C50 Walkway Slip-Resistance Tribometry With Elastomeric Test Feet

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The goal of this presentation is to inform the forensic safety community that situations exist in which the classical coefficient of friction equation can be inappropriate for use in quantifying walkway traction characteristics.

This presentation will impact the forensic community and/or humanity by demonstrating application of a methodology which will allow calculation of the adhesion component of elastomeric friction on a scientific basis.

In walkway slip-resistance metrology a constant coefficient of friction equation is utilized as both the empirical and rational relationship to quantify the traction characteristics of surfaces encountered during walking. However, rubber is widely employed in footwear. In 2001, various types accounted for 55.3 percent of worldwide shoe heel and sole material usage. It has been shown repeatedly that rubber exhibits a decreasing coefficient of friction with increasing applied load. Many pedestrians experience this situation in everyday ambulation. When such occurs, the friction coefficient will not only decrease, but vary with pedestrian weight. It has also been shown that decreasing friction coefficients can be produced in the testing regimes of certain static and dynamic tribometers utilizing elastomeric test feet. Although use of constant coefficients to quantify walkway skip resistance in comparison to the generally accepted standard of 0.5 has been employed for many years, they have been justified only on an empirical, experiential basis. Use of constant elastomeric coefficients in such circumstances has not been scientifically justified. A comprehensive foundation for application of static and dynamic friction theory applicable to the elastomeric materials involved in walkway slip-resistance metrology has not been presented.

A review of the literature revealed that constant coefficients of friction have been utilized in walkway slip-resistance metrology since about 1930. At that time, Hunter designed his articulated strut tester to measure the angle at which a leather test foot slipped on selected walkway materials when an 80-lb weight was applied. The tangent of the slip angle was taken as the coefficient of friction. The constant coefficient of friction equation (Amontons' law) was originally developed in classical metallic theory in which the static and dynamic coefficients equal the tangent force resisting slippage of smooth, contacting metal surfaces divided by the normal load. Application of constant coefficients in the assessment of walkway safety presumably arose from their wide application in metallic, machinery operation where minimization of metal-to-metal contact resistance is desired. In such circumstances, contacting asperities on the metal surfaces are predominantly in the plastic range. The significant friction forces developed between these asperities comprise atom-to-atom adhesion. This mechanism is characterized as cold welding. When a shoe heel is an elastomer, its deformation during ambulation will likely remain elastic. Furthermore, because of their elasticity, elastomers experience both atom-to-atom and van der Waals adhesion.

Considerable investigation has been carried out on frictional characteristics of elastomers employed in fields other than ambulation safety. Findings from these efforts have applicability in walkway slip-resistance tribometry. An empirical and rational relationship, derived from the Hertz equation, has been developed for quantifying friction force generation when coefficients of friction decrease. The physical mechanism at work in these circumstances involves real areas of contact, or near contact, of elastomeric asperities and a smooth walking surface, where either type of adhesion develops. When applied normal loads increase, the areas of contact, or near contact, also increase. As a result, the friction force increases. However, its rate of increase can be less than that of the applied load and their ratio falls. Thus, a decreasing coefficient in these conditions does not indicate decreasing frictional resistance.

When applied to elastomeric materials, the Hertz equation takes the form FT = c(FN)m; where FT is the developed, tangent, friction force, c is a constant associated with the Young's moduli and Poisson's ratios of the two materials involved, FN is the applied normal load, and 2/3(m(1. It must be emphasized, however, that the Hertz equation quantifies only the adhesional component of friction. Other friction force mechanisms exist when elastomers slide on a harder surface. The Hertz equation should be applied only after the frictional resistance arising from the other mechanisms is identified, quantified, and subtracted from the total, measured tangent force. This capability awaits development of a reasonably complete understanding of elastomeric friction as it applies to pedestrian ambulation.

Variable Coefficients of Friction, Elastomeric Shoe Heels, Walkway Slip Resistance

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