Loss Prevention Reference Note

Preventing Slips and Falls - Floor Surfaces and 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. This reference note will first discuss selection of flooring and then treatments alternatives.

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.

Although there are other surface roughness parameters that are good indicators of friction, R_{pm}, the surface roughness that represents the allowable volume of contaminant before the surface is fully covered, is the easiest to measure using a relatively inexpensive profilometer or roughness meter. 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).

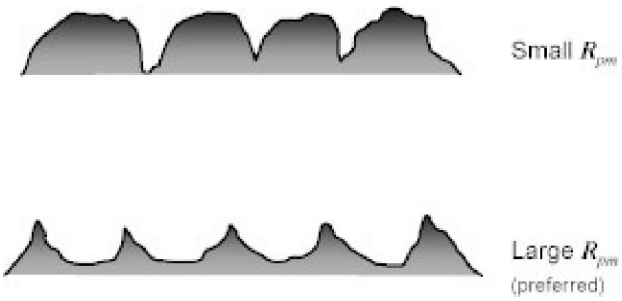


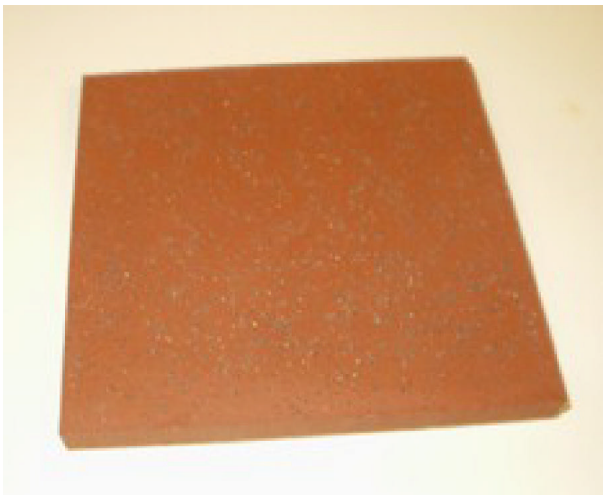
Figure 1: An Illustration of Surface Roughness Profiles with Different R_{pm} Values

At the moment, there are no slip-resistance and surface roughness criteria, however, this remains an emerging area of tribology research.

Tribology is defined as the interaction of sliding surfaces and includes three disciplines; friction, lubrication, and wear. Tribology is very important because 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. The following is a list of various floor surface materials and their slip resistant qualities.

Quarry tiles

A 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 an abrasive surface 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 may not last more than a few 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 manufacturing process.



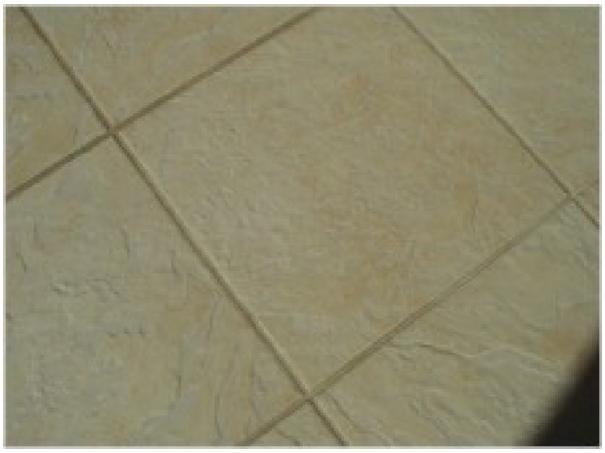
Ceramic tiles

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. 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 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. 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 common and inexpensive floor surface commonly found in schools, hospitals, offices, etc. Usually waxed and buffed to a high shine. Very slippery when wet. Limited slip-resistant treatments are available for VCT and resilient flooring. See **Floor Treatments** below.

Rubber tiles

Very common in airport lobbies, elevators, and elevator lobbies, parking garages, etc. Available in a variety of styles and colors. Offers excellent slip resistance when dry, but when worn and wet can be quite slippery.

Marble and granite

When dry offers good slip resistance (as does everything else) but when wet can be problematic unless treated. See **Floor Treatments** 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, or
2. a surface application is desired to improve an existing floor's slip resistance.

Examples of slip resistant treatments include abrasive floor treatments, chemical etching, carpeting and mats, and floor cleaners and polishes.

Abrasive treatments, finishes and coatings

Abrasive floor and stair applications provide a rough surface treatment to enhance surface traction and impart greater slip resistance. Cleaning, durability, and cost must be considered when selecting grit material and type of finish. Finishes include epoxy, urethane coatings, paint, and abrasive tapes or strips. Grit material must be selected based on expected environment such as whether water or contaminates are expected to be present, pedestrian traffic, and lift truck traffic. Grit material, in order durability from most to least, includes silicon carbide, aluminum oxide, garnets, and silica quartz (sand). Epoxy and urethane coatings are generally more durable than paint and abrasive strips. Most coatings are solvent based but some urethane finishes are water based and can be applied over VCT flooring.

Chemical etches

Chemical etching, hydrofluoric acid, 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. Absorbent mats with slip-resistant surfaces can be used in areas with slippery floor conditions such as near restaurant fryers, ice machines, and dish areas.

Cleaners and polishes

Some floor waxes and polishes have been tested for slip-resistance using ASTM D2047. Limitations of the ASTM D2047 test method is that it is valid for dry floors only. Also available are slip-resistant additives and cleaners that can be applied daily when the floor is washed. The disadvantage of these treatments is that they must be re-applied every time the floor is waxed. Plus, they can wear away with heavy pedestrian traffic or during subsequent floor washing. An advantage of these treatments is that they can be applied on VCT and resilient flooring normally damaged with solvent based treatments.

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 than others and some need to be

reapplied in high traffic areas. Regardless of surface or treatment, floors must always be kept clean to maintain slip-resistant properties.

References

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