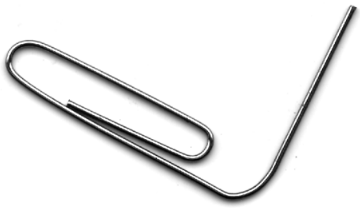
Plasticity model in CONTACT

Niels van der Wekken & Edwin Vollebregt

Plasticitymodel

- Global plasticity



source: bentpaperclip.com

Plasticitymodel

- Global plasticity

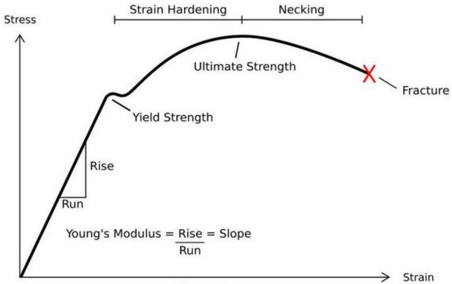


Figure 1

source: instructables.com

Plasticitymodel

- Global plasticity

Mainly works in normal direction. Influences the contactsurface but does not influence the frictioncoefficient.

source: Wikicommons

Plasticitymodel

- Local plasticity

Mainly works in the tangential direction.

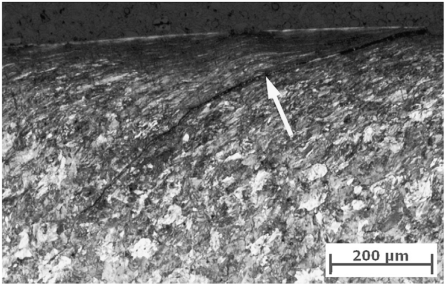
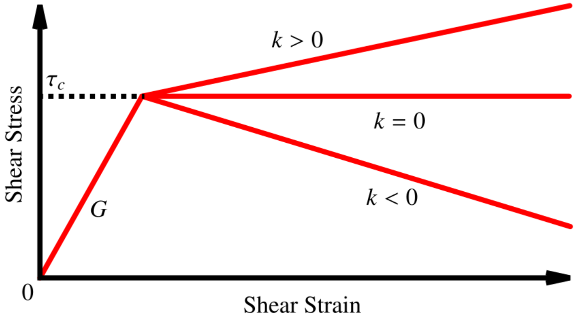


Fig. 1. Metallographic section in lateral direction through a rail from the metro network in Vienna, showing a rolling contact fatigue crack at the gauge corner of the rail. The crack follows the severely deformed microstructure of the material near the surface.

G. Trummer, K. Six, C. Marte, P. Dietmaier, and C. Sommitsch. An approximate model to predict near-surface ratcheting of rails under high traction coefficients. *Wear*, 314(1):28–35, 2014.

Stress-strain model

Model by Hou



K. Hou, J. Kalousek, and E. Magel. Rheological model of solid layer in rolling contact. *Wear*, 211:134–140, 1997.

Stress and slip condities

Original tangential conditions in CONTACT:

$$\begin{array}{rcll} \text{exterior } E & : & \mathbf{p} = 0, & \mathbf{s} \text{ free}, \\ \text{adhesion } H & : & \|\mathbf{p}\| \leq g, & \mathbf{s} = \mathbf{0}, \\ \text{slip } S & : & \|\mathbf{p}\| = g, & \mathbf{s} \,//\, \mathbf{p}. \end{array}$$

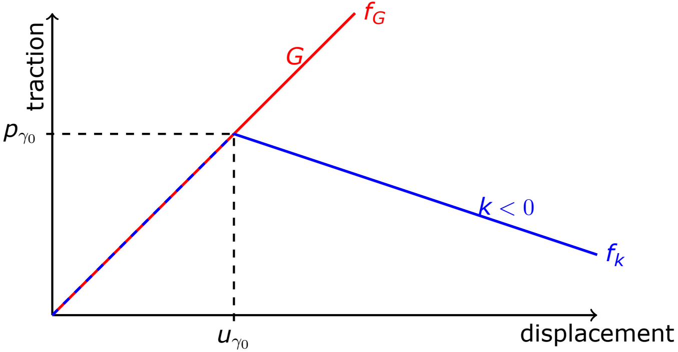
Stress and slip condities

Modified tangential conditions in CONTACT:

$$
\begin{array}{rcllll}
\text{exterior } E & : & \mathbf{p} = 0, & & \mathbf{s} \text{ free}, & \delta\mathbf{u}^{pl} = \mathbf{0}, \\
\text{adhesion } H & : & \|\mathbf{p}\| \le \min(g, \gamma_c), & & \mathbf{s} = \mathbf{0}, & \delta\mathbf{u}^{pl} = \mathbf{0}, \\
\text{plasticity } P & : & \|\mathbf{p}\| = \gamma_c < g, & & \mathbf{s} = \mathbf{0}, & \delta\mathbf{u}^{pl} \,//\, \mathbf{p}, \\
\text{slip } S & : & \|\mathbf{p}\| = g \le \gamma_c, & & \mathbf{s} \,//\, \mathbf{p}, & \delta\mathbf{u}^{pl} = \mathbf{0}.
\end{array}
$$

Yield point

The yield stress p_γ can change under the influence of (cumulative) plastic deformation:



Yield point

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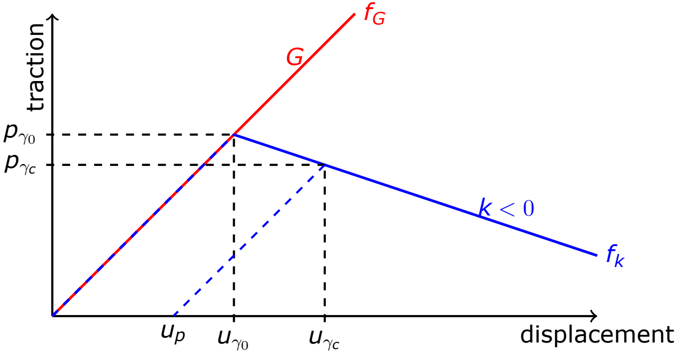

Yield point

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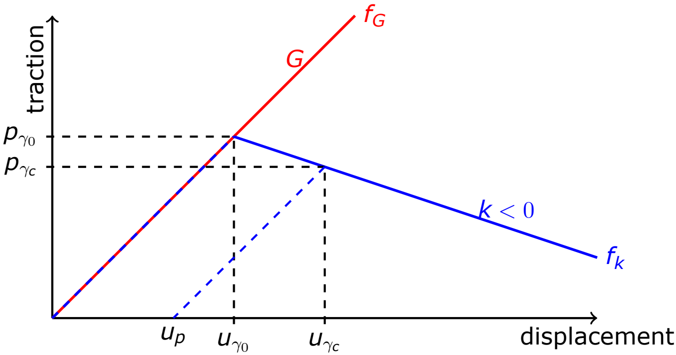

$$p_\gamma(p_{\gamma 0}, \tilde{k}, \mathbf{u}_{pl}) = p_{\gamma 0} + \tilde{k} \cdot |\mathbf{u}_{pl}|$$

Example results

Original elastic model.

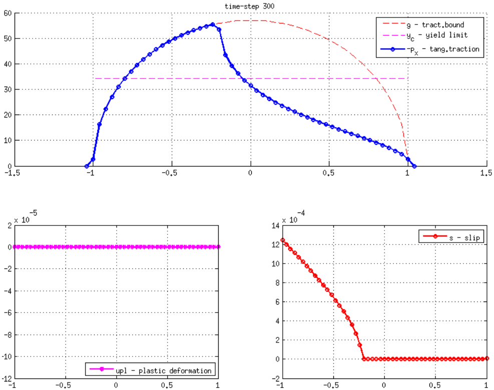

Figure: *Results for purely elastic Carter-test using:* $\delta_x = 0.04, \quad \xi = 0.000\,40$.

Example results

Positive: $k = 0.999G$.

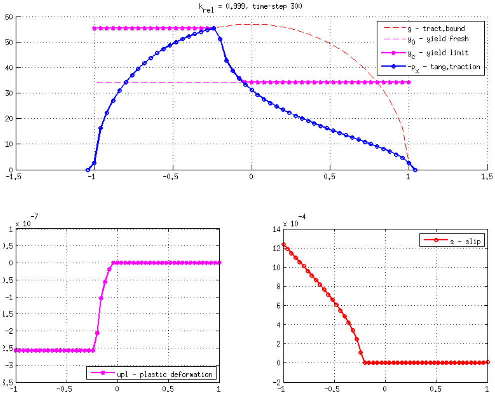

Figure: *Results for plastic Carter-test using:*
$k_{rel} = 0.999, \quad \delta_x = 0.04, \quad \xi = 0.000\,40.$

Example results

Positive: $k = 1/3G$.

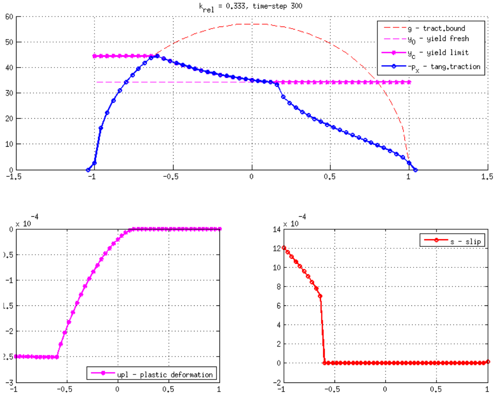

Figure: *Results for plastic Carter-test using:*
$k_{rel} = 1/3, \quad \delta_x = 0.04, \quad \xi = 0.000\,40.$

Example results

Zero: $k = 0$.

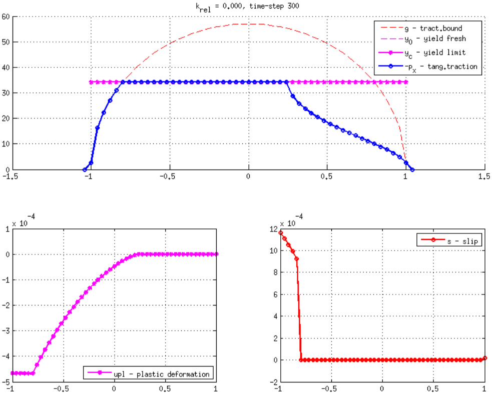

Figure: *Results for plastic Carter-test using:*
$k = 0, \quad \delta_x = 0.04, \quad \xi = 0.000\,40.$

Example results

Negative: $k = -1/3G$.

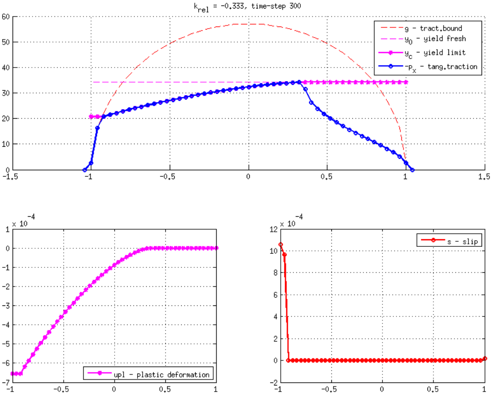

Figure: *Results for plastic Carter-test using:*
$k_{rel} = -1/3, \quad \delta_x = 0.04, \quad \xi = 0.000\,40$.

Thank you!

Thank you!

Questions?