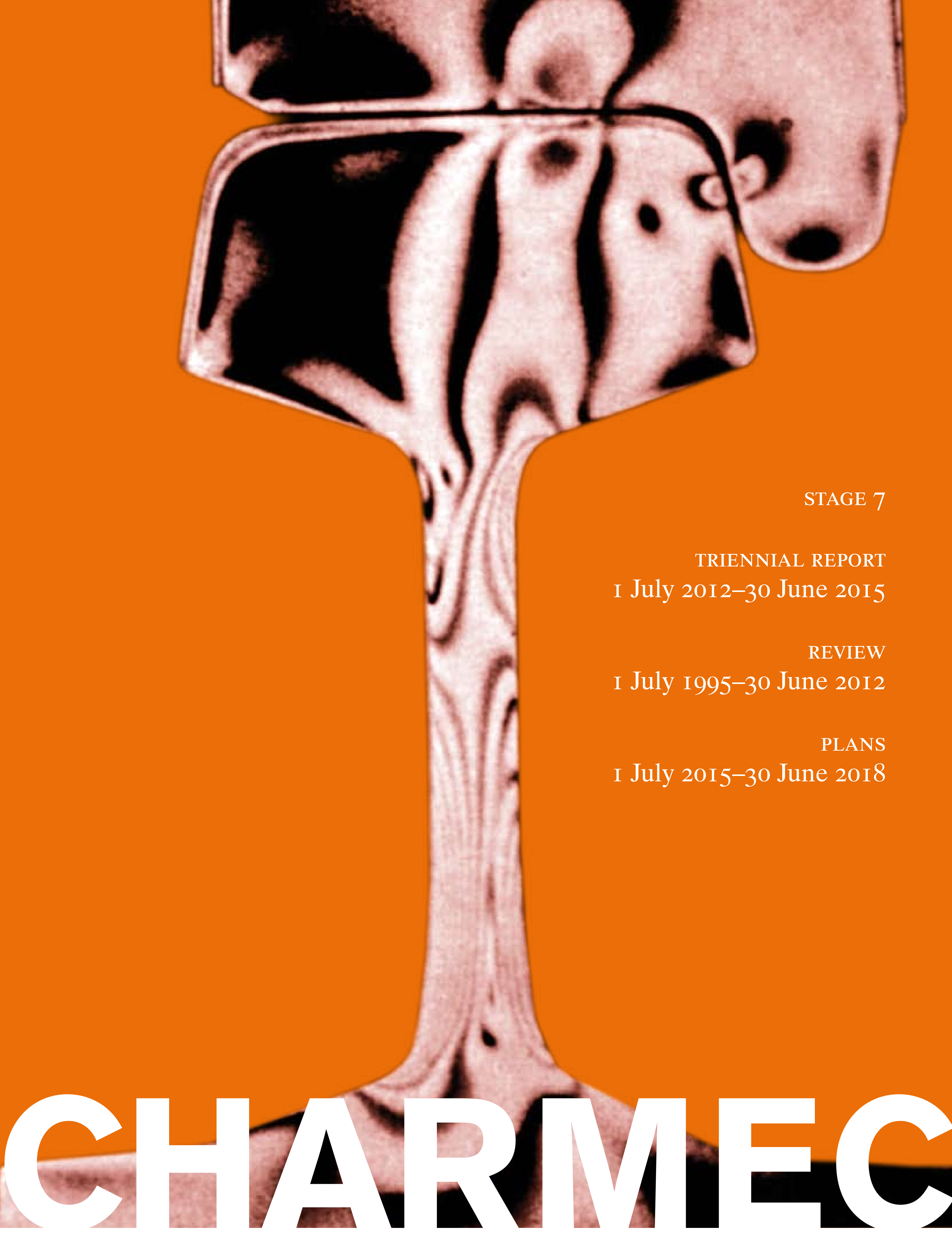

STAGE 7

TRIENNIAL REPORT
1 July 2012–30 June 2015

REVIEW
1 July 1995–30 June 2012

PLANS
1 July 2015–30 June 2018

CHARMEC

Chalmers Railway Mechanics – a NUTEK/VINNOVA Competence Centre
Chalmers University of Technology

The influence of corrugation on tangential forces and rolling contact fatigue

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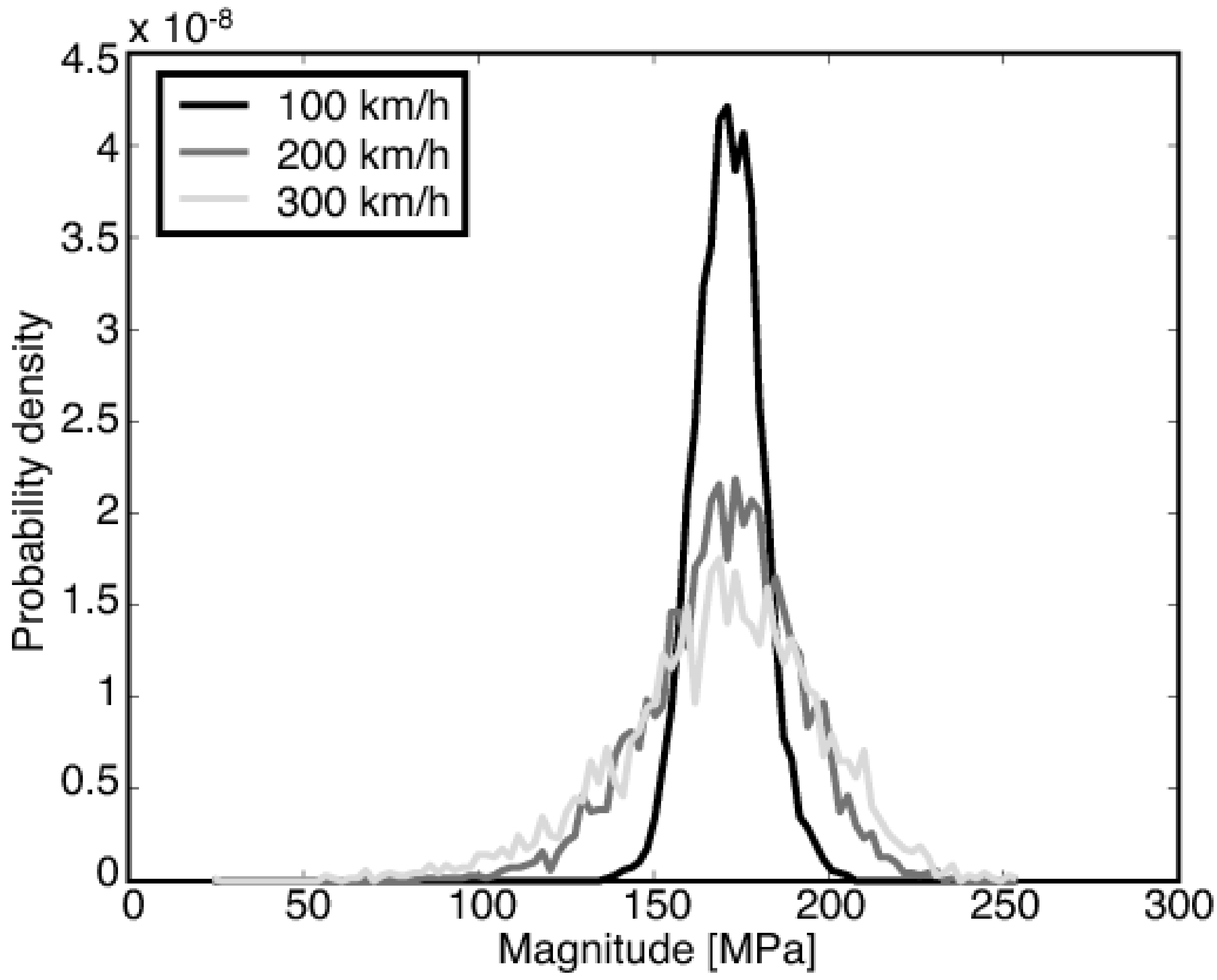
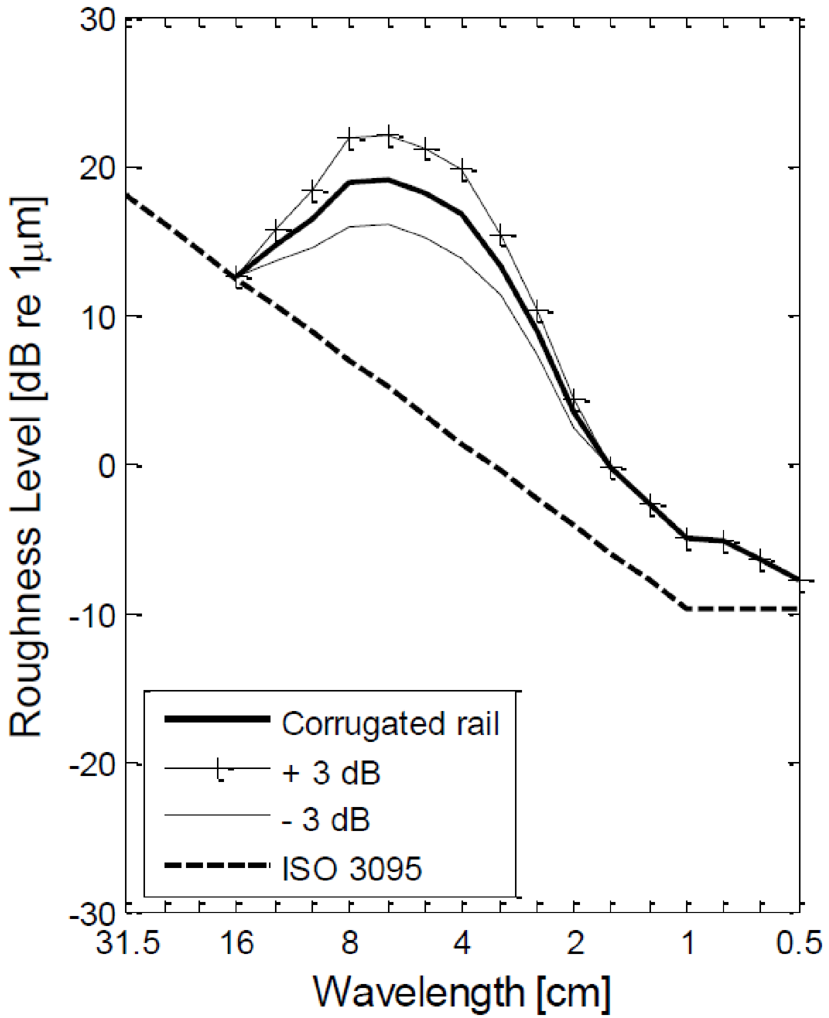
Background – subsurface RCF

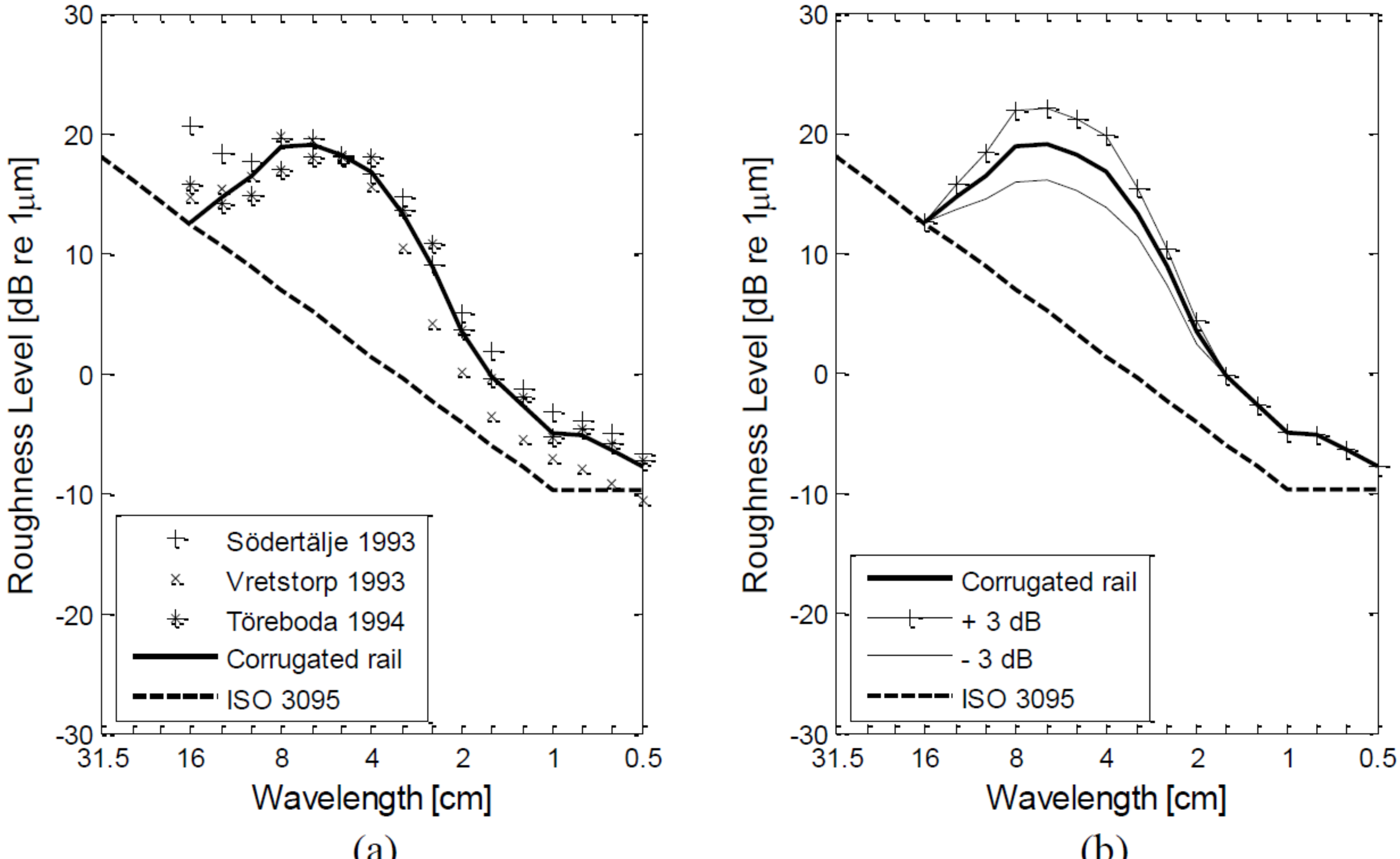


Aim and scope

- Investigate the influence of corrugation on surface initiated RCF
- Short-pitch rail corrugation (Swedish “standard case”)
- Vertical / longitudinal dynamics
- Influence of vehicle speed, tractive effort, roughness level, axle load and unsprung mass
- Quantification in the form of and FI_{surf} and $T\gamma$ values

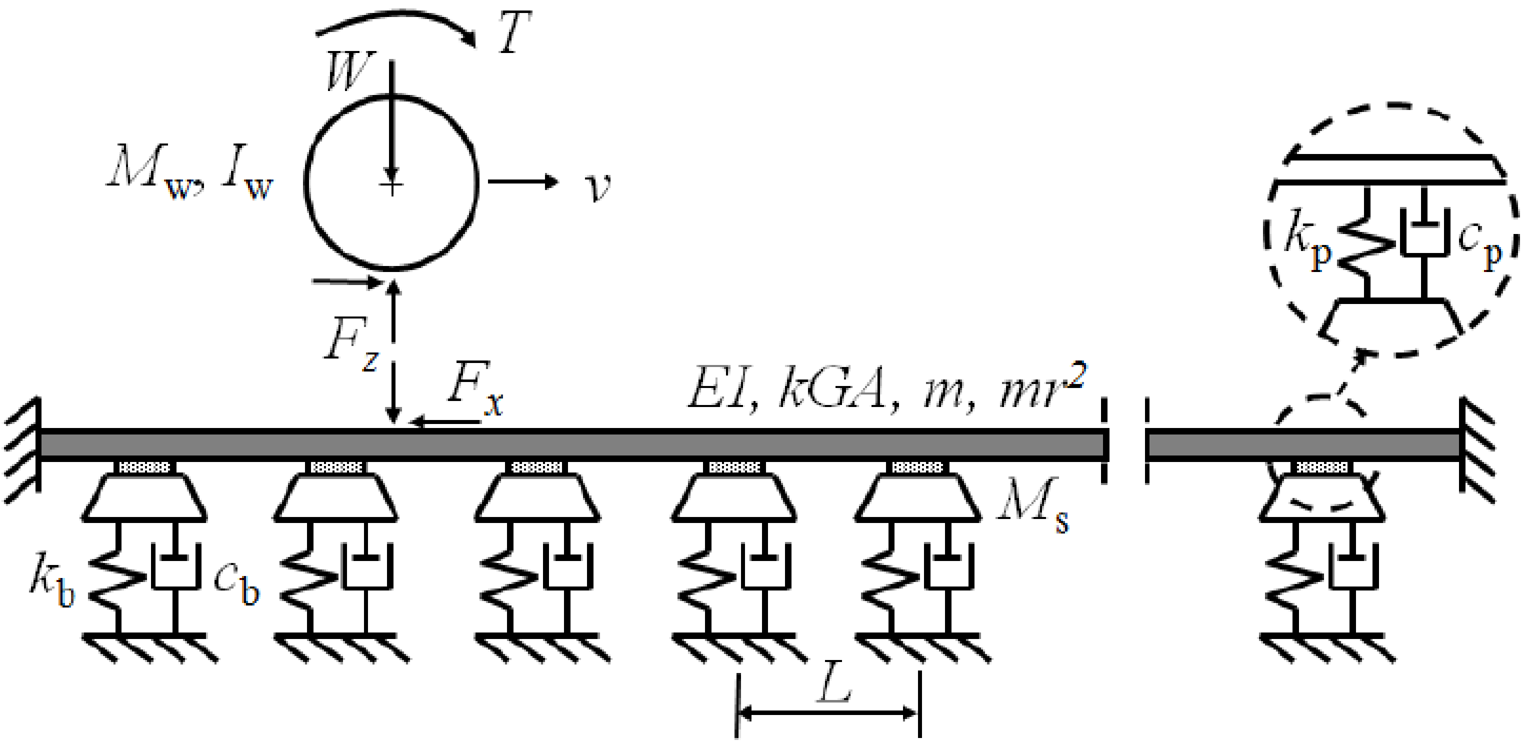


Rail roughness spectra



a) Roughness measured at sections Stockholm–Gothenburg
b) Roughness spectra used in the parametric study

Vehicle-track interaction



Coupled longitudinal and vertical vehicle–track interaction model used in DIFF. The wheelset is suspended by a primary suspension in the longitudinal direction (not shown)

Equations of motion

$$M_{\mathrm{w}}\,\ddot{x} + c_{\mathrm{w}}(\dot{x} - v) + k_{\mathrm{w}}(x - vt) = F_x$$

$$M_{\mathrm{w}}\,\ddot{z} = W - F_z$$

$$I_{\mathrm{w}}\,\dot{\Omega} = T - F_x\,R_{\mathrm{w}}$$

Creepages

$$\gamma_x^{\mathrm{rigid}}(t) = \frac{\dot{x}(t) - R_{\mathrm{w}}\Omega(t)}{v} \qquad \gamma_x^{\mathrm{elastic}}(t) = \frac{h\dot{\beta}(t)}{v}$$

Fatigue index

$$FI_{\text{surf}}(t) = f - \frac{2\pi abk}{3F_z}$$

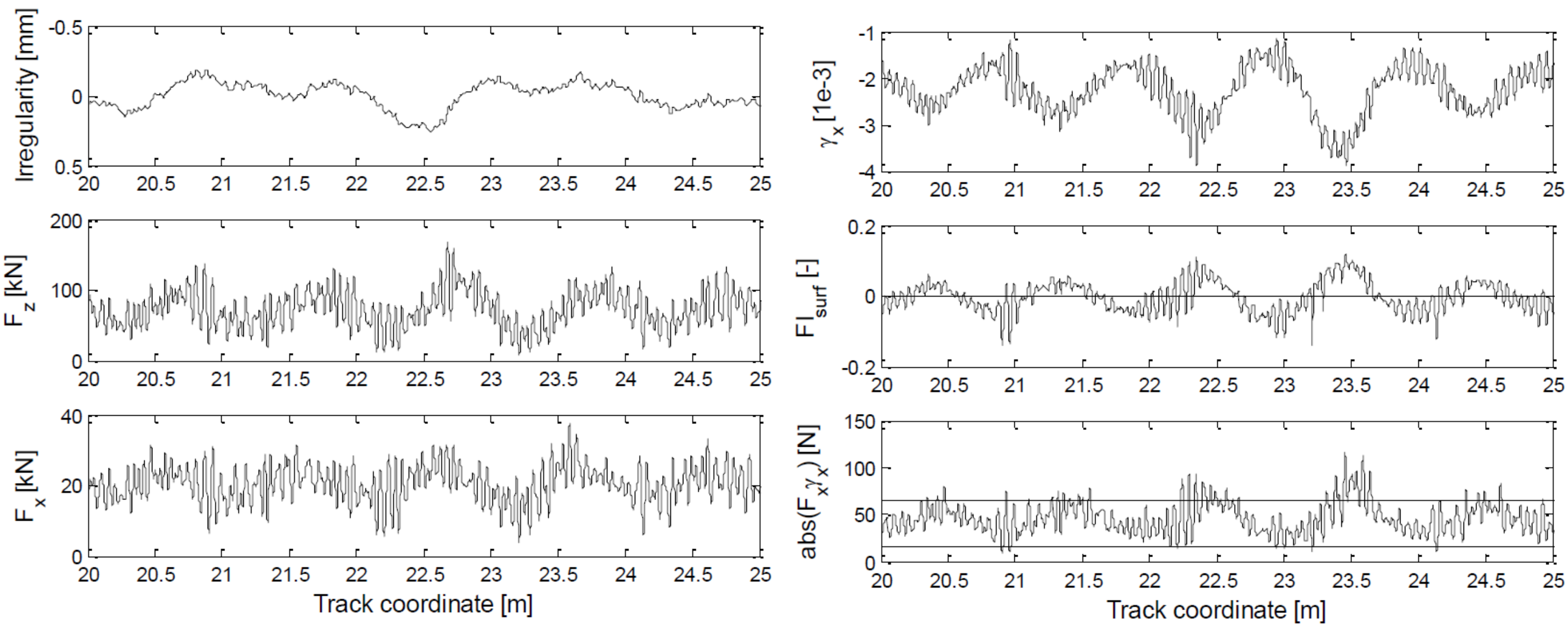
Energy dissipation model

$$T\gamma = F_x \gamma_x$$

Contributions to RCF:

- negligible for $T\gamma < 15$ N
- maximum for $T\gamma = 65$ N
- negative for $T\gamma > 175$ N (caused by high wear rate)

Rail irregulatity and time histories

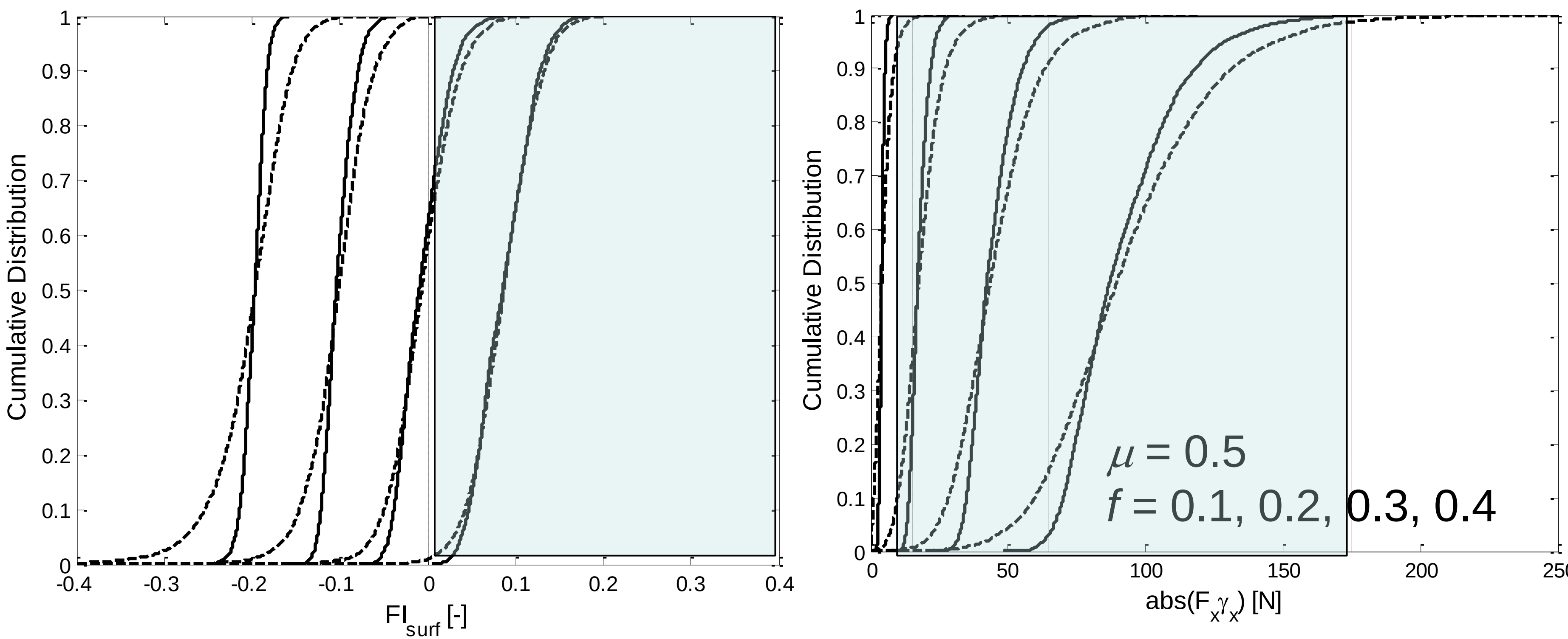


(a) (b)

Speed 200 km/h, axle load 15 tonnes,
friction coefficient 0.5, average traction $f = 0.3$, "Corrugated rail"
(a) Rail irregularity and vertical and longitudinal forces
(b) longitudinal creepage, FI_{surf} and $F_x\gamma_x$

Mean traction coefficient

- Will increase peak magnitudes of FI_{surf} and $T\gamma$
- Corrugation will shift risk of RCF to lower *f* magnitudes
- Saturation effect especially for FI_{surf}



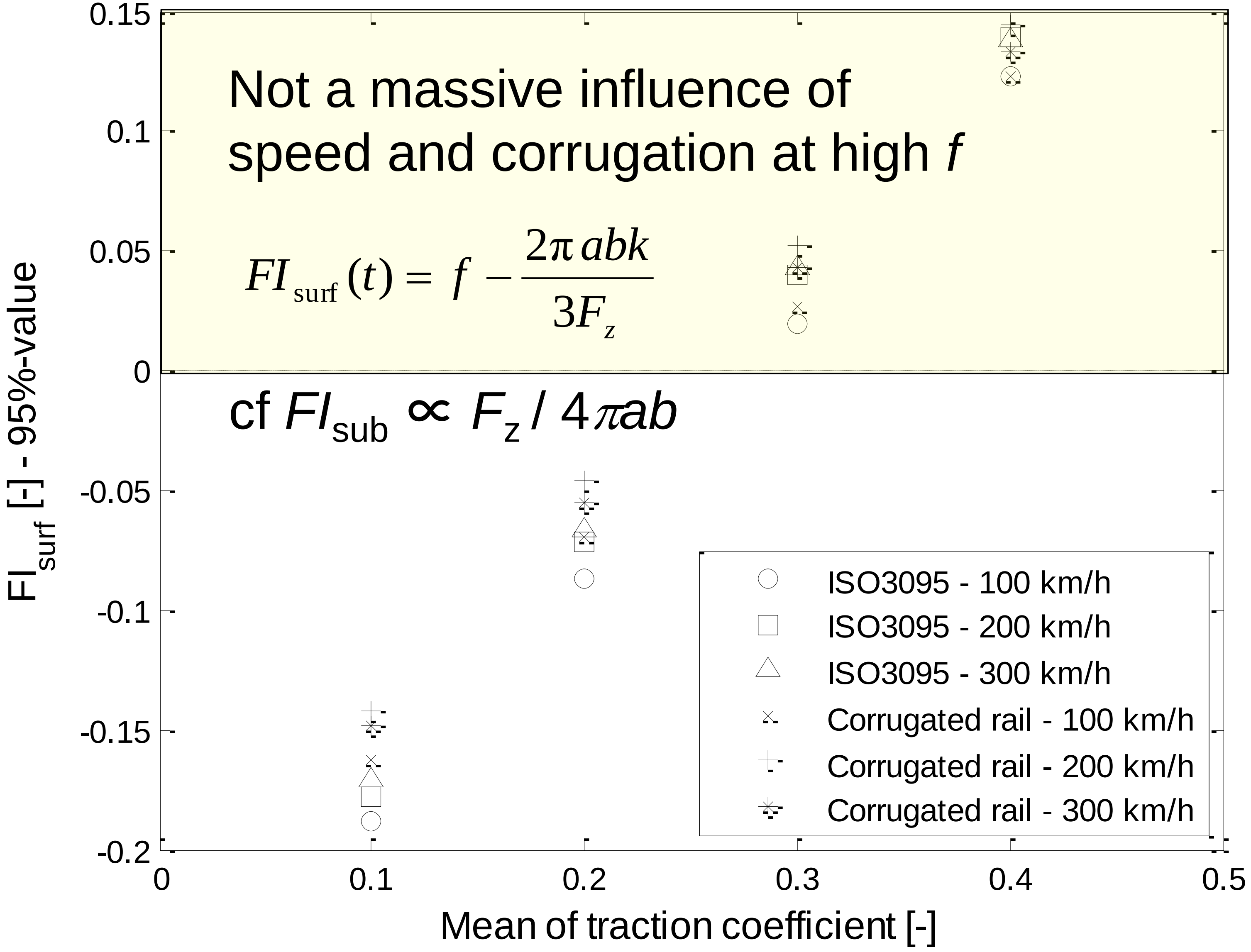
Solid lines: ISO 3095, dashed: corrugated rail

Speed and corrugation

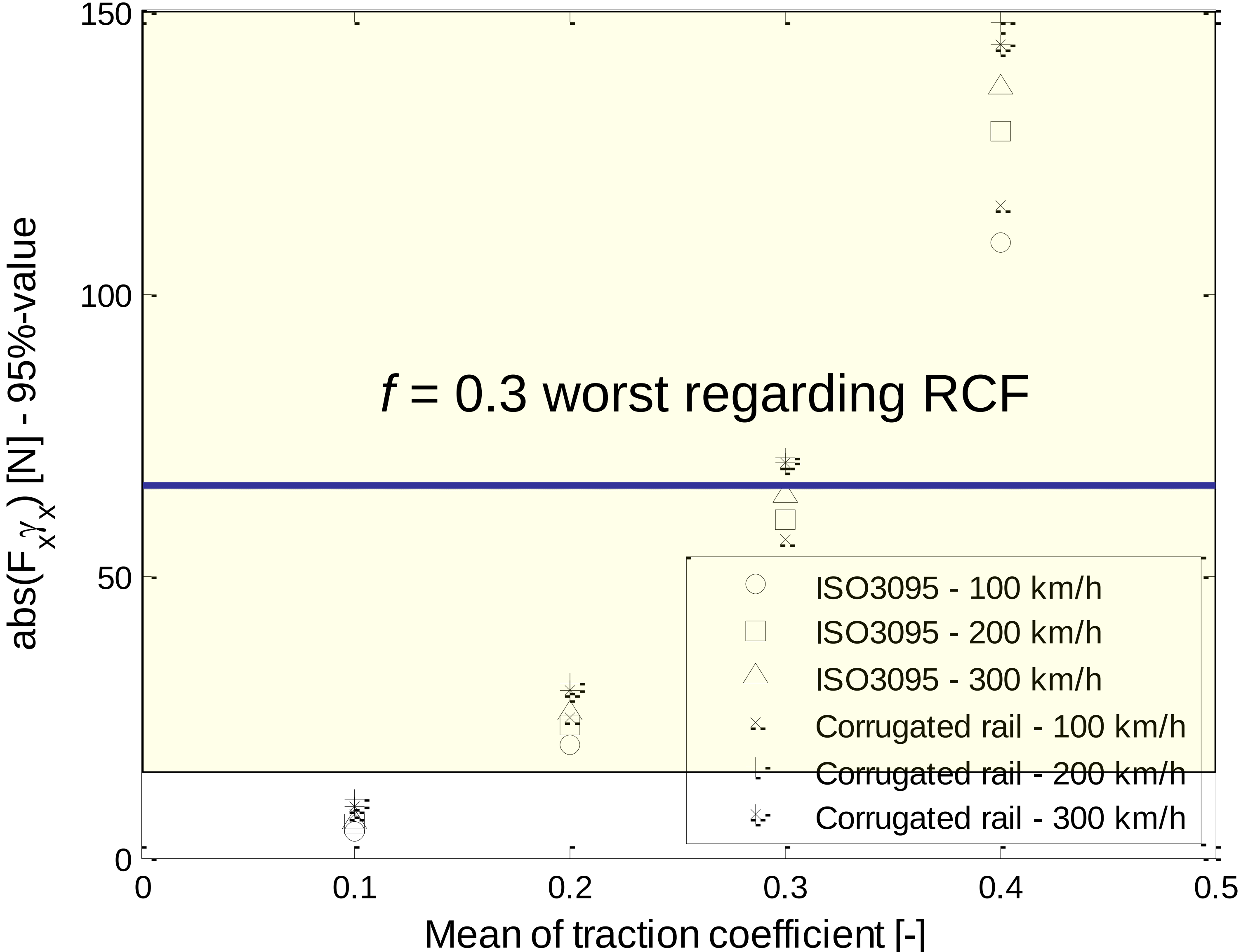
Not a massive influence of speed and corrugation at high *f*

$$FI_{\mathrm{surf}}(t) = f - \frac{2\pi abk}{3F_z}$$

cf $FI_{\mathrm{sub}} \propto F_z / 4\pi ab$

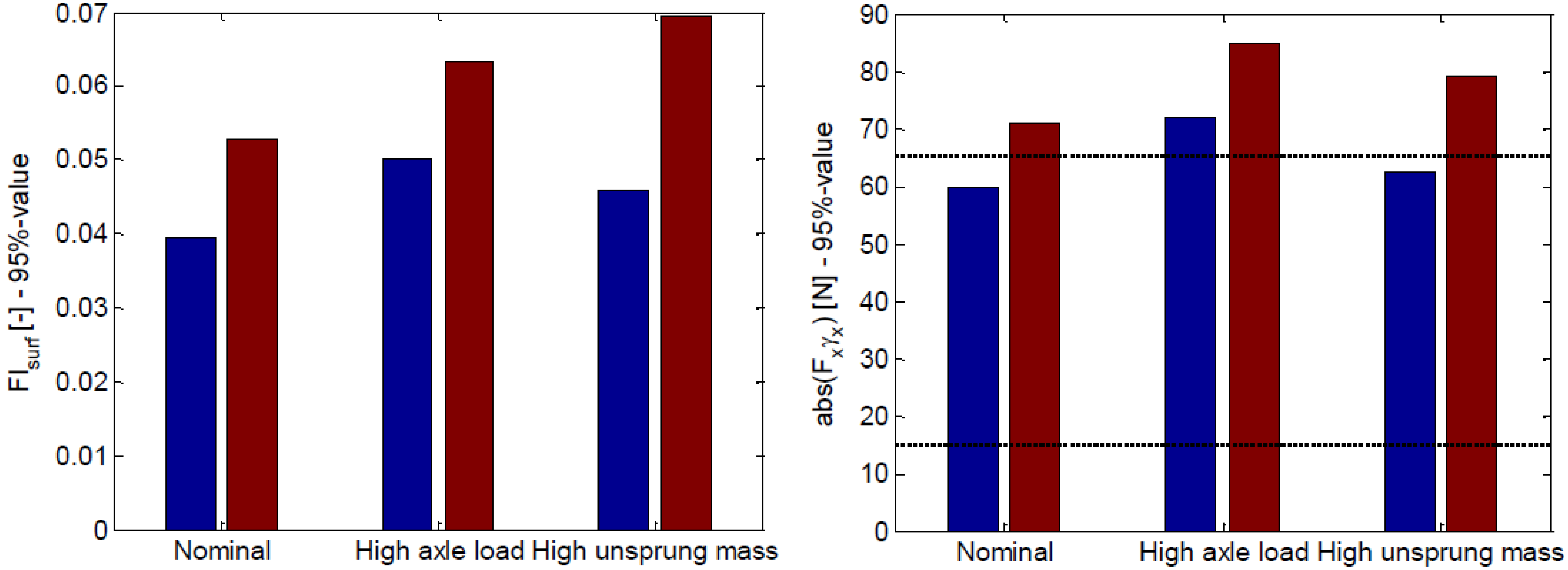


Speed and corrugation



Axle load and unsprung mass

- In contrast to the case of FI_{sub}, which showed no influence of unsprung mass
- Increased axle load will decrease in the RCF impact if the prescribed torque is kept constant



Speed 200 km/h, average traction f = 0.3, spectrum: ISO3095 (blue bars), "Corrugated rail" (red)

High axle load = 18 tonnes (nominal 15 tonnes), high unsprung mass = 1500 kg (nominal 1000 kg)

Concluding remarks

- Local maxima in damage indices are obtained **adjacent to troughs** in the rail irregularity, and that these positions are associated with **high magnitudes of longitudinal creepage**
- The tractive force is the dominating influential parameter on RCF
- For a given tractive force the corrugation level will have a fairly moderate influence
- Increasing speed 200 → 300 km/h actually decreases RCF impact (though longitudinal force increases with speed) for scenarios studied
- Future studies will include full slip, braking, low pas filtering of forces and instationary wheel– rail contacts

Article:

Roger Lundén, Jens Nielsen and Anders Ekberg: The influence of corrugation on frictional stress in the rail–wheel interface, *Proceedings 3rd International Conference on Railway Technology (Railways 2016)*, Cagliari (Sardinia, Italy) April 2016, 14 pp

Many Thanks!!