentrate on:

- Simulations for actual vehicles and track conditions
- Quantifying the relationship from irregularities to stresses to squats.
Vehicle-track interaction is complex due to multi-scale phenomena.

Integrated modelling becomes possible due to advances in simulation technology.

- Large-scale data-acquisition, e.g. accelerations and track irregularities;
- Flexible track model in SIMPACK Rail;
- Integration with the Kalker CONTACT add-on.

By providing new insights in RCF damage mechanisms this enables new ways for railway track asset management.