## C19 The Relationship Between the Measured Friction Coefficient and the Safety of a Walkway Surface

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After attending this presentation, attendees will have learned to define a “risk-adjusted friction coefficient”, which takes into account what is an acceptable risk of falling.

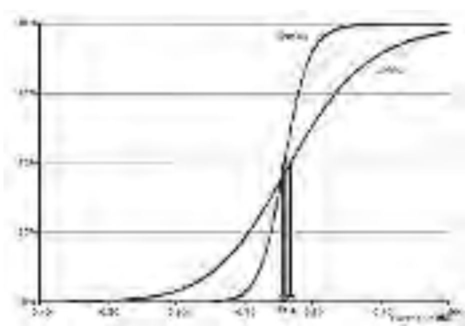
The presentation will impact the forensic science community by showing that merely using an average friction coefficient to characterize the friction of a walkway surface grossly oversimplifies the safety picture. A quantitative way of understanding the implications of friction variability on safety can allow users to understand better just how safe a surface actually is.

Historically, the average of a set of friction values is used to characterize the coefficient of friction between a shoe bottom (or test foot) and a walkway surface (or test surface). Oftentimes, a standard or practice sets a numeric target, a threshold, above which is considered “slip resistant.” For example, ASTM D 2047 Standard Test Method on

Floor Polish specifies that if the average of twelve determinations (4 orthogonal tests on each of three test tiles) of the static coefficient of friction, as determined using a James Tribometer and a Standard Leather test foot, is 0.5 or above, that polish can be considered slip resistant.

This approach is potentially inefficient and potentially problematic; inefficient when it requires a floor surface to have more friction than it needs to be safe; problematic when in spite of having an average friction level above a safety threshold (for example, 0.5), a certain proportion of the test results (or pedestrian steps, in real life) fall below the safety threshold.

An example can illustrate this. The following diagram depicts the logistic-regression curves for two real-world flooring materials, call them Surfaces A and B. The typical way to describe a single-point estimate of the friction from a logistic-regression curve would be the value at which the P(Slip) = 50%. We can see, by drawing lines down from the intersection of the logistic regression curves and the horizontal line at P(slip) = 50% that (a) both surfaces have excellent traction and (b) that Surface B has slightly better friction than does Surface A.



In fact, from a safety standpoint, these statements are misleading. To see this, the question should be framed a bit differently. Instead of asking for a single point estimate, like the average or median (or here, the P(Slip) = 50%) friction value, first (a) recognize that friction is stochastic, varying according to some probability distribution; and (b) pedestrians take many, many steps every day, so to prevent a fall, one must drive the probability of a fall in a single step to be quite low, for example, P(slip) = $^{1}/_{10,000}$. What is the “risk-adjusted friction coefficient?” The graph above does not give enough detail, but by plotting the ordinate on a logarithmic scale, we can see the answer. Drawing a line, not at the 50% level, but at P(slip) = 0.0001 = $10^{-4}$, it is shown that the risk-adjusted friction coefficient of surface A is about 0.6, about 0.33 for Surface B:

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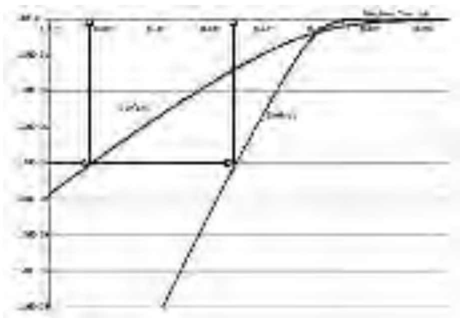
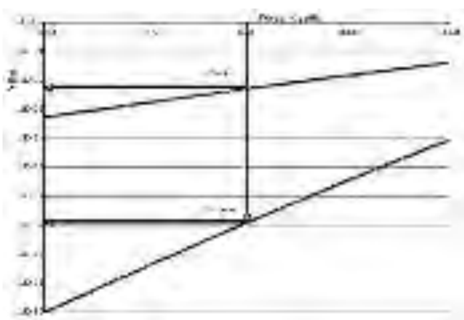


Thus, because Surface A has a much tighter spread of friction- coefficient values, i.e., a smaller standard deviation, it is ultimately superior to surface B, the one with the slightly higher ordinary friction coefficient.

Looking at this another way, many practitioners traditionally use a friction coefficient of 0.5 as the border between slip-resistant and not- slip-resistant surfaces. At 0.5, what is the imputed probability of slipping at a friction coefficient of 0.5? With surface A, the probability is about $^{1}/_{9,000,000}$; for surface B, it is about $^{1}/_{200}$.



This analysis has been accomplished using a friction-coefficient distribution that was generated using logistic regression, because the tribometer used in collecting the data was of a Slip/No-Slip design. It is clear that the method can be easily extended to tribometers other than dichotomous-outcome instruments (The Slip-Test Mark II and II and the English XL). Specifically, one can take a tribometer that produced a quantitative result, e.g., a James Tribometer or Horizontal-Pull Slipmeter, and repeatedly conduct friction determinations on a properly prepared sample with a properly prepared test foot. One can develop an ordinary histogram of those results and, from that, a cumulative- distribution function. If necessary, curve-fit an appropriate distribution to that cumulative distribution, take the log of the P(slip) and proceed as above. Not directly related to the probability of slipping but also potentially useful, the standard deviation or percentile/quintile/quartile metrics can also be used to intelligently characterize the variability aspects of the friction-coefficient distribution.

In summary, by recognizing that friction-coefficient are stochastic variables, and by utilizing the measure of that variability, one can gain insight into pedestrian safety that goes far beyond what one can discern using only an average, or other central-tendency metric, to characterize the friction coefficient.

**Tribometer, Slip and Fall, Slip-Resistant**

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