

APF TECHNICAL BULLETIN

MEASURING SURFACE TRACTION AND ENGINEERING FOR SLIP-RESISTANCE

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May 2002

Overview

Today, slip and fall accidents account for nearly 20% of all accidents and result in thousands of deaths each year, especially among the elderly. Various governmental agencies including OSHA have set legal and enforceable standards for slip-resistance on walking surfaces. In 1990, the American Disabilities Act (ADA) was passed that established elevated standards in slip-resistance for areas used by disabled persons.

Considering the potential harm and liability that may result from a slip and fall accident, it is clear that all responsible property owners, flooring suppliers and flooring contractors need to understand the issues surrounding pedestrian slip-resistance. These issues include accurate measurement of surface traction, effective slip-resistance engineering and maintenance procedures to keep the floor slip-resistant and safe.

Measuring for Slip-Resistance

Slip-resistance (traction) on a walking surface is based on the frictional force necessary to keep a shoe or crutch tip from slipping. A slip may occur when the friction between the shoe and the floor interface is inadequate. Pedestrian traction is affected by the flooring material and finish, shoe material, surface contaminants and pedestrian gait dynamics. To measure friction between the shoe and the surface, a factor called coefficient of friction is determined. The coefficient of friction is defined as the frictional force opposing the sliding motion divided by the force (or weight) perpendicular to the surface. The static coefficient of friction (SCOF) refers to the measurement of the force necessary to initiate movement of an object resting on a given surface. For example, if a 5 pound force is required to initiate movement of a 10 pound weight resting on the surface, the SCOF is 5 divided by 10 or .5.

SCOF has become the common performance measurement for slip-resistance in the United States and has been adopted by the National Bureau of Standards, OSHA and the ADA. Most codes recognize a SCOF of .5 as the threshold of safety. The ADA has determined that some disabled persons require higher values, .6 on level surfaces and .8 on ramps. Since the great majority of slip and fall accidents occur on wet or contaminated surfaces, accurate testing needs to be done on wet surfaces to have any practical value.

The two most common types of instruments to measure SCOF or slip-resistance are the dragsled type meter and the articulated strut machine. The dragsled meter determines the SCOF by measuring the force necessary to start a weight moving over the test surface. The weight has a friction pad adhered to the bottom that ideally meets certain requirements for non-absorbency and uniformity and also is representative of a range of materials used for shoe bottoms. The articulated strut machine uses an arm to push the friction pad against the surface until a slip occurs. The tangent of the angle from the vertical at which the slip occurs is the SCOF.

The most current research on slip metering has shown that accurate slip-resistant measurements cannot be done on wet surfaces with the dragsled meters or with the early articulated strut machines such as the James Machine (ASTM D 2047 limits the James Machine to dry surfaces only). The reason for this is that when a friction pad is placed on a wet surface, some of the water is squeezed out from between the pad and the test surface leaving a very thin layer of water between the two surfaces. This layer of water causes some degree of adhesion between the surfaces. This adhesion (called Sticktion) results in artificially high readings for slip-resistance on wet surfaces. Because the sticktion phenomenon occurs almost immediately upon placement of the friction pad on the test surface, the only valid testing that can be done on wet surfaces requires that the vertical and horizontal forces be applied to the test surface simultaneously. This eliminates the "residence time" of the friction pad on the surface and avoids the inaccurate readings caused by sticktion.

The English XL Variable Incidence Tribometer is one slip meter that avoids stiction and is capable of measurement of slip-resistance on wet or contaminated surfaces. Its use is detailed in ASTM F 1679.

ENGINEERING FOR SLIP-RESISTANCE

As the awareness of slip-resistant requirements increases, more end users are demanding that the flooring or overlay material meet the COF requirements called out for by OSHA and the ADA. However there are still many applications where the end-user relies on the contractor for guidance regarding slip-resistant treatment for his project. Considering the potential harm and liability that can arise out of a slip and fall accident, a conservative proactive approach is best. As a general rule, any exterior surface to be coated or sealed or any interior surface that will be exposed to wet or oily conditions needs a slip-resistant treatment. Exterior, sloped surfaces can be particularly dangerous. Surfaces with severe slopes are not good candidates for polymer sealers or coatings.

Occasionally the end user will resist the idea of a slip-resistant treatment fearing that the surface will become more difficult to clean. Engineering for slip-resistance involves choosing the right size and shape particle to be embedded in the coating film and the proper spacing of the particles. If the slip-resistant treatment is properly engineered and executed, surface cleanability will not be reduced. Observe the following guidelines for the successful use of slip-resistant particles in coatings:

1. **Choose the appropriate particle for your application** -- The most effective particles for increasing slip-resistance have an angular configuration and increase surface roughness. These particles must extend up through the water or contamination on the surface and effectively engage the shoe bottom. Round particles such as glass beads or polypropylene are generally not effective and should be avoided. Certain synthetic acrylic particles have the necessary angularity, but because they lack the hardness of minerals, they are easily worn away in heavy traffic areas. These acrylic particles are convenient because they are lightweight and can be suspended into the coating material. They are suitable for residential and light commercial applications. For heavier use areas, bleached aluminum oxide, colored quartz or silica sand must be broadcast into the wet coating. Aluminum oxide is generally considered the best slip-resistant particle because of its superior hardness to other minerals.
2. **Choose the correct particle size and distribution for your application** -- In general, larger particles spaced fairly close together provide the best slip-resistance. As long as there is adequate spacing between the particles, cleaning remains easy. For example, a distribution of 60-75 30 mesh particles per sq. inch provides an excellent balance of slip-resistance and cleanability. Smaller particles provide less texture and slip-resistance but may be appropriate for certain interior applications.
3. **Be sure that 30-50% of the particle is embedded in the resin matrix** -- If not enough of the particle is embedded in the resin, it may become dislodged during use. For example, 60 mesh aluminum oxide has a height of approximately 10 mils. It would need to be embedded in 3-5 mils of resin. Conversely, if too much resin is applied for the size of the particle, not enough of the particle will protrude through the film to be effective. Often, slip-resistant particles are embedded into the primer material and then top coated.

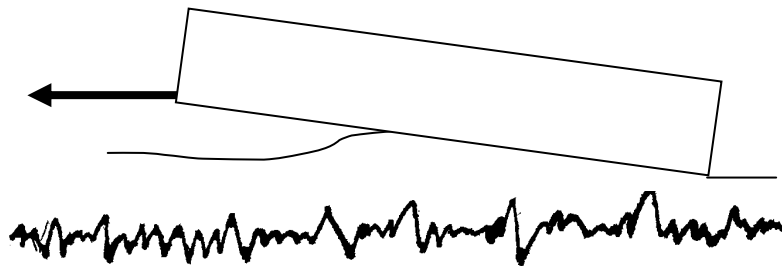


Figure 1. *The dangerous heel-slide that produces the most common disabling fall on smooth surfaces is controlled by installing a walking surface having asperities sufficiently aggressive to penetrate the hydrodynamic squeeze film and arrest the sliding tendency.*¹

¹Illustration used with permission of William English, CSP, P.E. taken from "Pedestrian Slip Resistance. How to Measure It, How to Improve It"

Maintenance Procedures

The most useful service the flooring contractor can provide his customer regarding slip-resistance is to deliver an appropriate slip-resistant surface and outline effective maintenance procedures for retaining the slip-resistant properties. The contractor may want to sell effective cleaners or even a routine maintenance program to the end user.

The most dangerous floors for slipperiness are food service areas where grease and animal fats can build up on the surface. If these contaminants are not removed regularly and effectively, the grease can actually polymerize and form a difficult to remove (and slippery!) coating film. Even if the original slip-resistant design is adequate, if these areas are not effectively and regularly cleaned, they will lose their slip-resistant properties.

Old ideas about mopping a commercial kitchen floor need to be abandoned. The best cleaning method is scrubbing with a floor machine using an aggressive black pad or nylogrit brush with a good commercial degreaser. Rinse the floor well to remove possible detergent residue and either vacuum the rinse water or flush it down the drain.

Conclusion

The time has now arrived for everyone to take more responsibility for the avoidance of slip and fall accidents. The ideal situation is for the flooring contractor to install flooring systems that meet the current requirements set forth by OSHA and ADA. Arizona Polymer Flooring now has the capability to do effective wet surface slip-resistant testing. We also have a set of actual samples showing different coefficients of friction that can be loaned to our customers to help design compliant systems. If a dispute arises on a particular job, we are available to do on-site slip-resistance testing. Another very good option would be the purchase of an effective slip meter. For information on this, I recommend exploring the web site of William English, www.englishxl.com.