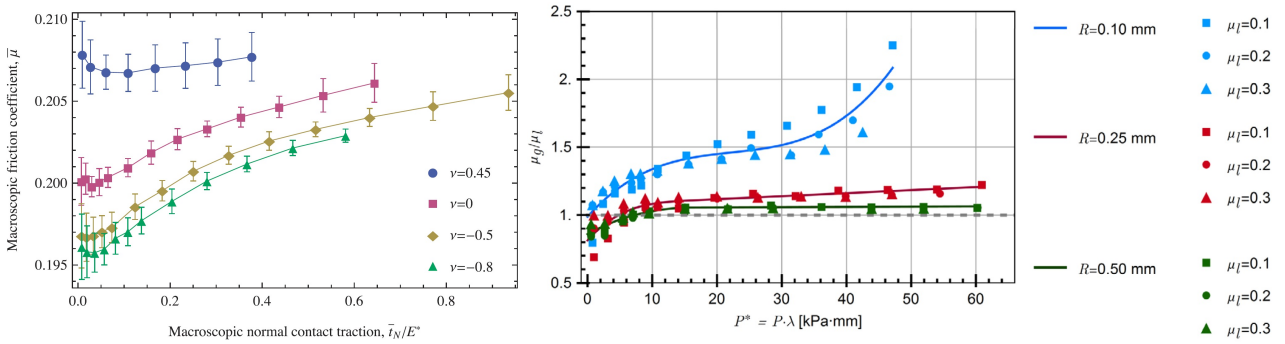
2. Frictional response of microscopically rough soft elastic contacts

Two families of contact systems have been analyzed. The first family (further referred to as Case 1) is based on randomly generated rough periodic surfaces [4], see Figure 1a, and is characterized by relatively low asperities' heights and slopes' angles. The second family (Case 2) uses the geometry and material properties which correspond to a real anatomy of skin section. It features a complicated surface topography at the microscopic scale and a layered structure [5, 6], see Figure 1b. In Case 2, a simplified counter-surface has been considered, represented by isolated rigid cylinders (not shown in Figure 1b).

In both cases, FEM-based contact homogenization procedures have been used (different for each case) to analyze the frictional response. As expected, it was shown that the macroscopic friction coefficient can be in general different from the microscopic one. But it was also observed that it can substantially depend on the normal contact pressure. A further study of how the friction-pressure relationship depends on various problem parameters has been performed in both analyzed cases. In Case 1, for the Poisson's ratio $\nu \leq 0$, a counter-intuitive effect has been observed, in which the macroscopic friction coefficient drops below the microscopic one, see Figure 2a. In Case 2, the global-to-local friction coefficient ratio is higher than in the Case 1, and it possibly depends on asperities' radii on the counter-surface, see Figure 2b.



(a) (b)

Figure 2: Friction-pressure relationship in macro scale: (a) in Case 1, [4], for different values of the Poisson's ratio ν and for the micro-scale friction coefficient $\mu_l = 0.2$, (b) in Case 2, [6], for different cylindrical indenter radii R and different micro-scale friction coefficients μ_l.

References

[1] R.W. Carpick, The contact sport of rough surfaces, *Science*, 359:38-38, 2018.

[2] P. Wagner, P. Wriggers, C. Klapproth, C. Prange, B. Wies, Multiscale FEM approach for hysteresis friction of rubber on rough surfaces, *Computer Methods in Applied Mechanics and Engineering*, 296:150-168, 2015.

[3] K.I. Kilic, I. Temizer, Tuning macroscopic sliding friction at soft contact interfaces: interaction of bulk and surface heterogeneities. *Tribol. Intern.*, 104:83âĂŞ97, 2016.

[4] S. Stupkiewicz, M. Lewandowski and J. Lengiewicz, Micromechanical analysis of friction anisotropy in rough elastic contacts, *Int. J. Solids Struct.*, 51:3931-3943, 2014.

[5] M.F. Leyva-Mendivil, J. Lengiewicz, A. Page, N.W. Bressloff and G. Limbert, Skin microstructure is a key contributor to its friction behaviour, *Tribol. Lett.*, 65:12, 2017.

[6] M.F. Leyva-Mendivil, J. Lengiewicz and G. Limbert, Skin friction under pressure. The role of micromechanics, *Surf. Topogr.: Metrol. Prop.*, 6:014001, 2018.