Probing the micromechanics of a multi-contact interface at the onset of frictional sliding

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1. Introduction

The transition from static to sliding friction is a crucial process in various fields, ranging from contact mechanics, earthquakes dynamics to human/humanoid object grasping. In the classical Amontons-Coulomb's framework, when two solids are brought in contact under normal load P and subjected to a shear force Q, no relative motion occurs until Q exceeds some threshold value $Q_s = \mu_s P$, where μ_s is called the static-friction coefficient. However, in most real situations, the transition from static to dynamic friction does not follow this ideal simple scenario. As soon as $Q > 0$, partial slippage generally sets in owing to the large stress heterogeneity within the contact zone, which depends on the geometry of the objects in contact as well as on the loading conditions. Understanding this incipient sliding regime thus requires to gain access to the interfacial micromechanics within the contact zone.

2. Summary

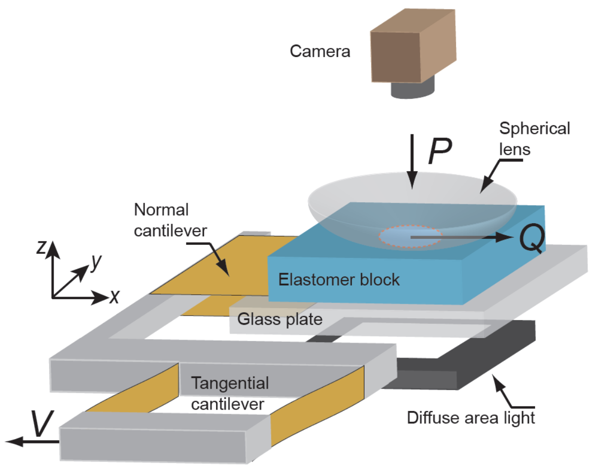

Fig.1 Sketch of the experimental setup.

We will discuss the role of surface roughness on the transition between static and kinetic friction, on the example of a flat rough elastomer in contact with a spherical smooth glass surface (fig. 1). Digital Image Correlation is used to monitor the in-plane elastomer deformation as the shear load is increased [1]. An annular slip region is found to progressively invade the contact, in coexistence with a central stick region. The main features of these local measurements are correctly captured by Cattaneo and Mindlin (CM)'s model [2]. However, close comparison reveals significant discrepancies that reflect the oversimplifying hypothesis underlying CM's scenario. In particular we will show that, instead of the rigid-plastic behavior assumed in CM's model, the interface obeys an elasto-plastic-like friction law involving a roughness-related length scale. We will discuss this local constitutive law in the light of a recent model derived for homogeneously loaded macroscopic multi-contact interfaces [3].

3. Conclusion

Overall, the present study suggests the need to replace the rigid-plastic-like Amontons-Coulomb friction law with an elasto-plastic constitutive friction law in CM-like derivations of the displacement/stress fields, and more generally in any micromechanical analysis of contact mechanics problems. The effective modulus of the elastic part of this constitutive law is i) proportional to the local applied pressure and ii) inversely proportional to the thickness of the rough interfacial layer. The type of measurements developed and validated in this work opens the way for more focused studies in any other contact geometry or loading configurations, for which no explicit model might be available. The time resolution of the measurements being entirely controlled by the frame rate of the imaging system, we anticipate that the very same method could also be used in the fast transient regimes involved in frictional instabilities.

4. References

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