8th. World Congress on Computational Mechanics (WCCM8)
5th European Congress on Computational Methods in Applied Sciences and Engineering (ECCOMAS 2008)
June 30 –July 5, 2008
Venice, Italy

A MULTISCALE PROJECTION METHOD FOR CONTACT ON ROUGH SURFACES

Ralf Nitsche[1], **Peter Wriggers**[1], **Ali Rezgui**[2]

[1] G. W. Leibniz Universität Hannover
Institute for Mechanics
and Computational Mechanics
Appelstraße 9A, 30167 Hannover, Germany
nitsche@ibnm.uni-hannover.de,
http://www.ibnm.uni-hannover.de

[2] Manufacture Française des Pneumatiques Michelin
Centre de Technologies Ladoux
63040 Clermont-Ferrand Cedex 9
ali.rezgui@fr.michelin.com
http://www.michelin.com

Key Words: *MultiScale, Contact Mechanics, Rubber friction.*

ABSTRACT

Multiscale methods offer great promise in modelling mechanical effects if the physical response on different length scales is of great interest. In the field of tire manufacturing, the behavior of the tire considering traction, wear and noise is mainly influenced by the roughness of the road surface. The physical interaction between the rubber and the road surface is thus very complex and a general computation of frictional contact using the Coulombs law is insufficient. Resolving the macro- and micro roughness parts with a multiscale method offer an efficient framework to compute these local effects in certain subdomains.

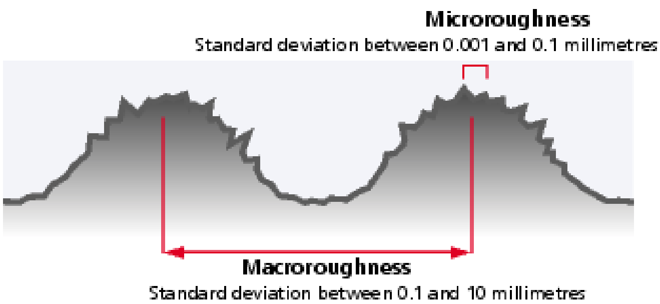

Figure 1: Macro- and Microroughness of a road surface, courtesy of MICHELIN

We present a new multiscale projection method for the computation of contact mechanical problems. This approach is based on a two-scale decomposition of the displacements, a change of geometry on the contact boundary and a projection to the coarse scale by using coarse scale shape functions. In this framework, the computation of the fine scale can be done independently from the coarse scale computation which is ideal for parallelization.

We consider a body subjected to body forces $\boldsymbol{f}$ so that the equilibrium equation is

$$div\boldsymbol{\sigma} + \boldsymbol{f} = \boldsymbol{0} \tag{1}$$

In addition, the traction boundary condition on the traction boundary $\partial\Omega_t^0$ and the contact constraint condition on the contact boundary $\partial\Omega_c^0$ must be satisfied.

$$\begin{aligned} \boldsymbol{\sigma} \cdot \boldsymbol{n} &= \boldsymbol{t} \,\text{on}\, \partial\Omega_t^0 && (2) \\ p_N \cdot \boldsymbol{n} + \boldsymbol{t}_T \cdot \boldsymbol{a} &= \boldsymbol{t}_C \,\text{on}\, \partial\Omega_c^0 && (3) \end{aligned}$$

In Ω_1 the displacement is given by $\boldsymbol{u}^1 = \boldsymbol{u}^0 + \bar{\boldsymbol{u}}^1$, where $\bar{\boldsymbol{u}}^1$ is the displacement caused by the deformation of the micro domain [1].

The weak form of equilibrium on the coarse scale Ω_0 is based on the macro displacement field including a part stemming from the projection of the stresses and the contact forces from the micro to the macro scale [1],[2].

$$\int_{\Omega^0} \boldsymbol{\sigma}(\boldsymbol{u}^0+\bar{\boldsymbol{u}}^1) : \text{grad}^{\text{sym}}(\boldsymbol{\eta}^0)\, \mathrm{d}\Omega^0 - \int_{\Omega^0} \rho(\bar{\boldsymbol{b}}-\dot{\boldsymbol{v}})\cdot\boldsymbol{\eta}^0\, \mathrm{d}\Omega - \int_{\Gamma_t^0} \bar{\boldsymbol{t}}\cdot\boldsymbol{\eta}\, \mathrm{d}\Gamma_t^0 - \int_{\Gamma_c^0} (\epsilon_N g_{\bar{N}}^1 \delta g_{\bar{N}}^1 + \boldsymbol{t}_T^1\cdot\delta\boldsymbol{g}_T)^1\, \mathrm{d}\Gamma_c^0 = 0 \tag{4}$$

The micro scale computation is only performed in zones of active contact on the coarse scale (domain search). Due to the change in geometry on the fine scale, certain contact areas may not be in contact on the microscale.

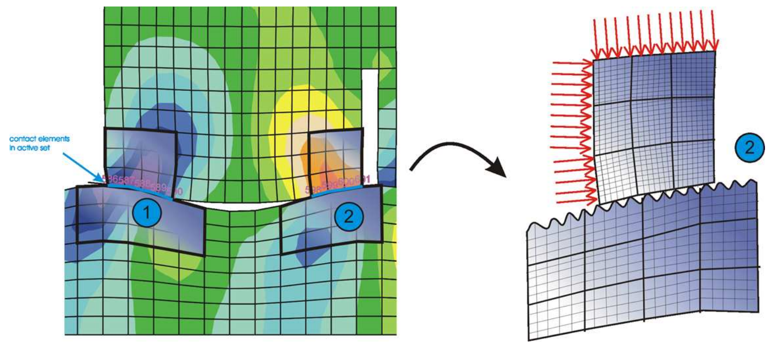

Figure 2: Subdomains for the microscale computation

REFERENCES

[1] S. Loehnert and T. Belytschko. “A multiscale projection method for macro / microcrack simulations.“ *International Journal for Numerical Methods in Engineering* 2007,

[2] P. Wriggers. ” Computational Contact Mechanics, 2nd edition.“ *Springer* 2006.