



# Risktopics

4-3.001 July 2008

## Floor surfaces and design

### Introduction

In public places, slips and falls occur more frequently than any other type of accident. Along with the alarming frequency of these accidents, slips and falls can result in severe disabling injuries especially to the head and back. The problem is even more serious when the clientele includes elderly people. Although vehicular accidents lead the accident statistics year after year, falls continue to remain the next leading cause of disabling injuries and deaths, particularly among the elderly.

Falls can be from same level or from different levels. Falls from different levels generally tend to be low frequency but high severity and are more common among workers in the construction segment. Slips and trips are more common in same level falls. With aging of population, slips, trip and falls (STF) are expected to increase, both in frequency and severity. In addition to the concern for STF accidents in public places such as hotels, retail establishments and healthcare facilities, these accidents account for 20-25% of worker injuries in many segments.

### Causes of falls

Although STF accidents may appear simple, the causation is complex. In addition to type of floor surface and changes in the type of surface, there are many risk factors that cause or contribute to STFs. They include level changes, adequacy of illumination, contamination/spills, notice of floor hazards and potential for distraction. Among people factors, characteristics of footwear, person's stride, vision, weight, and ergonomic issues in carrying packages, etc. in hand.

There are many factors that affect slips and falls, but selection of appropriate floor surface type for the expected use is the single most important design factor under your control that can help in prevention of slips and falls. By analyzing the effects of surface type and composition and by proper selection of floor surfaces for specific conditions, you can reduce the potential for serious accidents.

### Coefficient of friction

Coefficient of friction (CoF) is a ratio of sliding force required to move one surface over another to the total vertical force applied to the two surfaces in contact. In simple terms, it is an indicator of "grab" or friction present between the two surfaces in contact. Higher CoF is desirable as it reduces the possibilities of slipping. CoF

can be static or dynamic. Static CoF relates to the horizontal force needed for initial movement and dynamic CoF is the force needed to continue that movement in stable walking. Static CoF is generally higher than dynamic.

CoF is going to vary considerably for different types of floors, and it is affected by the material (leather, rubber, barefoot) and design of footwear, and also the environmental conditions (wetness, oil, spills and other contaminants). CoF helps in quantifying a floor's slip resistance and should be used in floor design specifications.

## Measurement of CoF

Measurement of CoF for floor surface is a complex and controversial subject, particularly due to diversity of standards and test methods. American Society of Testing Materials (ASTM) and other organizations have developed several standards. ASTM D 2047 addresses use of James Machine in laboratory for testing of polish coated resilient floor and floor waxes and coatings. Ceramic and quarry tile industry has adopted ASTM C 1028. Footwear industry uses ASTM F 609 using Horizontal Pull Slipmeter (HPS) for measurement of static slip resistance of material for footwear sole and heels. ASTM F 1679 for use of the English XL variable incident tribometer device for dry and wet testing was withdrawn in 2006. There are a few more test methods and standards in use and adopted by specific stakeholder groups.

American National Standards Institute ANSI/ASSE A 1264.1-2007 is the latest of such STF standards that addresses slip resistance of walking and work surfaces in industrial workplaces. In addition to floor and walkway openings, it includes guidance on fixed stairs, platforms and railings.

CoF of 0.5 or greater, when measured using the James Machine and leather shoe sensor, has become a commonly accepted minimum threshold for slip resistant surfaces in accordance with Underwriter's Laboratory. A static CoF of 0.6 is accepted for disability accessible walking surfaces and 0.8 for ramps. CoF is not an absolute value for specification. It is not correct or even possible to specify CoF without referring to test method and device used, shoe sensor material and wet/dry test conditions. Many test methods are for laboratory testing and may not be suitable for in situ testing. Consistent CoF measurement using the same method and device can be used for relative comparison of slipperiness between floor surfaces or coatings as part of the selection process.

## Floor surfaces

Depending upon the location and use, a wide variety of floor surfaces can be selected. In selecting the appropriate floor surface for your needs, consider several factors that affect the selection. They include:

- Desired slip resistance
- Durability
- Appearance
- Maintenance
- Exterior/interior use
- Environmental conditions
- Sanitation needs
- Traffic patterns
- Heavy loads
- Effect and likelihood of foreign substances
- Footwear characteristics

Masonry floors like brushed and quarry tiles are commonly found at the entrances of building lobbies and provide adequate level of surface friction even when wet. Concrete and asphalt paved surfaces are used for parking lots. Decorative surfaces like marbles, terrazzo, and ceramic tiles are used in a number of interior applications. Base floors of some of the high traffic interior areas may be covered by carpeting, linoleum, rubber, and vinyl tiles. Runners, mats and grates are used at building entrances to reduce water tracking into the building in bad weather conditions. Grates do cause problems for wearers of high-heeled shoes.

Some floor surfaces are inherently slippery, and the presence of foreign substances like food spills, grease, oil, or water makes it even worse. Leaking oils and grease from cars and striping in parking lots can be a problem.

Special attention is required for susceptible areas like entrances, restrooms, loading docks, and restaurants. Water on polished marble floors in bathrooms and tiled surfaces in swimming pools present a very serious slip hazard. Use of suntan lotions and oils result in an oily film being deposited on the floors around the lounging areas which can lead to slippery conditions.

## Design considerations

In addition to the selection of suitable floor surface and prompt maintenance, there are other design considerations. Although the CoF on each section of floor surface is important, sudden and unexpected changes in surface characteristics, levels and changes in CoF are even more important. A sudden and unexpected encountering of a high friction surface from a low friction surface is likely to result in a stumble forward. Conversely, an unexpected encountering of a low friction surface from a high friction surface in the travel pathway may result in a backward fall. Major changes in levels are easy to notice, but subtle minor changes as small as 3/8 of inch are not very conspicuous and may be overlooked until a fall occurs. Level changes should be highlighted to make them conspicuous by appropriate striping or color contrasts. If a ramp is needed for wheel chair access, high friction surfaces and maximum slope of 1 in 12 should be specified and handrails should be provided.

Good visibility is an important part of good design for prevention of slip and fall accidents. More than just proper illumination, it addresses visibility of changes in surface composition and levels and any obstructions within the travel path.

## Floor treatments

If traction on walking surface is not adequate, floor treatment may provide an option to compensate for the slippery conditions. The use of slip resistant footwear provides a limited solution in the workplace. In public establishments, specifying people to wear only slip resistant footwear is not a feasible option. There is no substitute for careful selection of floor surface that will provide adequate traction under almost all expected use conditions. Floor treatments, including slip resistant coatings, do help in improving the CoF. A number of wax base products, synthetic resins, and paint coatings are commercially available for this purpose. It is best to consult floor treatment suppliers to determine the most suitable treatment for your surface. It is also suggested that a comparative testing based on CoF values should be used for evaluation and purchase specifications.

Snow removal and salting are special cases of surface treatment to improve the friction of exterior walking surfaces. Use of mats at the entrances can help with water tracking indoors in times of inclement weather. In addition, water logged mats should be promptly replaced. The mats should be sturdy and non-curling to reduce potential for tripping.

## Maintenance

Pot holes in parking lots, broken tiles, torn carpets, and damaged rain mats are some important maintenance issues. Periodic inspection, housekeeping, and prompt repairs of damaged floor conditions can certainly help reduce slip and fall accidents. These maintenance activities, including mopping and installation of floor treatment, should be completed promptly. It is important to assure safety while the repairs are in progress by restricting access to the work area. Upon completion of work, all the tools and debris should be removed to reduce potential tripping hazards. A scheduled inspection program can help in identifying these critical maintenance issues. Whenever possible, maintenance work should be scheduled when the pedestrian traffic is expected to be light.

Mopping in kitchen and food processing areas with oily and greasy spills requires special care to avoid further spreading of oily residue all over the surface, making it more slippery. Water spills and leaks in restrooms and baths can make the floor slippery.

Housekeeping to remove clutter from walking surfaces and regular inspection of floor surfaces should be conducted and documented to spot hazardous conditions and the need for maintenance. Sweep log and inspection in public restrooms are examples of such documentation. Once a notice of a hazard, such as a broken tile, torn carpet or snow/ice at the entrance, is given, it is important to take prompt action to reduce the hazard.

## Summary

Slips and falls appear to be simple trivial accidents that occur frequently, but they result in thousands of disabling injuries and deaths and cost billions of dollars in direct and indirect costs to the business. Preventing and reducing slip and fall accidents requires a systematic approach, and selection of appropriate floor for specific use and environment is an important first step in prevention of STF accidents.

## References

Rosen, S.I. *The Slip and Fall Handbook*. Columbia, MD: Hanrow Press, Inc.

Chaffin, D.B., and R.D. Andres. *Evaluation of Three Surface Friction Measurements, Devices for Field Use*. Ann Arbor, MI: The University of Michigan. Center for Ergonomics and Safety, September 1982.

United States Access Board: Technical Bulletin # 4 - Ground and Floor Surfaces  
<http://www.access-board.gov/Adaag/about/bulletins/surfaces.htm>

Construction Industry Research Information Association (CIRIA) "Safer surface to walk on- reducing risk of slipping" [http://www.ciria.org/downloads/01/c652\\_restricted\\_access.pdf](http://www.ciria.org/downloads/01/c652_restricted_access.pdf)

American Society for Testing Materials (ASTM) relevant standards  
<http://www.astm.org/DATABASE.CART/WITHDRAWN/F1679.htm>  
<http://www.astm.org/Standards/F609.htm>  
<http://www.astm.org/Standards/D2047.htm>

American National Standards Institute (ANSI) standard  
<https://www.asse.org/shoponline/products/A1264-1-2007.php>

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