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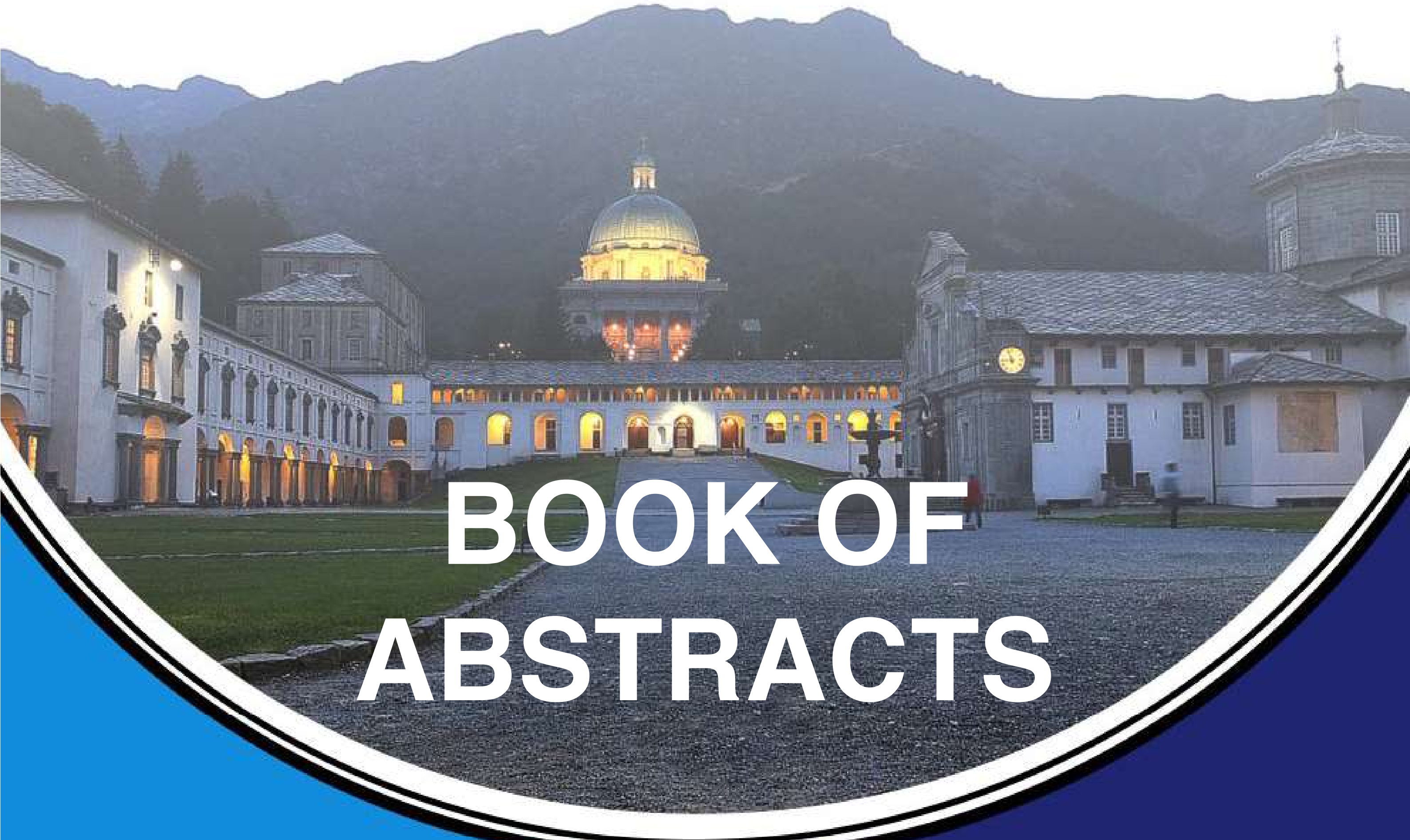

BOOK OF ABSTRACTS

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Multiscale frictional effects in rough soft contacts

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Summary: Non-trivial macroscopic frictional response in rough contacts can be observed even for purely elastic bodies with local Amonton-Coulomb friction law. The effect have been analyzed by the series of FEM-based numerical experiments.

Introduction

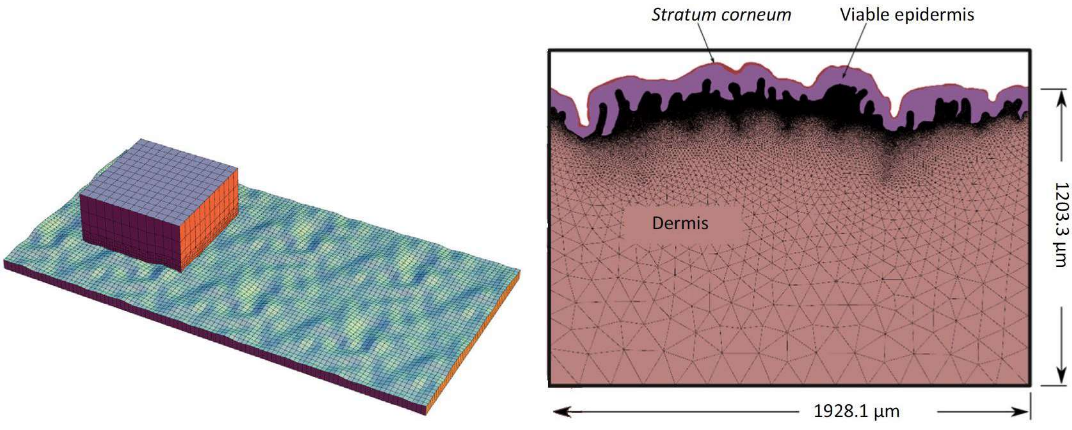
In tribology, the question of how to describe the sliding of rough contacts is still viewed as one of frontiers for modeling [1]. This is due to a number of possible mechanisms and sources of dissipation at different length- and time scales, which contribute to the observed macroscopic frictional response. Quite conveniently, despite their limitations, multiscale approaches are commonly applied to understanding and effectively modeling the friction.

Of our particular interest is the specific class of contact systems in which one or both surfaces are compliant. These can be, for instance, rubber-like materials like elastomeric seals or biological contacts like the skin. For such systems, the viscoelastic hysteresis induced by non-homogeneous contact loading due to roughness is usually viewed as a dominant effect that modifies the macroscopic frictional response versus the microscopic one [2, 3]. However, even when only considering purely elastic contacts and the simple Amonton-Coulomb friction model at the micro scale, one can observe non-trivial frictional effects at the macro scale [4–6]. The latter case is more deeply analyzed and discussed in this work.

Macroscopic friction of soft rough elastic contacts

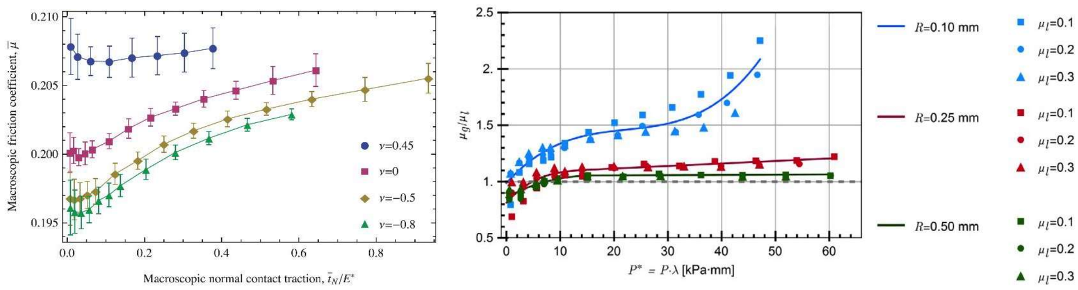
Two types of rough elastic contact systems have been considered. First systems (Case 1) are based on randomly rough periodic surfaces [4], see Figure 1a, in which the asperities' heights/slopes are relatively low. Second systems (Case 2) are based on anatomical model of the skin section, which is characterized by a complicated surface topography at the microscopic scale and additionally by a layered structure [5, 6], see Figure 1b. In the case of skin, a simplified counter-surface has been considered, represented by the isolated rigid cylinders (not shown in the Figure).

Both cases have been analyzed using FEM-based contact homogenization procedure (different for each case). The main observation is that the macroscopic friction coefficient can differ from the microscopic one, and moreover can significantly depend on normal contact pressure. The further study has been performed in both cases to analyze how the friction-pressure relationship depends on various problem parameters. In the Case 1, for Poisson 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 the Case 2, the global-to-local friction coefficient ratio is higher than in the Case 1, and it possibly depends on the asperity radius on the counter-surface, see Figure 2b.



(a) (b)

Figure 1: Two rough contact systems: (a) randomly rough periodic surfaces, (b) 2D anatomical model of the skin.



(a) (b)

Figure 2: Macroscopic friction-pressure relationship: (a) in Case 1, for different values of Poisson ratio ν, (b) in Case 2, for different cylinder radii R and different local friction coefficient μ_l.

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