Slip Resistance Information

What is Coefficient of Friction?

Stone used on commercial and residential floors should provide a safe walking surface in both wet and dry conditions. By measuring the coefficient of friction (COF), a quantitative number can be used to express the degree of slip resistance of a floor surface.

When the coefficient of friction is measured from a resting position, it is called the *"static coefficient of friction" (SCOF).* When it is measured when the surfaces are in relative motion, it is called the *"dynamic coefficient of friction".* Measuring the dynamic COF is difficult and requires a strict laboratory environment for accurate results. Almost all portable and laboratory meters measure only the static COF and most measuring devices (slip meters) refer to static COF. The higher the SCOF, the less slippery the surface. It is possible to have too high a SCOF; the surface can be too slip resistant and difficult to walk on.

How is the coefficient of friction measured?

There are two types of machines that can measure static COF – permanent laboratory models and portable field models that are commonly referred to as pull meters.

The most common method of measuring slip resistance uses a 50-pound weight placed flat on a Neolite shoe heel which is then placed flat on the stone surface being tested. The heel and weight assembly are pulled across the stone with a spring or electronic scale. The maximum amount of force (pounds) needed to start the assembly in motion is recorded. This measurement is divided by the weight (50 pounds) and yields the coefficient of friction value.

Tests to measure slip resistance were developed primarily for man-made materials, with the earliest from the 1940's when Sidney James conducted experiments to rate floor polishes and other floor maintenance chemicals for Underwriters Laboratories. From these experiments came the James Machine (ASTM D-2047) and the 0.5 static coefficient of friction as the threshold of safety for normal ambulation. Unlike other test methods, the James Machine can only be used in a laboratory for testing smooth, dry surfaces and test results cannot be compared to those of other test methods.

ASTM Tests

The American Society for Testing and Materials (ASTM) currently recognizes several standard methods for measuring coefficient of friction depending on the application.

C-1028-96- (Standard Test Method for Determining the Static Coefficient of Friction of Ceramic Tile and Other Like Surfaces by the Horizontal Dynamometer Pull-Meter Method) This is the most common test used to measure slip resistance in the field and uses a portable horizontal pull meter. This test method may be used under both wet and dry conditions and uses Neolite heel assemblies.

D-2047-93- (Standard Test Method for Static Coefficient of Friction of Polish-Coated Floor Surfaces as Measured by the James Machine) The James Machine is designed for measuring COF in the laboratory under strictly controlled conditions and cannot be used in the field. It is not suitable for use on wet, rough or corrugated surfaces; it can only be used to measure dry surfaces. The James Machine is considered by most authorities to be the most accurate and reliable measurement of slip-resistance.

F-462-94- (Consumer Safety Specification for Slip-Resistant Bathing Facilities) This test covers the slip resistance of bathtubs and shower structures or combinations. It uses a device with a silicone rubber attached to an arm and is conducted in soapy water to evaluate the COF.

F-609-96- (Standard Test Method for Using a Horizontal Pull Slipmeter [HPS]) In addition to C-1028 this test standard is the most widely accepted method for measuring slip resistance. It uses a horizontal pull slip meter to measure the static slip resistance of footwear sole, heel or related materials on walkway surfaces.

F-1679-96-(Standard Test Method for Using a Variable Incidence Tribometer [VIT]) and

F-1677-96- (Standard Test Method for Using a Portable Inclineable Articulated Strut Slip Tester [PIAST]) These standards measure the slip resistance of footwear sole, heel or related materials against planar walkway surfaces or walkway surrogates in either the laboratory or field under dry, wet or contaminated conditions.

The two most common tests for measuring static coefficient of friction are C-1028 and D-2047. The methods and results of these two tests are very different and cannot be compared. D-2047 uses the James Machine in a controlled laboratory environment that measures on dry, smooth surfaces and cannot be used in the field on existing flooring surfaces. Because of the consistency of the testing method of the James Machine, it is considered to provide the most accurate and reliable measurement of SCOF for smooth, dry surfaces. C-1028 is a portable field test procedure that uses a horizontal pull meter. It can be used on wet or dry as well as smooth or textured flooring surfaces. Because of the environmental variables associated with tests using portable pull meters, the results are inconsistent from surface to surface and the reliability is low.

There are portable slip meters on the market which claim to measure the static COF. When purchasing slip meters, be sure they comply with the ASTM requirements for the applicable test procedure. For further information on slip meters contact ASTM at 100 Barr Harbor Drive, West Conshohocken, PA 19428 or see their web site at www.astm.org.

ADA Recommendations

In 1990 The Americans with Disability Act was adopted and states that areas of public accommodation must comply with the provisions specified in the Americans with Disabilities Act Accessibility Guidelines (ADAAG). The ADA Handbook EEOC-BK-1 is available from the United States Government Printing Office.

The following is from appendix B, A4.5

A4.5 Ground and Floor Surfaces.

A4.5.1 General. People who have difficulty walking or maintaining balance or who use crutches, canes or walkers, and those with restricted gaits are particularly sensitive to slipping and tripping hazards. For such people, a stable and regular surface is necessary for safe walking, particularly on stairs. Wheelchairs can be propelled most easily on surfaces that are hard, stable, and regular. Soft loose surfaces such as shag carpet, loose sand or gravel, wet clay, and irregular surfaces such as cobblestones can significantly impede wheelchair movement.

Slip resistance is based on the frictional force necessary to keep a shoe heel or crutch tip from slipping on a walking surface. While the dynamic coefficient of friction during walking varies in a complex and non - uniform way, the static coefficient of friction, which can be measured in several ways, provides a close approximation of the slip resistance of a surface. Contrary to popular belief, some slippage is necessary to walking, especially for persons with restricted gaits; a truly 'non-slip" surface could not be negotiated.

The Occupational Safety and Health Administration recommends that walking surfaces have a static coefficient of friction of 0.5. A research project sponsored by the Architectural and Transportation Barriers Compliance Board (Access Board) conducted tests with persons with disabilities and concluded that a higher coefficient of friction was needed by such persons. A static coefficient of friction of 0.6 is recommended for accessible routes and 0.8 for ramps.

It is recognized that the coefficient of friction varies considerably due to the presence of contaminants, water, floor finishes, and other factors not under the control of the designer or builder and not subject to design and construction guidelines and that compliance would be difficult to measure on the building site. Nevertheless, many common building materials suitable for flooring are now labeled with information on the static coefficient of friction. While it may not be possible to compare one product directly with another, or to guarantee a constant measure, builders and designers are encouraged to specify materials with appropriate values. As more products include information on slip resistance, improved uniformity in measurement and specification is likely. The Access Board's advisory guide lines on Slip Resistant Surfaces provides additional information on this subject.

Commentary & Recommendations

The ADA does not specify slip resistance standards or test methods of measurement, and refers only to an OSHA recommendation and an Access Board recommendation for the numerical values. The guidelines recognize that the static coefficient of friction is affected by floor finishes, surface coatings, contaminants, water and other environmental variables. It is partly for this reason that all recommended values are given for a dry state only.

Slip resistance for natural stone is most commonly tested by ASTM C-1028, the test developed to measure the SCOF of ceramic tile. There is no test specifically designed to measure the SCOF of natural stone. ASTM C-1028, when used to test natural stone, yields differing results that are subject to the inherent variations in natural stone.

The Marble Institute of America recommends that when natural stone is installed in public facilities that come under ADA jurisdiction, consideration be given to stone with a textured surface or with an ASTM C-1028 test result of 0.5 or higher, especially in high traffic areas. In addition, there are slip resistant topical coatings that may be used on stone surfaces. Check the manufacturer's SCOF test results and be sure the product was tested on natural stone. Tests using the James Machine (ASTM D-2047) will generally provide the most reliable SCOF results for floor chemicals.

Above all, specify floor maintenance procedures and take precautionary measures to minimize the risk of slip/fall accidents.

There are several procedures that building owners, cleaning companies and others can take to minimize the risk of slip/fall accidents. The following suggestions are not intended to replace legal counsel if an accident occurs.

1. Pay attention to areas where water and/or spills occur. Walk-off mats should be placed inside the entrance of doors before and during wet and inclement weather. Spilled food and drinks can create slippery conditions on the floor and any spills should be cleaned up as soon as they occur.

2. If the floor is maintained by stripping and waxing, this procedure should be done at night or when there is minimal traffic. Daily wet mopping should also be performed at night or during off hours.

3. Always place wet floor signs in all areas where floor cleaning personnel are working, regardless of the time of day or night. Floor cleaning personnel should warn people who may walk across the floor that it might be slippery.

4. Keep accurate records on the maintenance of floor surfaces. Include in your records the name brands of all products used on the floor, specific procedures that are performed on the floor and how often, and who performed these procedures.

5. Keep a daily log of maintenance procedures. Designate one individual to keep track of the log, perform routine inspections of the floor, and record findings during inspections.

Slip Resistance Update: 0.5 COF?

Is it Required?

by Fred Hueston, Seminar & Publications Director

The debate over the required COF of 0.5 or greater goes on. Is this a requirement or not? In a November 1999 report issued by the Architectural and Transportation Barriers Compliance Board, (Access Board) a proposal was drafted to revise and update the accessibility guidelines for buildings and facilities covered by the Americans with Disabilities Act of 1990 (ADA) and the Architectural Barriers Act of 1968. As stated by the Access Board "These guidelines cover new construction and alterations and serve as the basis for enforceable standards issued by other federal agencies."

I reviewed this proposal and discovered that there is no reference to coefficient of friction. I contacted the ADAAG (Americans with Disabilities Act Accessibility Guidelines) office to get further clarification and was told that the 0.5 COF was such a big issue that it had been eliminated from the recommendations. The Access Board's proposed changes will be voted on sometime in 2000. Comments can be sent to the Board before March 15 to the Office of Technical Information Services, Architectural Transportation Barriers Compliance Board, 1331 F Street NW, Suite 1000, Washington DC 20004-1111. Comments may also be e-mailed to *docket@access-board.gov*. Include full name and address in the e-mail for comments to be considered.

I also checked out the Access Board's web site (*www.access-board.gov*) and the Frequently Asked Question (FAQ) section. Here's what I found:

Q. Is there a specific coefficient of friction required for a surface to be "slip resistant"? (ADAAG 4.5.1)

A. No. There are a variety of ways to measure the coefficient of friction for different materials and no single test device or procedure has been identified. A Board-sponsored research project, described in the ADAAG Appendix Section A4.5.1, suggested some values, but without a defined test procedure, these recommendations cannot be applied.

What does this mean to the stone industry? The definition is vague, slip resistance is subjective, and there are no laws or standards that require a COF of any numerical value, at least as required by the ADA. I've been told that there are several other organizations such as ANSI that may be considering issuing slip resistant standards. I will continue to follow this issue and keep MIA members informed as regulations are changed and updated.

Marble Institute of America

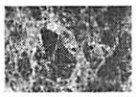
Industry Term Definitions & Common Uses

Granite - Granite is an igneous rock, which means it was once molten and formed as it cooled deep within the earth. Minerals within granite typically appear as small flecks throughout the stone, once creating a "salt and pepper" look. Other types have veining similar to marble. Granite is a dense-grained, hard stone. It can be highly polished or finished in a variety of other ways. A broad spectrum of color is available.

Most common uses:

Interior and exterior wall cladding, interior and exterior paving, residential & commercial counter tops, monuments, curbing, statuary, balance tables, novelty items.

Marble - Marble has both a scientific and commercial definition. Scientific marble was once limestone that achieved metamorphosis from intense pressures and high temperatures within the earth. This altered its crystalline structure and introduced other minerals that produced the valuable colors and veining. Commercially, any stone capable of taking a polish (with the exception of granite) is known as marble. This includes travertine, onyx, serpentine and limestone.



Most common uses:

Interior and exterior wall cladding. Interior and exterior paving, Fireplace facing and hearth, Lavatory tops, Residential & Commercial counter tops, Table Tops, Statuary, Novelty items, Many non architectural uses, such as tooth paste, paint whiting, agricultural lime, etc.

Travertine - Travertine marble is a variety of limestone formed in pools by the slow precipitation of hot, mineral-rich spring water. The "holes" characteristic of travertine were created when carbon dioxide bubbles were trapped as the stone was being formed. Although the classic travertines are recognizable by their homogenous ecru to dark colors, dark reds are available to dark brown veining.

Most common uses:

Interior and exterior wall cladding, interior and exterior paving, statuary, curbing

Limestone - limestone is widely used as a building stone because it is readily available and easy to work with. It is a sedimentary stone, layered and formed from the skeletons and shells of sea creatures that lived in vast, warm seas millions of years ago. Much domestic limestone is gray to buff in color, while some pastel shades of yellow to pink are available. Imported limestones are available in colors ranging from light beige to dark brown, red and black. When the mineral dolomite is present, it makes the limestone harder and capable of being polished in the same manner as metamorphic marble.

Most common uses:

Interior and exterior wall cladding, interior and exterior paving, limited counter top use

Quartz-Based - quartz-Based stones vary widely in color because of different materials and clays contained within the stone. These stones can be found in varying hues of light gray, yellow, green and red. (The dark, reddish-brown "brownstone" was widely used in building construction in the northeastern United States and Canada in the early 1900s.) They may be either sedimentary in formation (such as the sandstones, bluestones and brownstones) or metamorphic (as in quartizite that is formed in exceedingly hard layers)

Most common uses:

Interior and exterior wall cladding, interior and exterior paving

Slate - Slate is a fine-grained, metamorphic stone derived from sedimentary rock shale. It is uniform in color, available in shades such as dark to light green, mottled purple, black, gray or dark red. Veined patterns from overseas have also recently been introduced. Unless its surface has been honed smooth, slate can be recognized by its distinct cleft pattern.

Most common uses:

Residential and commercial counter tops, fireplace facing, roofing, interior & exterior (American only) wall cladding, interior & exterior (American only) paving, Fireplace facings, table tops and many non-architectural uses

Soapstone - Soapstone is a metamorphosed, easily worked igneous stone characterized by a "soapy" feeling when touched. Colors range from dark gray to bluish or greenish gray. Its heat retention qualities make it an ideal cladding for free-standing coal or wood-fired room heaters. Soapstone is also chemical, stain and weather-resistant, and is useful for sinks and laboratory tops as well as general building purposes.

Most common uses:

Chemistry and fire resistant work surfaces, fireplace facings & inner hearths, where heat is an issue

Onyx - Onyx marble is a translucent, layered calcitic stone in pastel shades. It is typically formed in caves as stalactites and stalagmites by the slow precipitation of cold, mineral-rich water.