Preventing Slips and Falls: Floor Surfaces and Treatments

HIGHLIGHTS:

- Floor design and selection
- Various floor surface materials and their slip resistant qualities
- Floor treatments

Most people give little thought to the flooring on which they work and walk each day, unless they slip, trip or fall or experience feet, leg or low back pain from standing. Flooring, however, can be a critical component of workplace safety. Liquid contaminates on floors, or subtle changes in elevation, may contribute to slips, trips and falls.

A strategy focusing on the design, selection and maintenance of flooring can go a long way toward reducing safety problems—especially slips and falls.

Floor Design and Selection

There are many different types of flooring, including a variety of tiles, carpeting, epoxy floors, terrazzo and concrete. In the selection of flooring, one should consider contaminants expected and transition areas. A transition from a carpeted floor or non-slippery floor to a glazed tile or more slippery walking surface could increase the likelihood of a slip and fall due to the individual's lack of detection of the transition (change in slip resistance) and adjustment of gait, accordingly. In general, flooring should have similar slip resistance properties when transitioning between different types of flooring, especially when liquid contaminants may be present.

Surface roughness affects friction; selection of floor surfaces with adequate roughness characteristics may potentially reduce slip and fall accidents. A floor that will be used under mostly dry conditions offers more flexibility in terms of both selection and use, since most dry, clean floors are "slip resistant" by design. If liquid contaminants are expected on the floor, potential interventions could include molded surface patterns or profiled surfaces at the macro-scale, or surface roughness on nominally flat surfaces at the micro-scale. One of the selection criteria should be to choose floors with high values in particular surface roughness parameters. These surface roughness parameters have been shown to relate to increased friction under such conditions.

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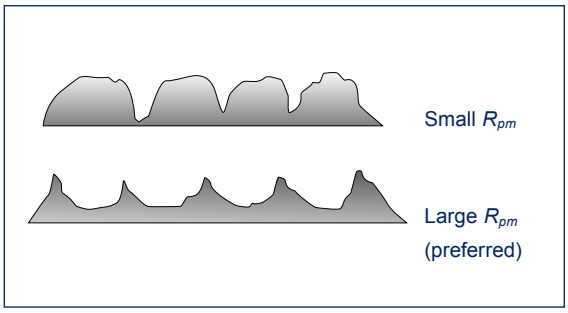
Figure 1: An Illustration of Surface Roughness Profiles with Different R_{pm} Values



Although there are other surface roughness parameters that are good indicators of friction, R_{pm}, which represents the allowable volume of contaminant before the surface is fully covered, the surface roughness is the easiest to measure using a relatively inexpensive profilometer (an instrument designed to measure the degree of surface roughness in micrometers). A surface with a larger void volume can contribute to a higher friction by allowing direct contact between the shoe and floor surfaces covered with liquid contaminants.

An increase in surface irregularities at the peaks of the surfaces due to a large R_{pm} value also makes it more difficult to establish lubrication due to liquid contaminants at the shoe-floor interface. Even under conditions where a floor is completely covered with liquid contaminants, it is easier for the footwear surface to penetrate the contaminants and establish a direct solid-to-solid contact when the floor surface has a larger R_{pm} value.

A surface with a higher R_{pm} value (the lower drawing in **Figure 1**) is preferred compared to a surface which has a lower R_{pm} value (the top drawing in **Figure 1**).

Tribology includes “wear,” therefore a new floor that offers slip resistant qualities today may not tomorrow if high traffic is expected and the floor offers little durable qualities. What might seem inexpensive today could be more expensive in the long run if the floor has to be replaced sooner than expected.

Various Floor Surface Materials and their Slip Resistant Qualities

Quarry Tiles

An extruded natural clay tile with a porous surface. Very common in restaurant kitchen floors and some dining areas. Quarry tiles offer good slip resistant qualities when clean and wet. Quarry tile offers poor slip qualities when soiled and wet; especially when polymerized grease is present. Some quarry tiles come with a “texture” or abrasive surface material of aluminum oxide grit. This grit material is sprinkled on the surface of the tile and offers improved surface roughness. The problem is that the grit material doesn’t last long (one or two years) in heavy foot-traffic areas, as it is removed or worn away with time. Some manufacturers offer a “double abrasive” product that actually imbeds the grit material into the clay during the extrusion process.

Ceramic Tiles

A versatile clay product mixed with ceramic materials and baked at a higher temperature than quarry tile. Glazed and unglazed surfaces are available, and some tiles have abrasive granules imbedded in the glaze to enhance traction. An unglazed tile can be determined by looking at it. The colors in unglazed tiles extend through the full thickness of the tile and will not wear off. For glazed tiles, the glaze can be seen on the surface and can vary from high gloss to low luster. Smooth glazed tiles offer poor slip resistant qualities when wet—unless treated.

Porcelain Paver Tiles

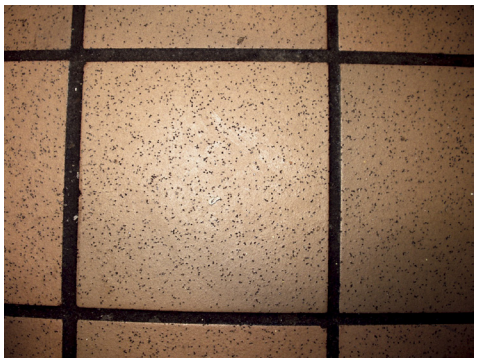
A clay product baked in a kiln at high temperatures. Very dense, hard and impervious to water and wear. Commonly found in vestibules, lobbies and restaurant dining areas. Can come glazed or unglazed. Decorative porcelain tiles simulate mineral floors such as slate or stone. Some textured styles offer good slip resistant properties when wet.

Vinyl Composition Tile (VCT)

A very common and inexpensive floor surface commonly found in schools, hospitals, offices, etc. Usually waxed and buffed to a high shine. Very slippery when wet. Floor treatments are available for VCT and applied to improve slip resistance. The downside is that these products must be continually reapplied to be effective (see Floor Treatments section below).

Rubber Flooring

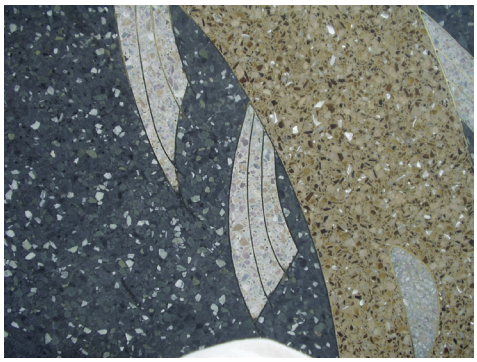
Very common in airport lobbies, elevators and elevator lobbies, parking garages, stair treads, healthcare applications such as operating rooms and scrub areas, recovery rooms etc. Available in a variety of styles and colors. Offers excellent slip resistance when dry, but when worn and wet can be quite slippery. Manufacturers do not recommend polishing or waxing these floors as it will reduce slip resistance.



Quarry Tiles

Porcelain Paver Tiles

Vinyl Composition Tile (VCT)



Terrazzo

Marble and Granite

When dry offers good slip resistance, but when wet can be problematic unless treated (see Floor Treatments section below).

Terrazzo

Terrazzo is a poured-in-place decorative flooring commonly seen in airports and retail stores. Usually chips of glass, marble, and other decorative aggregates are suspended in a urethane or epoxy resin with a bonding agent. Dividers separate each floor section or decorations within the floor. Similar slip resistance issues as marble and granite floors; very slippery when wet.

Concrete

Another poured-in-place flooring is concrete. Overall, concrete offers a very good slip resistant floor finish as long as it is cleaned. When sealed, concrete floors may lose some of their slip resistant qualities. While sealed concrete floors are easier to clean and more attractive, tradeoffs must be considered for slip resistance. Broom-finished concrete is considered the gold standard for slip resistant floors and is very durable as well.

Floor Treatments

There are two reasons floor treatments might be applied:

1. The wrong floor was installed in the first place and a hard lesson is learned (i.e. slips and falls are occurring)
2. A surface application is desired to improve an existing floor's slip resistance

Examples of slip resistant treatments include abrasive floor coatings, chemical etches and cleaners, carpeting and mats, floor waxes, and new slip resistant floor treatments applied daily.

Abrasive Treatments and Coatings

Abrasive floor applications provide a rough surface treatment to enhance surface traction and impart greater slip resistance. Inexpensive abrasive tapes or strips are available as well. A grit material can be blended or broadcast into paint, acrylic, epoxy or urethane finishes and coatings. Acrylic coatings can be applied to floors such as vinyl or rubber that would otherwise be destroyed with solvent based coatings.

Abrasive Coating on Concrete

These applications are more durable and do not need to be reapplied as frequently as some of the waxes and finishes described below. Grit sizes vary, and cleaning, durability and cost must be considered when selecting grit materials. Grit material can be sand or silica quartz, aluminum oxide, garnets, silicon carbide and others such as micronized plastics. The least durable grit material is sand; the most durable grit material is silicon carbide. Aluminum oxide is a popular selection as it is relatively inexpensive and in the middle in terms of durability. **Table 1** shows grit size guidelines and suggested applications.

Grit Diameter *(inches)*	Grit Diameter *(microns)*	Mesh Size *(smaller is bigger)*	**Examples**
.008 – .006	254 – 145	60 – 80	Restaurants and food preparation
.014 – .008	356 – 254	40 – 60	Food processing
.027	686	20	Manufacturing workstations
.073 – .053	2210 – 1346	8 – 12	Vehicle ramps

Table 1. Grit Sizes and Applications

Chemical Etches and Cleaners

Chemical etching, ammonium biflouride and other chemicals professionally applied to marble, granite, ceramic and porcelain tiles, or concrete floors produce microscopic ridges and valleys in the floor and increase surface roughness. Etching produces a higher coefficient of friction with most shoe sole materials and with bare feet. Etching is commonly employed to improve the slip resistance of tiles used in showers and bath areas. Some new etching products are available that deep clean quarry tile floors in restaurant kitchens and compete with some of the cleaning chemicals. An etched floor can lose its effectiveness if not cleaned thoroughly and frequently.

Carpeting and Mats

Carpeting offers inherent slip resistant qualities but can be difficult to keep clean and must be replaced often in high traffic areas. Mats with slip resistant surfaces are available that can be used in areas with slippery floor conditions, such as near restaurant fryers and production operations.

Finishes and Slip Resistant Applications

Floor cleaners, polishes, waxes and finishes are available and some have been tested for slip resistance using ASTM D2047 and other ASTM standards. Limitations of the ASTM D2047 test method is that it is for dry floors only. Some new slip resistant floor surface treatment additives are available that are applied daily when the floor is washed. These treatments must be reapplied anytime the floor is waxed and can wear away with heavy pedestrian traffic. The advantage of these treatments is that they can be applied over VCT or vinyl and rubber floors. The disadvantage is that they must be continually applied to be effective.

Summary

In summary, installing the right floor for the right environment is critical to preventing slips and falls. Floor surface treatments can help. Some are more durable, and others need to be reapplied in high traffic areas. Regardless of surface or treatment, floors must always be kept clean to maintain slip resistant properties.

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