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Erratum: “Asperity Interaction and Substrate Deformation in Statistical Summation Models of Contact Between Rough Surfaces” [Journal of Applied Mechanics, 81(4), p. 041012]

The purpose of this errata note is to reinterpret the effect of asperity interaction and to correct the related formulations given in Eqs. (5)–(7) of the original paper. For a rough surface in contact, deformation of a contacting asperity will also shift its neighboring asperities down through substrate deformation (interaction deformation). Specifically, given a single contacting asperity, the total interaction deformation Ω_a caused by this asperity depends on the distance to its n th neighbor, r_n , and the total number of n th neighbors, $k_n = \eta\pi(r_n^2 - r_{n-1}^2)$:

$$\Omega_a = \sum_{i=1}^n \omega_i k_i = \eta \left\{ \pi r_1^2 f(z, r_1) + \pi(r_2^2 - r_1^2) f(z, r_2) + \pi(r_3^2 - r_2^2) f(z, r_3) + \cdots + \pi(r_n^2 - r_{n-1}^2) f(z, r_n) \right\}$$

Here, η is the number density of asperities on the surface, and $\omega_n = f(z, r_n)$ —equivalent to ω_n given in Eq. (9)—is the individual asperity interaction as a function of the height of the contacting asperity and the distance to its neighbor as expressed by Eq. (4). It follows that the average interaction effect for all the N asperities over the surface is a net enlargement of the mean plane separation d between the two rough surfaces by a cumulative dimensionless interaction deformation given by

$$\Omega^*(d^*) = \frac{N \int_{d^*}^{\infty} \Omega_a^* \phi^*(z^*) dz^*}{N} = \int_{d^*}^{\infty} \Omega_a^* \phi^*(z^*) dz^*$$

where $\Omega_a^* = \Omega_a/\sigma$, and $d^* = d/\sigma$. The reader should juxtapose this with Eq. (7) in the original paper. When compared to the original case, the above formulations consider asperity interaction from the contacting asperities and sequentially calculate the substrate deformation of its neighbors. In the original formulation—Eqs. (5) and (6)—the interaction effect was considered only for noncontacting asperities. The effect of asperity interaction is to reduce the mean asperity height (cf. Fig. 1 in the original paper for a schematic description), resulting in smaller interference compared to the nominal case and, hence, a delayed onset and development of contact.

Since the asperity interaction is calculated via the Hertzian solution (Eq. (9) in the original paper), which decays as a function of distance from the contact, one would expect that the effect of interaction becomes negligible far away from the contacting asperity. This is shown in Fig. 1(a), where the cumulative dimensionless interaction deformation Ω^* as a function of the dimensionless mean plane separation d^* converges with increasing order of n . In Fig. 1(b), compared with the nominal model (Refs. [5] and [24] in the original paper) where asperities deform independently, asperity interaction delays the onset of contact and thus yields a smaller contact force at a given separation. When the increasing order of interaction is taken into account, the contact is further delayed. As the interaction effect converges with increasing order of n (shown in Fig. 1(a)), P^* is seen to converge as well.

Fig. 1 (a) Dimensionless cumulative interaction versus mean plane separation for increasing order of interactions and (b) dimensionless contact force versus mean plane separation for various orders of interactions