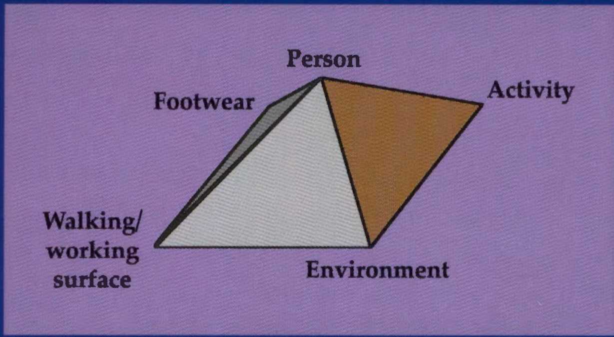
STOP Slip and Fall Accidents!

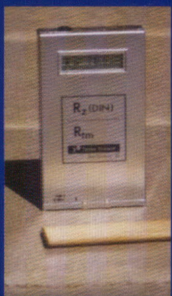
A PRACTICAL GUIDE
for architects, building owners, safety managers, and pedestrians in every walk of life

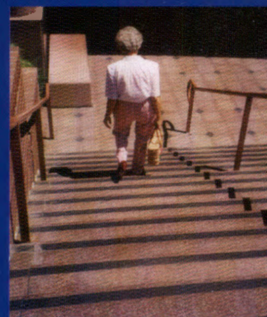
Flooring traction guidelines for over 150 situations

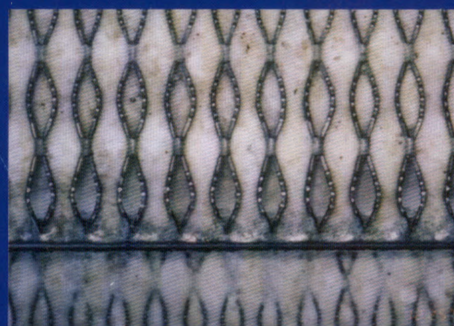
by George Sotter, P.E., Ph.D.

How to remedy existing floors and avoid buying slippery new problems!



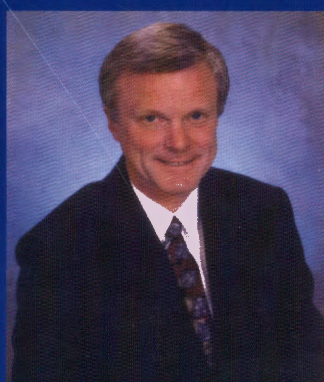






About the Author

George Sotter, Ph.D. is a registered Professional Engineer who specializes in preventing and investigating accidents caused by slips, trips and missteps. His clients include attorneys, builders, floor treatment or maintenance companies, flooring manufacturers, insurance companies, property owners and managers, and restaurant chains.



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STOP Slip and Fall Accidents!

UPDATE July 18, 2018

Slip Resistance Test methods

On December 3, 2001, Ceramic Tile Institute of America (CTIOA) announced that they endorse the ramp and volume displacement test methods, and the associated safety standards as discussed in Chapter 5, and the Tortus and British Pendulum portable testers for wet testing. ASTM C 1028 static friction test method has been withdrawn by ASTM. The main value of the Tortus is in economically checking large areas for uniformity of slip wet and dry resistance while producing printed records for file. This can be effective in monitoring floor maintenance as well as for quality control of in-situ applications that improve slip resistance.

As described by CTIOA, two changes to previous Tortus procedures made the Tortus more useful. Add a trace of Triton X-100 wetting agent to the demineralized water (three drops per 250 milliliters), and use a minimum average dynamic coefficient of friction (DCOFw) for safety of 0.50. (The previous customary minimum average DCOFw for the Tortus was 0.40.) No single test point should have a DCOFw lower than 0.38. Tortus has since been validated in published human traction studies by the University of Southern California Medical Center (Powers et al., *J. Forensic Sci.*, March 2007, p. 400).

For the pendulum, the recommended minimum sustainable Pendulum Test Value, PTV is 36. When using the pendulum, CTIOA recommends a Four-S rubber slider for most floors, but a (softer) TRRL rubber slider for showers and pool decks. The minimum BPN of 36 then applies to either slider material. The pendulum is now a national standard for pedestrian traction testing in at least 49 nations on five continents. In the USA, the BOT-3000 digital tribometer in January 2012 became the only test device for ANSI standard B101.3 for dynamic coefficient of friction with a minimum for level floors of 0.43 for low probability of slipping and 0.30 acceptable (with possible remedial action). The BOT-3000 (current version BOT-3000E) is now specified in ANSI A137.1 (and more recently A216.3), and for that reason was part of the 2012 International Building Code, applying to slip resistance of indoor surfaces. The DCOFw safety criterion for level floors is 0.42 or higher — not very conservative.

The pendulum is more suitable than the Tortus where some pedestrians are very likely to be running (airports, outdoors, etc.). In case of conflict between Tortus and pendulum results, CTIOA recommends that the pendulum results take priority. However, CTIOA states that passing periodic wet tests using the Tortus should be considered due diligence for a property owner.

Chemical treatment

A professionally applied chemical treatment is available for nearly all types of surfaces: vinyl, wood, ceramic tile, terrazzo, marble, granite, etc. It's suitable mainly for commercial, institutional and industrial properties, since quarterly slip resistance testing is recommended to confirm continued effectiveness and maintain the five-year warranty. The treatment is Non-Slip 21. It is endorsed by the Ceramic Tile Institute of America (www.ctioa.org, see "Slippery Floors"). This type of floor treatment was very successfully applied to the passenger stations of London Underground railroad system in the largest slip-resistance improvement project in history. The same manufacturer makes floor cleaning compounds that also enhance wet slip resistance. In the USA, contact Safety Direct America (phone 949-582-0889, or see www.SafetyDirectAmerica.com).

Sustainable Slip Resistance

Some flooring that is slip-resistant as delivered loses its slip resistance very quickly due to heavy foot traffic or to cleanup (sometimes immediately after installation) using abrasive floor pads. A test developed by McDonalds Restaurants identifies flooring that has low propensity to lose its wet slip resistance; see www.SafetyDirectAmerica.com/19.html. Samples are tested with the pendulum, abraded wet (500 cycles, load of 1 kg or 2.2 lb) with a standard three-inch-square abrasive pad, and then tested again. A final wet PTV of 35 or higher (for a level floor) indicates Sustainable Slip Resistance by McDonalds criterion. Several other large companies have adopted this standard.

In June 2014 Standards Australia adopted updated situation-specific slip resistance standards, the world's most sophisticated. Different safety standards are shown for dry areas, commercial kitchens, outdoor walkways, fast food outlets, etc. For this and other recent developments in slip-fall prevention, see blog.SafetyDirectAmerica.com/.

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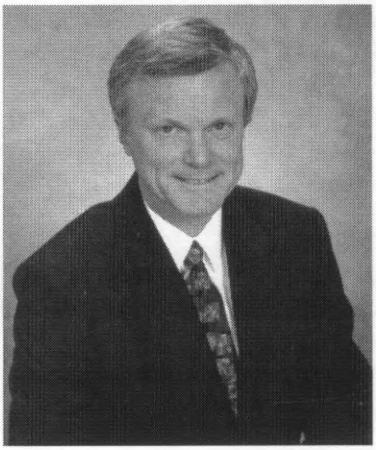
About the Author

George Sotter is a registered Professional Engineer who specializes in prevention and investigation of slip, trip, and fall accidents. He has investigated accidents from Hawaii to Bermuda and has testified in court as an Expert Witness, for the plaintiff and for the defense. He has personally conducted thousands of slip-resistance tests. He's a member of eight slip resistance committees in the United States, United Kingdom, and Australia. He conducted landmark research in causes and prevention of slips by steel erection workers, who work at height and are at high risk of death when they fall for any reason. That project, sponsored by the OSHA/SENRAC Steel Coalition, was the largest slip-and-fall research project to date for any particular occupation. He is certified by the City of Los Angeles for floor slip resistance testing. His clients include attorneys, builders, floor treatment or maintenance companies, flooring manufacturers and vendors, forensic consultants, insurance companies, property owners and managers, and restaurant chains.



George has 30 years of experience as a consulting engineer and some 35 publications in such periodicals as *Scientific American, Occupational Health and Safety,* international symposia, and industry-specific journals. He earned a Bachelor of Science degree from the Pennsylvania State University and a degree of Doctor of Philosophy in rocket science from the University of Sheffield, England.

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Invitation to Comment

Comments from you, the reader, will make it possible to improve this book periodically by incorporating your suggestions. Please contact the author by E-mail, mail, fax, or telephone:

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Dedication

This book is dedicated to the victims on both sides of slip-and-fall accidents: the people and organizations who are hurt physically, emotionally and/or financially *because they don't know how to prevent the accident.*

Contents at a Glance

Table of Contents

Part I:
Slips Happen

What's in this part –

Slips and falls are a little-talked-about but very destructive part of modern society. They cause many thousands of injuries and a significant number of deaths yearly in every large country. However, most slips and falls are preventable using the principles you'll learn from this book.

After a brief introduction, Part I shows you the extent of the slip-and-fall problem, both in human terms and in financial terms. It explains the ingredients of a slip-and-fall incident, as well as some of the simple physical laws that help you understand why slips occur.

CHAPTER 1

How to Use this Book

Since the mid-1990's, a "slip-and-fall revolution" has been quietly occurring in some of the world's most developed nations. Slip-and-fall accidents, for centuries considered an inevitable part of civilized life, are now largely preventable. The revolution started in Germany and spread to other European countries, and as far as Australia. Some employers in the United States are beginning to get more involved in the campaign to eliminate these accidents, which are very costly financially, and in too many cases are disastrous — or even fatal — for the victims.

Falling gags have been a part of the humor of some great comedians such as Chevy Chase, silent movies' Charles Chaplin, and Michael Richards (Kramer on television's *Seinfeld*). Football and basketball players often have falls without apparent injuries. This tends to condition us to think of falls as a trivial, even comic, matter. However, unexpected falls by pedestrians on floors and stairs can, and too frequently do, produce horrendous injuries, requiring huge medical expenditures and sometimes creating serious and permanent disabilities.

Our purpose in this book is to help you to prevent accidents that are caused by slips, trips, and missteps by people on foot, whether at work or on their own time.
For brevity we'll occasionally use the term, "slips" to include slips, trips, and missteps, since the word, "slip" can also mean "a mistake or error."

A few vendors are referenced in this book simply as starting point to aid the reader in making enquiries. These references are neither endorsements nor advertisements, and they are by no means a complete list of potential vendors. Please see your classified telephone directory and the World Wide Web for other possibilities. Since quality of a vendor's products and services may vary from one month to another, it's not feasible to recommend vendors in this book.

The book has four parts. The first part gives some general background and case studies that will help you understand the magnitude and causes of the problem. The second part talks about particular aspects of floors, footwear and other factors that lead to falling accidents. The third part gives some procedures to use in finding, evaluating and eliminating hazards. Part IV discusses lawsuits and slip-and-fall fraud.

Part I: Slips Happen

Part I shows you the extent of the slip-and-fall problem, both in human terms and in financial terms. It explains the five ingredients of a slip-and-fall incident, as well as some of the simple physical laws that help understand why slips occur. Case studies include jury verdicts of total damages as high as $10,000,000, with awards to the injured parties of up to $6,500,000.

Use this part to help you understand how important slip and fall hazards could be to you. It will also help you understand the basic physical principles used to evaluate hazards.

Part II: About the Causes of Slip, Trip, and Misstep Claims

The characteristics of footwear and floors cause many slips or trips resulting in injuries. Different circumstances apply in various situations: stairs and ramps, barefoot areas, outdoor walkways, etc. In this part, we discuss why these different circumstances can result in an accident, and how the characteristics of flooring and footwear need to be *appropriate to the situation.* Chapter 5 presents guidelines for floor slip resistance for 160 different situations. Chapter 6 helps you to recognize some of the qualities that footwear needs to give good traction.

This part gives you valuable guidelines for accident prevention. Use it to help you identify existing hazards and avoid creating new ones.

Part III: Play Defense!

You can be a "victim" of a slip-and-fall accident in either of two ways. You could be the pedestrian who has a painful , disabling and expensive accident, or the homeowner, tenant, or building owner who can experience financial loss — either directly or in the form of insurance premium increases.

This part gives some procedures to follow to help you prevent slips, trips and missteps that result in falls. The procedures apply to footwear and to both new and existing flooring. Use this part to help you assess relative risks of slips and falls, and preventive methods, so that you can apply remedial efforts where you most need them.

Part IV: Legitimate Lawsuits and Fraud

Many slip-and-fall claims settle through insurance channels with little or no dispute. Sometimes, however, a claim goes into litigation. Both sides in a slip-and-fall case need to take certain precautions immediately after an accident to protect them in case of a dispute.

Fraudulent claims may or may not result in a lawsuit, but there are a few hints that may help you assess whether you're the target of a slip-and-fall fraud. Your best protection against fraud, though, is to follow good floor-safety principles as outlined in this book so that you aren't vulnerable to charges that you caused an accident by your negligence.

Use Part IV to help you decide what to do when a slip-and-fall accident has occurred, or appears to have occurred. Your actions immediately following the accident may be important later.

What's Your Motivation?

CHAPTER 2

Everyone tries to avoid injury to himself or herself, and the information in this book can help you to avoid being the victim of a slip-and-fall accident. Most people would also like to avoid contributing to an accident that causes pain and suffering to anyone else. If you have responsibility for some aspect of a slip-and-fall case that causes you to become a defendant, your financial loss could be high — even if insurance "covers" the loss.

At present, many owners of large amounts of property, for instance hotel, store, or restaurant chains, know they can count on having millions of dollars of slip/trip and fall losses every year. Eliminating most of these losses can contribute significantly to their profits without requiring an increase in sales.

It's the Insurance Company's Problem — Right?

It's tempting to think that because we have bought insurance to protect us from large losses, those losses don't cost us anything — it's the insurance company's problem. For many organizations, this logic is false.

In everyday business, policyholders are the only source of money to pay insurance claims. For most large organizations, insurance premiums are based on the organization's own three-year loss history. If the losses go up, the premium will eventually go up accordingly. If losses go down due to prevention of accidents, the policyholder may be able to pocket some money that would have otherwise been spent for insurance. (Small organizations may not be affected as strongly if their premiums are calculated as part of a pool of policyholders rather than individually.)

Many large organizations are self-insured, meaning that injury-related losses come directly from profits. For losses under workers' compensation, reserves may need to be set aside to support a disabled worker for life.

Some insurance companies make efforts to help their policyholders reduce losses. This might include, for instance, going to the policyholder's property and checking for hazards such as slippery floors. The extent of these efforts varies from one insurance company to another and from one year to another. In general, it's necessary for the policyholder to take responsibility for reducing losses.

The *indirect losses* from an accident can be much greater than the direct losses. As an extreme example, consider baseball superstar Mark McGuire. If he were to be injured in an accident and unable to play for several months, there could be adverse effects on the income of his club. While medically the problem might not be a serious one, financially it could be very painful. While few companies have employees as famous as McGuire, many companies have "stars" whose loss from the workforce would be financially damaging. In fact, the usual reason for engaging any employee is the hope that the employee's value to the company will exceed the cost. Most employees aren't covered by "key person" insurance that compensates the employer when the employee is out of action.

Businesses that rely on walk-in customers can lose income due to slippery conditions. Some customers — particularly elderly ones — change their shopping patterns during wet weather, preferring stores where they feel surer footing.

How Much Money are We Talking Here?

For simplicity, let's consider just slips and falls that occur "on the same level." That means, for instance, that the victim doesn't fall down stairs or off a platform. In the United States slips and falls on the same level cost commercial businesses *direct* losses of $50 to $100 per year *per employed person.* For an average company with 1,000 employees, the yearly losses are in the range $50,000–100,000. They vary from year to year, and an individual case can cost several million dollars.

For larger companies, especially those that have the public onto their premises, the average yearly losses are correspondingly larger — and more dependable. Some companies, for instance many large store, hotel or restaurant chains, know they can depend on millions of dollars of these losses every year.

A National Disaster?

Airplane crashes make news, but slip-and-fall accidents cause far more deaths and disabilities in the United States every year. According to the National Safety Council, millions of Americans are injured annually from slips, trips and missteps, and nearly 15,000 die from these accidents. Slips, trips, and falls are the principal cause of accidental death indoors. Over two million Americans suffer temporary or permanent disabling injuries from these types of accidents yearly.

Now for the Good News

The good news is that we can prevent most of these accidents, avoiding the suffering and deaths that result. At the same time, we can stop the financial losses and put the money to productive use.

You don't have control over the footwear people use on your premises, except in rare cases in which employers can specify employee footwear. When the potential accident victim isn't your employee, your objective should be to make sure that if a slip-and-fall accident occurs, it's *not due to your negligence.* Exercise due diligence to make your property as safe as feasible.

An employer needs to go even farther than this. If your employee has an accident that's covered by workers' compensation, it doesn't necessarily matter whose fault it was — you still ultimately pay the bill. Your motivation is to *prevent the accident,* regardless of whether your negligence caused it or not.

How do you react to the difference in these two situations? Recognize that members of the public who come onto your premises may be negligent and endanger their own safety. They may have unsafe footwear, be impaired by alcohol, or engage in unsafe behavior like ignoring warning signs to walk through a spill area. If you're an employer, make sure your employees have the information and motivation to wear appropriate footwear for their job and to follow other basic rules of safety. In either case, make sure that the environment that you have control over is safe.

Companies that have large annual slip-and-fall losses can increase their profits, without any increase in sales, by reducing the accident losses. Many companies, whether large or small, can help assure their long-term stability (by avoiding catastrophic losses) and increase worker efficiency by implementing a few simple measures to avoid accidents caused by slips, trips and missteps.

Architects, designers, builders, and everyone who selects or specifies flooring must consider slip resistance. The easiest way to prevent slipping accidents is to install appropriate flooring for the situation, so that a slipping problem doesn't have to be remedied later. Even for existing problems, though, economical solutions usually exist. This book can help you to find them.

Background on Slips and Falls

CHAPTER 3

When a slip-and-fall accident occurs, the first reaction of many people is that a slippery floor must have caused it. The fact is that five general types of factors contribute to this type of accident, and are potential paths to prevention. In this chapter, we'll look at the causes of slips and falls.

Ingredients of a Slipping Incident

Slipping incidents result from one or more factors including the person(s) involved; the activity performed; environmental factors such as contaminants (water, grease, frost, dust), distractions (visual, aural), temperature and lighting; and the characteristics of the footwear and of the walking surfaces. All of these elements can combine to determine whether traction (or slip resistance) is adequate to prevent a slip. Figure 3-1 illustrates the combination. We'll discuss each factor individually below.

Person

The condition of the person involved can be crucial. For instance, age, experience and personal situation help determine how much caution a person uses. Such variables as sleep deprivation; physical and mental fatigue; personal problems; impaired vision; prescription, non-prescription, or illicit drugs; and alcohol use can have important effects. Middle-aged male diabetics who are insulin-dependent have a slip-and-fall injury risk more than six times that of the general population. Females in the same group have nearly ten times the slip-and-fall risk of the general population.

In normal walking, pedestrians often slip without even consciously noticing. Researchers have classified slips as as mini-, midi- and maxi-slips. In mini-slips the person is unaware of the sliding motion. In midi-slips the person notices the slip but doesn't adjust his or her gait. In the maxi-slips, compensatory swing-leg and arm

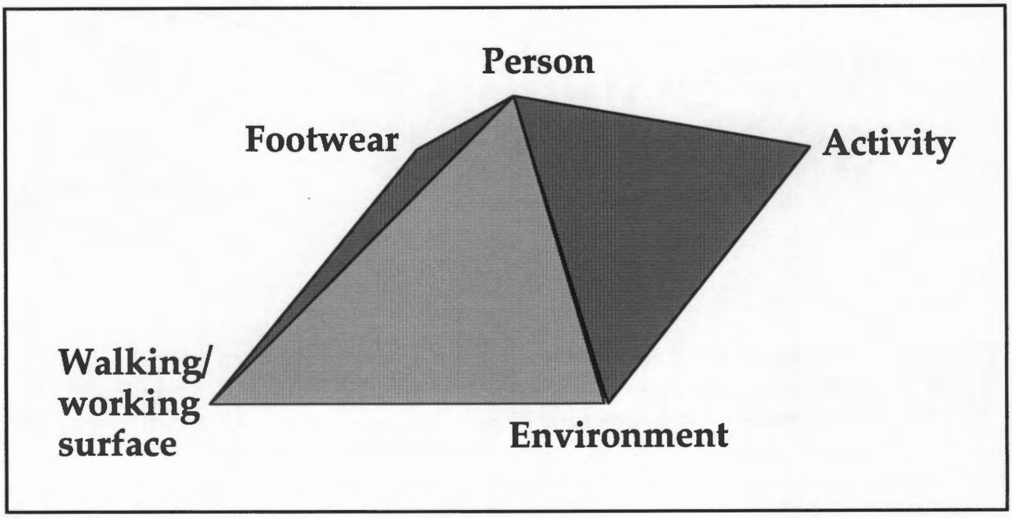


Figure 3-1.
Ingredients of a slipping incident

motions occur to maintain balance. If the slip is less than 1.5 inches, the person might notice it less than 50 percent of the time. If the slip exceeds three inches or a speed of 1.5 feet per second, it's likely to result in a fall.

Recovery from maxi-slips requires that the person's reflexes be adequate, and this emphasizes that the person's condition affects not only the likelihood of starting a slip, but the likelihood of recovering from one without a fall.

Activity

Some activities require more foot traction than others do. Walking at normal pace in a straight line (strolling) is one of the least demanding tasks in terms of traction utilized. Turning, accelerating, or stopping require more traction than strolling requires. Walking fast or running carry more risk of hydroplaning (skimming across a lubricant film) on a shoe/floor interface lubricated with a liquid or powder.

Pushing a baby carriage or wheelbarrow, pulling a cable, or turning a wrench horizontally can require far more traction than walking. An equal and opposite force from the floor or some other surface (such as a wall) has to counteract the horizontal force exerted on the baby carriage, wheelbarrow, cable or wrench.

Lubricants and other Environmental Factors

In this book, we use the term *lubricants* to mean *any substance between walkway and footwear (or bare foot) that reduces slip resistance.* Under that definition, water is a lubricant. In fact, it's the most common walkway lubricant in non-work situations. Water from rain can find its way far indoors when it's carried on shoes, raincoats, and umbrellas. Water also can get on the floor from drinking fountains and from just-washed hands reaching for a towel.

Indoors, the consumer can encounter a number of other lubricants. Examples include cooking oil and fat and spots of spilled beverage in a fast-food restaurant; shampoo, flour, meat drippings, and hundreds of other substances in a supermarket; and soapy water on a laundry floor.

In indoor industrial situations, the variety of lubricants is almost infinite. Nearly every product we buy involves raw materials, intermediates, or finished products that can fall on the factory floor and contribute to a slipping hazard.

Outdoor work has additional slipping hazards. For example, lubricants at an outdoor construction site include, rain, dew, frost, ice, snow, mud, sawdust, oil, diesel fuel, welding slag, and wet concrete.

On most walkways, liquid lubricants make *hydroplaning* a possibility. During hydroplaning, the film of liquid on the walking/working surface supports the shoe momentarily. As in water skiing, there's no solid-to-solid contact, and traction is essentially zero.

The potential for hydroplaning is encouraged when there's contact between a light weight spread over an area (that is, low pressure), a viscous liquid (oil is more viscous than water), high sliding speed, and smooth shoe and floor surfaces. When full hydroplaning occurs, traction for practical purposes can be considered to be nil. Partial hydroplaning, or as it's technically called, "boundary lubrication," can also provide very low traction. In this condition only part of the shoe-bottom contact area touches the floor while the remainder skims over a liquid film.

Thick snow on a surface might seem to overwhelm any frictional properties of the walking surface. However, snow firmly held by a rough underlying surface might give good traction. If the snow slides readily on the underlying surface, the result might be very unstable traction for the pedestrian or worker. For instance, snow on a roof might be less slippery to walk on if the roof grips the snow tightly. If the roof is very smooth or above the snow's melting point, the layer of snow itself can slip relative to the roof.

In addition to lubrication, other environmental effects can contribute to falling accidents. In hot, humid weather, several forms of heat stress can occur. *Heat stroke* occurs when the body's internal mechanisms fail to regulate the body's core temperature. Sweating stops and the body can no longer rid itself of excess heat. This can cause confusion, delirium, and loss of consciousness, which can lead to falling accidents.

Heat exhaustion results from not replacing fluids lost as perspiration. Workers who are older or in poor physical condition are particularly at risk. Heat exhaustion is not medically as serious as heat stroke, but it can cause weakness or fatigue, giddiness, and nausea, which can lead to falling accidents. *Fainting* may occur when people who are not acclimatized to a hot environment perform tasks that require standing for some time in one position. *Heat cramps* are painful muscle spasms caused by drinking large quantities of water without salt replacement.

Footwear

Slipping incidents occur when there's insufficient traction between footwear and walking/working surface. People often ignore the footwear part of this combination in favor of giving pedestrians and workers the freedom to wear any footwear they like, regardless of how unsuitable for the task or the walking surface.

When a consumer does intend to buy shoes that have good traction, he or she has little but instinct to rely on. There are no regulations setting minimums for shoe traction, and often no information on the subject readily available to consumers in shoe stores or anywhere else. Traction is sometimes of little concern to the shoe manufacturer, and shoes may have poor traction regardless of price. In litigation, accident victims predominantly blame property owners rather than footwear manufacturers for the accident.

The term "solings" includes both the heels and soles of shoes. On a hard wet floor, several phenomena combine to determine traction:

1. Fluid flow properties of the lubricating liquid (including hydroplaning)
2. Surface tension and suction
3. Adhesion (sticking) of the soling material to the flooring material
4. Elastic properties of the soling material
5. Resistance to wear (abrasion and tearing) of the soling material

A few words may help clarify this list.

For a shoe moving fast enough over a film of liquid, *hydroplaning* can momentarily reduce traction to essentially zero. Roughness of shoe and/or floor can help defeat hydroplaning, with greater roughness needed for the more viscous liquids, such as oil.

Surface tension and/or *suction* can sometimes make friction testing deceptive, but they seem to provide useful traction, for instance, on smooth ceramic tiles after they've been etched with acid to improve traction.

Adhesion between solids is the classic form of friction, but requires that the solids contact through the liquid film. For rough hard floors, *inelastic deformation* of the moving soling material after draping around the microscopic peaks of the floor can increase traction by converting sliding energy to heat, raising the temperature of the soling slightly.

Finally, *abrasion* and *tearing* of the soling material — though undesirable from the standpoint of removing the soling's tread — also require energy, and the amount of energy required can be a factor in slips.

Several major U.S. shoe companies are now marketing footwear with enhanced slip resistance especially for fast-food employees, who often must work at a fast pace on wet, greasy floors. A number of footwear companies offer slip-resistant solings for more general use. Footwear improvement can be fast and more cost-effective than floor replacement as a means of reducing slip-and-fall risks, particularly when lubricants are present.

In several European countries, there are standard methods of rating footwear for slip resistance. The European Community is now making efforts to agree on a common standard.

Walking/working surface

A major driving force for improvement of slip resistance in recent years has been the effort to ensure equal rights for the disabled. Floors accessible to the disabled are required to be slip-resistant under the Americans with Disabilities Act (ADA). (Almost all local building codes already required slip-resistant floors, though.) Limits are set by ADA on the slope of ramps for wheelchair accessibility, and ramps require higher minimum traction standards than level surfaces require. One method that's used to try to quantify slip resistance is measurement of coefficient of friction.

Coefficient of friction. Centuries ago, scientists noticed that frictional force resisting movement between two hard surfaces seemed to be proportional to the force (weight) pressing the surfaces together. "Coefficient of friction" is the term they used for the constant ratio between the frictional force and the pressing force. It's now known that traction, or slip resistance, is not as simple as this — particularly when water or oil separates the surfaces — but the concept of a coefficient of friction is still used.

If the two surfaces are at rest relative to each other, the *static* coefficient of friction applies. If they are not, *dynamic* coefficient of friction applies. Static coefficient is often somewhat higher than dynamic, but can be lower than or equal to dynamic. For dynamic friction, the speed is an important parameter, particularly when there's a liquid between the surfaces.

Static coefficients for wet walking surfaces usually are in the range 0.3–1.2. A low coefficient of friction indicates poor traction, but a person can adjust to this and can walk on ice if aware that traction is poor. A very high coefficient of friction (as between crepe rubber soles and some carpets or sharp steel gratings) can cause stumbling. A static coefficient of friction of 0.5 or 0.6 is usually considered the minimum suitable for pedestrians, the figure chosen depending on the test method and the slider material used to represent a shoe soling.

Coefficient of friction for a given surface is not a unique number, but *depends on the test method used to determine it.* The minimum coefficient of friction needed for good traction thus also depends on the test method.

In most U.S. building codes there are no specific requirements for traction of walking surfaces other than statement that pedestrian surfaces should be "slip-resistant." This has led to definition of "slip-resistant" by means of individual lawsuit. Well over a hundred different test methods and devices, many of them homemade, have been used by expert witnesses in court cases in the United States alone to characterize the slip resistance of pedestrian surfaces.

National standard-setting organizations sanction some of these methods. One such organization, the American Society for Testing and Materials (ASTM) has at least eight "standard" test methods applicable to pedestrian traction. Within standard-setting organizations, unpaid volunteer committees establish the standards for various industries and purposes. Because the committees work on their own time, establishing a new standard test method, or improving an old one, usually takes several years. This can be true even for improving an existing standard that's widely recognized to be a poor one.

In recent years, due to the high cost to society of slip-and-fall accidents, there has been increased research on slip resistance of pedestrian surfaces. Unfortunately, the United States is not a leader in this field. Courts still decide cases here according to criteria that vary, from case to case, over a wide range.

Methods having force of law. There are some places where pedestrian slip-resistance standards have the force of law. Why is this significant? Because rather than being the result of the opinion of one person or a small standard-setting committee, the standard has been subjected to scrutiny by many people. The standard has also had an effect on the marketplace in the buying and selling of flooring.

The test methods have withstood the test of time for some period, although improvements are still desirable. Table 3-1 (see the next page) lists some standards for flooring materials and some information on the test methods. In some cases the "minimum COF" (coefficient of friction) applies only to new or modified surfaces. In the table, "FFT" refers to a "Floor Friction Tester" that's sold commercially under the name Tortus. "TRRL rubber" is a soft rubber, similar in hardness to the solings of some athletic shoes and work boots.

The numerical "minimum COF" values shown in Table 1 range from 0.35 to 1.0. This is consistent with the required minimum being a function of the test method used to assess coefficient of friction, as we said above. The traction reasonably required for anticipated activities, and allowance for a margin of safety, are also considered in setting the minimums.

Australia and New Zealand have had legally binding floor slip resistance standards for several years and are now striving to improve and extend them. Significant pedestrian-slip-resistance research has been in progress for a number of years in England, Finland, France, and Switzerland.

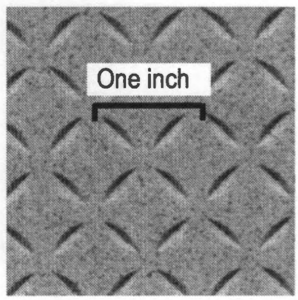
	Legal: jurisdiction	Test method	Slider	Slider speed, inches per second	Minimum COF	Comment
1	Australia	Dry: FFT (Tortus)	Four-S rubber	0.7	0.4 average; 0.35 minimum	Up to 0.5 for 1:12 slope ramp
		Wet: Road Research pendulum	Four-S rubber	105	0.4 average; 0.35 minimum	Up to 0.5 for 1:12 slope ramp
		Wet: Road Research pendulum	TRRL rubber	105	0.4 average; 0.35 minimum	For (rough) segmental pavers
		Dry: pull meter, 11 lb weight	TRRL rubber	0.8	0.7 min, 1.0 max	For wheelchair test surfaces only
2	Germany	Oil-coated ramp	Standard shoes	Human subjects walk ramp, facing downhill	Industry-specific	Values for specific environments
		Water-wet ramp	Bare feet		Area-specific	Values for specific barefoot areas
3	Italy	FFT (Tortus)	Four-S rubber	0.7	0.4	For "Enhanced slip resistance"
4	Los Angeles, CA, City of	ASTM C 1028-89 static COF	Neolite (beige)	0	0.6, 0.8*	Building Department covenant
5	New Zealand	Dry: FFT (Tortus)	Four-S rubber	0.7	0.4 average†; 0.35 minimum	Up to 0.5 for 1:12 slope ramp
		Wet: Road Research pendulum	Four-S rubber	105	0.4 average†; 0.35 minimum	Up to 0.5 for 1:12 slope ramp
		† plus increment on ramp, depending on slope, for building code compliance: NZBC D1/VM1				*ramp
	Industrial standards					
1	ASTM	D-2047, James machine	Military leather	0	0.5, dry only	For floor finishing compounds
2	Ceramic Tile Institute	ASTM C 1028-89 static COF	Neolite (beige)	0	0.6	Ceramic tile
3	BRANZ*	Wet: Road Research pendulum	Four-S rubber	105	0.6	Certain tile uses: Pool aprons, bakeries, large kitchens, etc.
		*BRANZ: Building Research Association of New Zealand				

Table 3-1.
Walking surface slip-resistance requirements having force of law

A portable machine can do a good job of measuring its own traction with the floor, but it might not necessarily be a good mimic of the traction of a human. Strangely, only two of the methods in Table 1 have been scientifically shown to be relevant to traction of humans. They are the ones listed under Item 2, Germany: the oil-coated ramp, using people in shoes to test, and the water-wet ramp, for which barefoot people are used. Since real people are used, this test is by definition relevant to human traction. Unfortunately, it isn't portable — it must be used in the laboratory using flooring that's laid directly on the ramp.

As a result of using this test method for some years, Germany has the most advanced system of floor slip-resistance classification for industrial and commercial workplaces, homes, schools and kindergartens, and recreational facilities. The codes R9–R13 refer to five categories of increasing slip resistance in areas where people use footwear. People walking a variable-angle ramp in standard shoes are used to assess the slip resistance of the flooring to assign it to a category, R9 through R13. We'll discuss this method further in Chapter 5.

For industrial areas subject to heavy contamination, relief surfaces for localized drainage are required in addition to slip resistance. The photo at right shows a portion of a ceramic tile that has a relief surface. The ribs in this sample rise 1/16-inch above the main surface.



Flooring manufacturers selling in Germany have adapted to the requirements, and flooring is available to fit all categories — in Germany and in other countries, including the United States. In Germany, the standards play an important role in workers' compensation insurance. The system has been in place for years and it's an accepted part of business.

Ideal method of rating surfaces. An ideal method of rating walking/working surfaces for slip resistance would have the features shown in Table 3-2 (please turn the page). So far, there is no single device that's been shown to fulfill all these requirements. (The German ramp method isn't portable.) As we'll see later, a combination of two devices, to measure both static coefficient of friction and surface roughness, does a better job.

A major drawback in the effort to promote installation of slip-resistant pedestrian surfaces, especially indoors, is that some slip-resistant surfaces are more difficult to clean than slippery surfaces are. Some of the features that make the floor grip shoes

Feature	Benefits
Relevance to work or pedestrian situation, based on traction of humans	Acceptance of flooring based on rational criteria that include the critical aspects contributing to slip resistance (lubricants, footwear, gait, etc.)
International recognition	Used in countries advanced in slip resistance requirements
	All manufactured surfaces tested using methods relevant to the world flooring marketplace
Precise (Repeatable and reproducible)	Dependable test results every time, regardless of who conducts the test
Portable	Can be used both in factory and for checking on-site installed flooring

Table 3-2.
Traits of the ideal method of rating pedestrian surfaces for slip resistance

tightly also can make them hold on to dirt, stains and mop strands. Slippery floors often can be made to look clean by simply mopping them. Slip-resistant floors may require stronger chemicals or more vigorous cleaning methods, such as (in some cases) mechanical scrubbers.

Traction

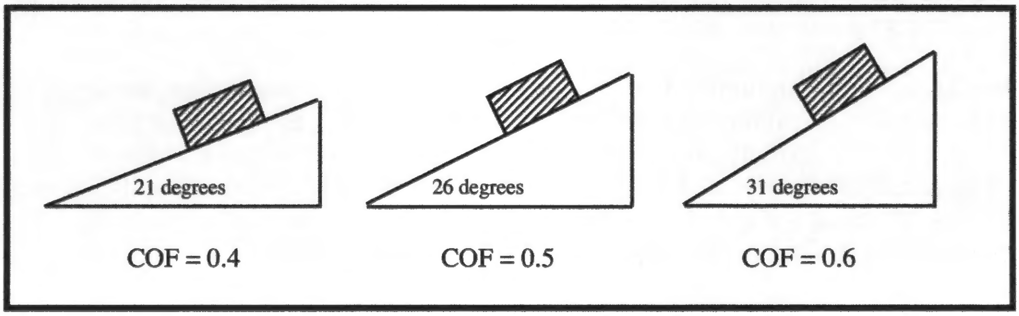
The five factors we discussed previously — person, activity, environment, footwear, walking/working surface — combine to determine traction in a given instance, and whether that traction is adequate to prevent slipping. This leads to a method, discussed in a later chapter, that can help decide logically on a solution to a slip hazard.

Every surface has some degree of roughness, though the scale of the roughness might be microscopic. Traction between two rough surfaces (soling and floor) results from two types of interactions: *adhesion* and *interlock*. Adhesion results from molecular attraction between the two surfaces and exists even when both surfaces are quite smooth. Interlock is a mechanical interaction involving peaks and valleys on one or both of the surfaces, even though the peaks and valleys may be microscopically small. A lubricant, for instance water or oil, can defeat both adhesion and interlock to some extent.

Coefficient of Friction

As mentioned before, centuries ago scientists noticed that when one hard surface slides over another, the frictional force that opposes the sliding is proportional to the force, or weight, pressing the two surfaces together. They called the constant ratio of the two forces the "coefficient of friction." It seemed to have a different value depending on whether the two surfaces were at rest with respect to one another, or sliding was in progress. For instance, if the lower surface was tilted up until the upper object (let's say a block of wood) just barely began to slide, the ratio of forces was called the *static* coefficient of friction. As the block of wood continued to slide, the ratio of forces during motion was the *dynamic* coefficient of friction.

They calculated the coefficient of friction (using high-school trigonometry — but let's not get into that) from the angle of the surface. For instance, if they could raise the surface to 26 degrees from horizontal before the object on top started to slide, then the static coefficient of friction was 0.5. If they could raise the surface to 31 degrees before the object started to slide, the static coefficient of friction was 0.6. If the object *kept* sliding even after lowering the surface to an angle as low as 21 degrees, then the *dynamic* coefficient of friction was 0.4. The sketch that follows illustrates these three coefficients of friction (COF).



There are other ways of measuring the coefficients of friction that don't require tilting the surface. They all involve the same principle, though: determining the ratio between the friction force and the force (or weight) pressing the two surfaces together.

In the United States, we traditionally assess slip resistance of wet floors using a slider of beige laboratory-grade Neolite, a synthetic rubber. In other countries a specially formulated black rubber called Four-S (Standard Shoe Sole Simulating) rubber is used. The quality control for Four-S rubber is more rigorous than that for Neolite, but otherwise the materials are somewhat similar.

One specialty laboratory makes small quantities of the Neolite using an old formula, not used in shoes for decades. The advantage of using an otherwise obsolete formula is that like the Latin language, the composition of this material supposedly doesn't change. (One change occurred when the original colorant became unavailable.) The Neolite is relatively hard and has fairly low wet slip resistance, and thus has traditionally been considered a conservative choice as a slider material.

The classic idea of coefficient of friction is that it doesn't depend on the area of the surfaces in contact, or on the amount of load (weight) applied, and that static friction is greater than dynamic. However, scientists learned more than 70 years ago that none of these classic rules are true for some materials used in shoe solings, such as rubber. For this reason, the constant "coefficient of friction" doesn't really exist in pedestrian situations.

In addition, the term "static" applied to coefficient of friction is a misnomer because even under very low forces, rubber tends to creep and therefore not remain stationary. This implies that all coefficients of friction for rubber are "dynamic," although we use the term "static" when speed is very low. This book uses the term "static coefficient of friction" because of its traditional role. However, in evaluating pedestrian traction it's not strictly necessary to know a "coefficient of friction." What is important is having some means of rating what traction the pedestrian will have under various relevant conditions.

In addition to the amount of traction, *unexpected variations* in traction are important. The slip resistance at the interface between footwear and working surface needs to be adequate for the activity performed and the probable degree of care and the reflexes of the person. If there is a decrease in slip resistance that the person didn't anticipate, the risk of falling is higher than if the slip resistance is constant. If the person is elderly and has slow reactions, this also increases risk of falling.

Two Minutes of Freshman Physics

Now that we've covered coefficient of friction, let's discuss two other elementary principles that apply pedestrian slipping incidents. First, the relationship between force and acceleration determines how much traction force (or slip resistance) we need in a given situation. Second, non-friction forces acting in footwear traction, particularly on a smooth wet floor, can help in solving some slip resistance problems.

Force and Acceleration

The force (including traction force) needed for various activities is described in classical physics by Isaac Newton's Second Law of Dynamics, which states that the time-rate-of-change of momentum is proportional to the force applied.

For a free-standing person to move an object, such as a baby carriage or a wheelbarrow, a shoe traction force is needed. The amount of force proportional to the weight of the object multiplied by the rate-of-change of speed of the object. If the person wants to walk with the object, she must apply additional traction force to accelerate her own body as well.

The significance of this is that *the traction force required depends on the activity*, and can be much greater than the traction required for simple walking. Moving an object manually can require traction — even if the person's feet don't move.

In the scientific literature, the coefficient of friction needed for constant-speed walking has often been quoted, and it's approximately 0.4 or lower. This number applies to the actual shoe soling, not to a test slider. Although it's nice background information, this number doesn't tell us what coefficient of friction is needed in real-life situations.

Non-friction Forces Acting in Pedestrian Traction

Friction, resulting from adhesion and interlock, is the force most often mentioned in discussing pedestrian slip resistance. On a water-wet walking surface, other forces — namely, suction and surface tension — can be of significant help to the pedestrian.

For instance, smooth ceramic tiles can have their slip resistance increased appreciably by etching with acid solutions. The resulting change in surface texture improves pedestrian traction without necessarily increasing peak-to-valley surface micro-roughness of the tile. Non-friction forces are involved.

The non-friction forces make it important for a coefficient of friction test to model correctly the attack of a footwear soling onto the flooring if tests are to be relevant to pedestrian traction. In addition, contributions of the non-friction forces mean that it's possible for some surfaces to have *more slip resistance wet than dry* — but anyone who has moistened a finger to turn a page already knows that.

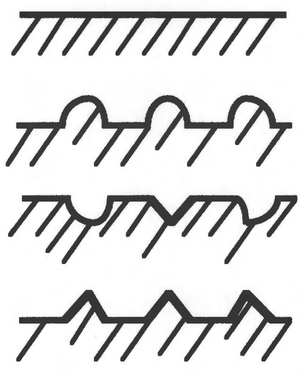
Roughness and Slip Resistance

We all know intuitively that roughness has a lot to do with slip resistance. Very smooth floors tend to have low wet slip resistance, and to some types of solings (as on some dancing shoes) can have low dry slip resistance too. However, "rough" floors aren't always slip-resistant, and this has to do with the character of the peaks and valleys.

Roughness on a microscopic scale, or "micro-roughness," is an aid in assessing slip resistance. We'll sometimes use the term micro-roughness to remind you that we're talking about small-scale peaks and valleys rather than tread on solings or raised relief on flooring.

There are at least three basic forms of micro-roughness relevant to pedestrian traction, as illustrated in the sketch on the next page. Different surfaces having the same peak-to-valley roughness can have appreciably different wet slip resistance depending on the character of the roughness. Tiny smooth bumps can give a surface some roughness, but if the bumps have a low static coefficient of friction the slip resistance of the surface can be low. Here, we're recognizing that there's a difference between *coefficient of friction* and *slip resistance.* A static coefficient of friction is a number, derived from testing, that can help in evaluating slip resistance, but it isn't enough information to define slip resistance completely. In Chapter 5, we'll talk about how to use surface roughness together with static coefficient to help assess slip resistance. We'll also discuss the variable-angle ramp test, which measures walking slip resistance directly.

"Diamond-plate" metal surfaces include embossed diamond shapes intended to improve wet traction. Although the diamonds are sometimes an improvement over



flat metal, they usually have the effect of "bumps," and don't result in good slip resistance. The problem can be compounded if the diamond plate *appears* to offer good traction, inspiring misplaced confidence on the part of the pedestrian.

Including abrasives in walkway surfaces has traditionally been a method that flooring manufacturers use to improve wet slip resistance by giving the surface "teeth." These teeth can be very effective in wet or otherwise lubricated situations, whether the teeth are a sixteenth of an inch (or more) high or less than three thousandths of an inch high. To be effective, though, they must be sharp and must not be buried under coatings. A host of flooring and coating materials are available commercially that use "teeth" to give good wet traction.

An alternative method of improving wet slip resistance is to include millions of tiny suction cups in the surface. When the suction cups have gentle contours, they can improve traction while maintaining easy cleanability.

A measurement of surface micro-roughness indicates the potential for interlock with soling materials. However, because rounded bumps can add roughness but aren't very effective at interlock, we need to know the static coefficient of friction as well as the surface roughness to evaluate a floor's slip resistance.

CHAPTER 4

Accidents and Financial Losses

In this chapter, we'll discuss financial losses that result from personal injuries from two significantly different standpoints. First, the direct costs when the injured person is a company's direct employee who was working at the time of the accident; and the total costs regardless of whether or not the injured person was employed.

If you're the injured person, it might not seem as if it should make any difference whether, when the accident occurred, you were working or not. Your ruptured disc is a ruptured disc, and the time, pain and expense involved will be the same regardless of what the circumstances were. The damage to your personal life, and perhaps to your dreams for the future, is the same. However, as we'll see, the relationship of the victim to the other parties in the case can make a tremendous difference in what society perceives the costs of the accident to be. It also affects to what extent the victim is compensated for an accident that occurred due to the negligence of others.

If you're not the person who's physically injured, but are in charge of the premises or work location where the accident occurs, there's a big difference in the control you have over the accident causes and financial losses. The difference depends on whether the injured person is an employee or someone else. You have little control over the footwear or behavior of non-employees, and might have no say over what members of the public visit your premises; yet you may need to pay for all the losses an injured person incurs due to an accident. It behooves you to exert *due diligence* to prevent any accidents that might be caused, wholly or partly, by your negligence.

If you're an employer, you may be able to exert some control over the footwear and the safety-related behavior of your employees. This can help you to prevent accidents. The downside of being the boss is that when your employee gets injured on the job, you get to pay for it through your workers' compensation program — regardless of whose fault it was. You need to *prevent the accident,* regardless of whether it occurs due to your negligence or not.

Workers' Compensation and Uninsured Costs

Workers' compensation laws vary from one state to another, but the general idea of the system is to see that employers compensate employees promptly for injuries. In exchange for this, the employee gives up the right to sue the employer under most circumstances. This means that the employee must absorb some of the non-medical, non-wage losses, regardless of who caused the accident.

Employers must also absorb some losses that most insurance doesn't cover. There's a tendency to ignore some of these losses because they don't show up as a bookkeeper's line items directly attributed to the accident — but they're real costs nevertheless.

The good news is that if we can prevent the accident from happening, we can eliminate all of these costs. Instead, the employee can go on with his or her life uninterrupted, and the employer can show lower costs and/or higher profits.

Employee's Losses

For an accident that occurred while at work, the injured employee generally gets compensation for the following:

- Medical expenses
- Lost income, temporary or permanent
- Death

For an example, let's look at the steel erection industry, which assembles steel beams, columns, roofing and decking and other building components. The cost to the insurer for a typical lost-time fall on the same level (that is, no stairs or other change in elevation is involved) in steel erection in the United States is about $10,000. Some accidents cost much more than this. At the other extreme, some accidents don't require time off or medical attention, and thus have little or no cost.

When the victim is disabled permanently, the average cost including disability pay, for a steel erection fall of any type (same level or different level, slip or other cause), totals about $200,000. If death results from the accident, though, the average cost to workers' compensation is only about $115,000.

The proportions vary from state to state. In Florida, for instance, the average lifetime disability cost for steel erection falls of all types is $260,000, but the average cost of a case in which death results is about $90,000. The differences are partly due to how each state defines what the employee's potential future income was. The numbers are different for other occupations, but the same principles apply.

Two things are clear, though. First, workers' compensation awards can be much lower than the damages (sometimes exceeding $10,000,000) awarded in some lawsuits in cases of similar injury. Second, workers' compensation doesn't do a good job of functioning as a life insurance policy. The average cost to the workers' compensation system of a death can be much lower than the cost of supporting a victim who lived through the accident and subsequent complications.

In certain circumstances, such as gross and willful negligence on the part of the employer, or injury-related discrimination, the employee may be able to sue his or her employer and recover the actual damages. In most cases, though, the worker can only recover the lower amount allowed by workers' compensation.

The Boss's Losses

The employer, too, can and does suffer uninsured costs from the accident. The employer suffers losses of several kinds, and only some of them show up directly on the books as attributable to the accident. All of them can reduce profits, though.

The workers' compensation may or may not be covered by an outside insurance company. If it is, and the employer is a large company, the insurer will eventually adjust the premium to reflect the losses. If the employer is a smaller company, it may be part of a pool that spreads out the losses over a number of companies. That way, a bad year for one insured company doesn't have to increase that insured company's premiums to the point where their costs are non-competitive, and they are effectively out of business.

If the employer is self-insured (and is a for-profit company), the loss comes out of profits. A whole spectrum of methods of covering workers' compensation runs between the two extremes — insured externally and self-insured. For most large organizations, though, the employer is ultimately the only source of the money to cover the workers' compensation losses.

In addition to the workers' compensation losses, there are less obvious ones. Co-workers' and supervisors' work is lost in such activities as getting medical attention for the victim, filling out reports, and preventing recurrences. When an employee is out of the lineup because of injuries, it may be necessary to pay overtime premiums to others to meet deadlines and otherwise satisfy customers' requirements. If the victim will be unable to work for quite some time, hiring and training a replacement might be necessary. In some cases, the employer may need to pay fines levied by the U.S. Occupational Safety and Health Administration (OSHA) or state agencies. Finally, under certain circumstances the employer may be subject to a lawsuit due to negligence and/or injury-related job discrimination.

When the negligent party isn't the victim's direct employer, the situation is quite different. For instance, the victim may have been working as a subcontractor on a general contractor's project. The subcontracting company who is the victim's employer may be able to recover accident costs from the general contractor. The victim may be able to recover full damages from the general contractor. Sometimes the general contractor's only negligence leading to his liability may have been in hiring an unsafe subcontractor — namely, the victim's own employer!

Non-employee's Losses

When the negligent party isn't the victim's own employer, the victim (or the victim's heirs) may have an opportunity to regain losses and possibly punitive damages as well. The compensation might then include all or some of the following, both from losses already incurred and estimated future losses resulting from the accident:

- $ Medical expenses and/or death benefit
- $ Pain and suffering
- $ Loss of consort (companionship) by others (security, ego support, encouragement, feeling of well being, feeling of being useful and needed, etc.)

- $ Economic losses from failure to complete real estate transactions, fulfill contracts, etc.
- $ Decreased quality of life
- $ Loss of anticipation of future activities, pleasures or comfort ("loss of hope")
- $ Punitive damages

Punitive damages punish the negligent party for outrageous conduct and thus discourage such conduct. Other than punitive damages, though, the items above are to reimburse the victim financially for losses that are both financial and emotional. This can't always work, since money doesn't really solve every medical or emotional problem. Having a high-loss slip-and-fall accident is not like winning the lottery. For both the victim and the defendant, it's better if the accident doesn't happen.

Injury-related Job Discrimination

Sometimes an injured employee can lose a job because although the on-the-job injuries didn't produce total disability, they did make the employee incapable of continuing in the same job. This is what happened to Ms. Theresa Dillon, who had been an employee of the City of Moorpark, California. After a knee injury that made it difficult for her to move about the premises where she worked, the City terminated her employment. The state Supreme Court, in "The Moorpark Decision," ruled that employees who are injured in the course and scope of their employment can't be discriminated against based on resulting disability.

The result was that *employees can sue their employers* for injury-related discriminated under the state's Fair Employment and Housing Act. This may set a trend for other states, increasing the costs of on-the-job accidents as employers make greater efforts to accommodate workers who become partially disabled in the course of their work.

Case Studies

Although the majority of slip-and-fall settlements total less than $100,000, and average less than $20,000 when covered by workers' compensation, individual cases can be much larger. To get an idea of how a catastrophic falling accident can occur,

Damages	Accident	Age*	Comments
$10,100,000	Contractor tripped over unseen chain at Texaco oil refinery	53	Plaintiff 45% negligent
$6,500,000	Nurse walked off unmarked edge of pier to sand at Lake Tahoe	47	Jurors deliberated 3 days
$3,877,000	Architect malpractice; officer slip on water on glass floor at jail	40	Medical $146,000 up to trial
$2,150,738	Female attorney slipped on marble floor at Radisson Hotel	35	Sealer apparently degraded
$1,340,000	Fell on defective and negligently installed stair nose piece	45	Fell down 16 stairs
$1,253,688	Drywaller carrying drywall stepped on loose piece of conduit	34	Plaintiff 12% negligent
$1,127,535	Leasee's manager slipped on battery acid near K-Mart auto center	59	Leaking used battery
$1,020,000	Woman slipped on construction dirt while boarding pickup truck	28	Settlement (out of court)
$1,006,606	Worker tripped over cigarette-butt coffee can on dark stairs	55	Plaintiff 49% negligent
$1,000,000	Painter slipped on paint remover left on floor by janitor	49	Settlement (out of court)
$970,831	Woman slipped on rainwater on floor at Blockbuster Video		Binding arbitration award
$959,906	Fund-raiser slipped on rainwater in medical building	48	Rubber runner non-absorbent
$839,500	Teacher slipped on liquid soap spill on Wal-Mart floor	45	Plaintiff 2% negligent
$765,000	Woman slipped on leakage in laundry room of apartment bldg	46	Plaintiff asked for $149,000
$710,000	Electrician slipped on drywall mud at construction site	44	Jurors deliberated 4 hours
$687,900	Law librarian tripped on bulging rain mat at entry to Arco Tower	53	Includes hip replacement
$637,500	Restaurant patron fell coming down unsafe stairs from rest room	62	In coma for 2 months
$595,000	Police sergeant slipped on slimy carpet; violence call on rainy day	37	Moss and algae on carpet
$559,343	Truck driver tripped on broken driveway at furniture store	37	Jurors deliberated 3 days
$525,000	Trip on loose carpet seam in commercial building.	37	Loss of consortium included
$500,876	Construction worker at freeway project tripped over debris		General contractor defendant
$500,000	Visitor slipped on outdoor stairs at apartment bldg	35	Settlement (out of court)
$500,000	Security officer running toward assault slipped on mopped floor	29	Plaintiff 5% negligent

* Age of victim at the time of the accident

Table 4-1.
Some high-dollar court decisions

let's look at some high-dollar cases. Table 4-1 on the facing page shows cases in which the total damages ranged from over $10,000,000 down to $500,000. The Table shows the total damages, a brief description of the accident, the age of the victim at the time, and brief comments. In some cases, there was no jury verdict because the two parties settled the case outside the courtroom or in binding arbitration.

In some cases, the amount paid to the plaintiffs (victims) was less than the total damages because the victim was partially at fault in the accident. For instance, the $10,100,000 damages shown at the top of the table were reduced 45 percent because of the plaintiff's negligence. (We'll look into this case in more detail below.) The defendants were required to pay the remaining $5,555,000.

The summaries are very brief, and in all cases, a large amount of detail was presented at trial or elsewhere. We shouldn't be critical of jurors' decisions based on the scant information presented here; in some cases the jury deliberated for three days or more. Sometimes the juries awarded substantially more than the Plaintiff had asked. Below we'll look in a little more detail at three of the cases: one slip, one trip, and one misstep.

Slip and Fall at Blockbuster Videos store

A woman slipped and fell on water that had accumulated on the floor of a video store after a rainstorm. Employees at the store had known for several hours that there was water inside the store entrance, tracked in by customers. The employees had not followed the store's rule about prompt cleanup. Blockbuster admitted liability, but there was dispute over the damages.

Because of a court backlog, the parties agreed to settle the dispute through binding arbitration by a judge rather than in trial. In previous non-binding arbitration, another Arbitrator had decided that the Defendant should pay the Plaintiff $175,000.

Experts who testified at the binding arbitration included a vascular surgeon, an orthopedic surgeon, an internist, a psychologist, and an economist for the plaintiff; and a radiologist for the defense. After the fall, the Plaintiff had suffered from loss of consciousness, neck pain, head pain, and shoulder pain. Following extensive medical treatment, she still had substantial residual pain and disability.

The Defendant had offered $30,000 to settle this case, but the Plaintiff demanded $475,000. The binding arbitration resulted in the following award:

Medical to date	$ 85,736
Future treatment	75,474
Past and future loss of earnings	407,137
General damages	402,484
TOTAL	$970,831

Trip on Chain at Texaco refinery

A 53-year-old man employed as a general foreman for an asbestos removal company was working at a Texaco oil refinery. He tripped and fell over a rusty metal chain that he didn't see. The chain was 12–18 inches above the ground.

The victim sustained cervical spine injury, paralysis of lower extremities and hands, and bowel and bladder problems. After hospitalization for six weeks and extensive therapy, the victim had neurological impairment in all four extremities and was quadriplegic.

Several years before, a Texaco employee failed to see a metal chain and sustained serious injury. Texaco had then decided that to replace metal chains with safety yellow plastic chains. The chain in the more recent case had not been replaced.

Nine technical experts testified for the Plaintiff, and six for the Defense. The Plaintiff demanded $2,999,999, but the Defense had offered less than $1,000,000 to settle. The verdict was gross damages of $8,600,000 for the man and $1,500,000 to his wife for loss of consort — a total of $10,100,000. The Plaintiff was 45 percent negligent and received a net of $5,555,000, which included $140,000 recovery for the workers' compensation carrier.

Misstep on Pier at Lake Tahoe

A 47-year-old nurse fell off a pier at Lake Tahoe. The pier had no guardrail and due to drought, there had been no water under the pier.

In the area where the victim fell, there was a lower catwalk that looked similar to the top deck. The edge of the top deck was not marked, and due to the optical illusion, the victim thought that the catwalk was at the same level. She stepped where she perceived there to be more pier than there was.

After surgery on her spine, she was a complete paraplegic with bowel and bladder incontinence. Her medical expenses to the time of trial were $127,000, and she had demanded total damages of $1,250,000.

At trial, two medical experts and seven technical experts testified. The jury deliberated for over three days. They awarded the Plaintiff $6,500,000, including estimated future medical expenses of $1,250,000.

Part II:
About the Causes of Slips, Trips and Missteps

What's in this part –

The characteristics of floors and footwear cause many slips or trips resulting in injuries. Different circumstances apply in various situations: stairs and ramps, barefoot areas, outdoor walkways, lubricated work areas, etc.

Chapter 5 gives important guidelines for flooring slip resistance for some 150 specific types of situations. Chapter 6 tells you the characteristics that give footwear good slip resistance. Other chapters give additional information on outdoor slips and falls, lighting and distractions, and how to care for floors to maintain their best slip resistance.

CHAPTER 5

Evaluate Flooring for the Task Afoot

Most flooring, if clean and dry, gives adequate traction for normal pedestrian activities as long as the footwear is reasonably appropriate. Problems occur mainly when solids (for instance, powders) or liquids, including water, lubricate the surface of the flooring. In some situations, we can't prevent the presence of a liquid or solid — an obvious case being outdoors during rainfall. This lubrication must be accounted for, and most often the solution chosen is to increase the slip resistance of the flooring surface according to the demands of the *environment* and the *activities* that are conducted.

This chapter first tells you about the most reliable method of rating flooring for slip resistance. Then it explains how you can use the ratings together with slip-resistance guidelines to select safe flooring for your application. For flooring that's already in place, the ratings together with results of on-site tests can help you to assess slipping risk and decide whether you need to take remedial action.

Data from three tests described in this chapter can help you to select the appropriate slip resistance for different situations. The first and most important test is the variable-angle ramp test. Together with the guidelines in this chapter, results of this test can help you to select the appropriate slip resistance for over 150 different situations. When ramp test data aren't available, the *combination* of data from a static coefficient of friction test and a surface roughness test can enable you to estimate the slip resistance.

For new flooring, the flooring supplier may be able to supply, at no charge, the test data you need. For existing flooring, a commercial laboratory can conduct the tests for you or, for economy, you can conduct them yourself. What's required is that you have enough testing to justify a small investment in equipment and time, and the time and inclination to conduct the tests accurately.

Use the Appropriate Slip Resistance for the Situation

In the United States as in many other countries, the suitability of flooring for the environment and the task is usually decided by individual lawsuit after a costly accident. Jurors must make their decision based on conflicting inputs from forensic experts and other witnesses. Sometimes millions of dollars are at stake in a single case, and the lives of some of the litigants may change drastically depending on the outcome.

What jurors hear often amounts to the notion that from a traction standpoint floors fall into only two categories: "good" ones and "bad" ones. The "good" floors are usually said to have a coefficient of friction above some minimum threshold (usually 0.5 or 0.6) when tested, wet with water, using some test method chosen by the individual forensic expert. The "bad" floors have a coefficient of friction less than the threshold.

A much more realistic viewpoint is that the slip resistance of the floor needs to be appropriate to *the environment and the activity*. An example will illustrate this point.

> A popular retail bakery had the same flooring both in the customer area and in the employee area behind the counter, where ingredients were mixed and baked and servers helped customers.
>
> Because the store was often very busy, customers would enter and queue for several minutes to make their purchases. Their footwear might be wet with rain, but the customers shuffling slowly in line made little demand on the traction properties of the floor. To the customers, the flooring was safe.
>
> The employees, on the other hand, were rushing to perform their work on a floor that could at times be lubricated by water, shortening, flour, raisins and currants, dough, and other solids or liquids. They also had to push trolleys that carried dough or baked goods. The employees knew that for them, the flooring was very slippery.

Thus in this case the same flooring was "good" as perceived by the customers, and "bad" as perceived by the employees. Clearly, it doesn't make sense to divide all types of flooring into one of the two categories, good and bad, depending solely on the properties of the flooring. The flooring must be appropriate for its intended use. Fortunately, now there's a way of assuring that.

The flooring is tested using a laboratory method that relates directly to human traction, and the flooring is categorized according to the test results. When you have flooring installed in a new building or renovation, you should choose flooring from a category that's known to be suitable for the activity and the environment. Risk of slipping on clean existing flooring can be assessed using two simpler test methods, but the laboratory test is the "gold standard." Let's look at that one first.

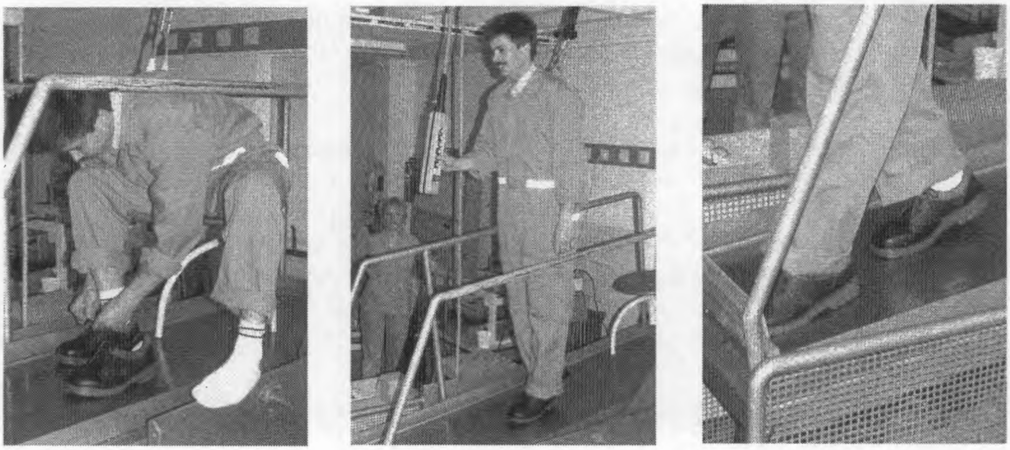
The Variable-Angle Ramp Test for Flooring and Footwear

To avoid the controversy over the many portable devices that have been used for simulating human traction, the variable-angle ramp test uses human traction directly. Certain commercial laboratories conduct this test. The photographs on the next page show a ramp test in progress. Ratings are determined by finding the steepest ramp angle at which a person can walk without slipping.

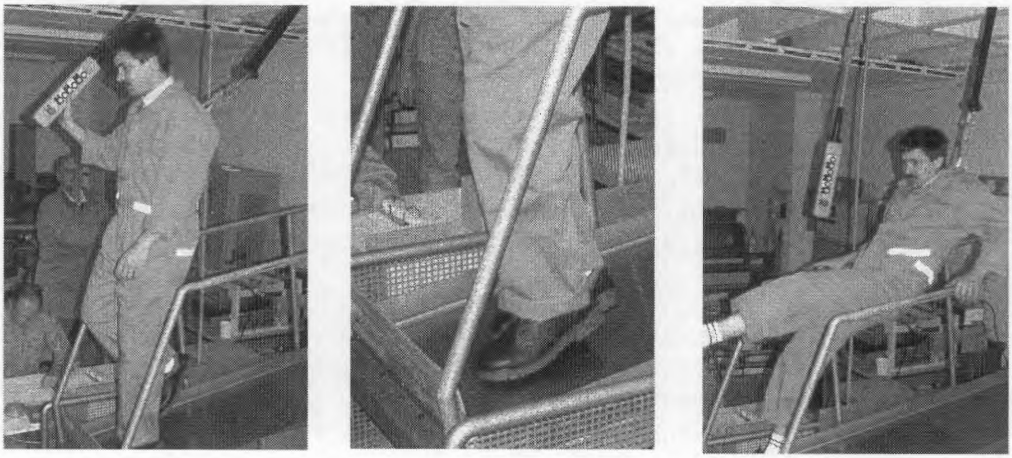
The ramp has handrails, and a full body harness protects the test person (the "walker") from falling. The harness has an overhead safety strap that suspends it. A mechanism similar to an automobile seat-belt mechanism controls the strap, and restricts the distance the walker can fall. For flooring tests, the walkers wear specified standard shoes.

The flooring manufacturer can choose to supply you with ramp test results, and this is the most efficient way for you to get the data. Not only can the flooring manufacturer use the laboratory results for all his potential customers, but also he can test periodically to make sure that his day-to-day production is consistent — resulting in known slip resistance.

The ramp test originated and was first adopted as a national standard in Germany. Then research funded by the British Government further validated the method. There are now variable-angle test ramps in at least 11 countries (including the United States) on four continents.



(a) (b) (c)



(d) (e) (f)

[PFI Test and Research Institute for the Shoe Industry]

Figure 5-1.
A walk and a slip-and-fall in the variable-angle ramp test. The walker raises or lowers the slope half a degree at a time (at a speed of one degree per second) using the controller he holds in his right hand.

Procedure for, and Validation of, the Ramp Test

This subsection explains how the ramp test is conducted and why it's the most reliable slip-resistance test for flooring. The objective is to give you confidence in the method and the ratings that result from it. If you're not interested in this much detail, you can skip to the next subsection, "Spillage Displacement Volume of Flooring."

In the variable-angle ramp test the walker, who always faces downhill, can control the angle of the ramp while he or she is walking. The ramp is repeatedly raised and lowered until the smallest angle is found at which the walker can't walk without slipping. The walker then repeats the angle determination two more times, for a total of three. Each time the ramp starts out in the horizontal position. After the first walker finishes, a second walker repeats the entire procedure on the same sample. The average of the six angles (three from each of the two walkers) determines the "acceptance angle" for the sample being tested.

To account for human variables, the laboratory first checks the performance of each walker every test day. For flooring tests, each walker must qualify for the day's testing by first rating two standard flooring types. If he or she rates these reference floorings outside of certain tolerances, that walker can't test that day. If within the tolerances, the walker's performance on the two reference floorings is used to adjust the acceptance angles he or she determines on other samples that same day. In other words, if the walker is having a relatively good or bad day in terms of being able to walk steeper slopes without slipping, that difference is accounted for by adjusting the individual walker's test results on samples tested that day.

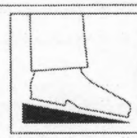
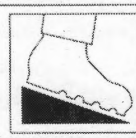
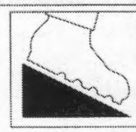
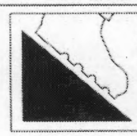
This correction procedure developed from a scientific study published in 1989. It involved 98 walkers of both sexes (70 males, 28 females), ages 18–58, weights 110–231 pounds, heights 5 feet 2 inches to 6 feet 8 inches, and a wide range of shoe sizes and body types. Statistical analysis of the results showed that by using two walkers, the acceptance angle of typical flooring could be determined to within one degree. Even greater accuracy, but at greater cost per test, could be achieved by using more walkers on a single sample. For instance, with ten walkers the acceptance angle could be determined accurate to within one-half of one degree.

This validation effort has not been equaled, or even approached, by any other human traction test device to date. Furthermore, it uses human walkers rather than some debatable portable device that's intended to simulate traction in human walking. Therefore, the ramp method is the "gold standard" for pedestrian traction tests.

There are different procedures depending on what's being tested: flooring for areas where people will be using footwear; flooring for barefoot areas; or footwear.

Areas with footwear. When a laboratory tests flooring for areas where people will be using footwear, they coat the flooring with a specified weight of motor oil to make it slippery. The motor oil is a surrogate for whatever lubricant might be on the flooring in actual use. Most floorings won't have anything this slippery on them — in fact, most won't have anything more slippery than water plus detergent on them. However, the ramp test gives a slip resistance comparison of floorings, and this ranking is likely to be unchanged whether the lubricant is water, cooking oil, or various industrial substances.

Flooring that has at least some slip resistance is classified in five categories, R9 through R13. The category R9 has the lowest slip resistance (lowest ramp acceptance angles), and R13 has the highest. If flooring isn't good enough to achieve even the R9 category, it is not classified. To achieve the highest category, R13, the acceptance ramp angle of the oily flooring must exceed 35 degrees. Figure 5-2, at right, illustrates the ramp angles for the various categories. In that sketch, the symbol ">" means "greater than."

Tests on "inclined plane"/Industrial and commercial areas		
	Angle of inclination	
R 9	>3°-10°	
R 10	>10°-19°	
R 11	>19°-27°	
R 12	>27°-35°	
R 13	>35°	

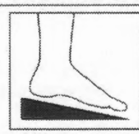
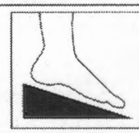
Buchtal Corp.

Figure 5-2.
Ramp-test angles of the five slip-resistance categories for areas where footwear is used. Category R13 has highest slip resistance.

A number of experts feel that the lower end of the R9 category is not slip-resistant enough, since it requires a ramp angle of only three degrees. When selecting flooring in the R9 category, you should ask for the actual ramp angle and *accept only angles above seven degrees.* Alternately, when the surface is classified R9 ask for test data using Method ASTM C 1028-96 (described later in this Chapter) and require that the static coefficient of friction determined in this way exceed 0.60. Most U.S. ceramic tile and dimensional stone manufacturers and imported tile distributors supply ASTM C 1028-96 data routinely. (A third alternative, more conservative, is to use R10 flooring wherever the guidelines call for R9.)

Barefoot areas. When a laboratory tests flooring for barefoot areas, a different set of reference tiles is used. Running soapy water covers the flooring, and the walkers are barefoot. The walkers determine whether the samples to be tested are more or less slippery than the three types of reference tiles. Each of two walkers tests every sample four times, and the average of the eight results establishes the rating.

Flooring wet barefoot slip resistance is classified in three categories: A, B or C. Of these, A has the lowest slip resistance and C has the highest. For Category A, the acceptance ramp angle of the wet soapy flooring is between 12 and 18 degrees. For Category C, the acceptance ramp angle must exceed 24 degrees. Figure 5-3 illustrates the angles. In that sketch, the symbol "≥" means, "greater than or equal to." For instance, if the ramp-test angle is greater than or equal to 12 degrees, but less than 18 degrees, the flooring is in barefoot Category A. If the ramp -test angle is greater equal to or greater than 24 degrees, the flooring is in barefoot Category C.

Tests on "inclined plane"		Wet barefoot area
Valuation groups	Angle of inclination	
A	≥12°	
B	≥18°	
C	≥24°	

Buchtal Corp.

Figure 5-3.
Ramp-test angles of the three slip-resistance categories for barefoot areas. Category C has highest slip resistance

Footwear. When a laboratory ramp-tests footwear, the standard flooring surface is smooth stainless steel sheet coated with a standard glycerin-water solution. This solution has a high content of glycerin and is much more slippery than water. (The method uses glycerin, a gooey water-soluble liquid, because unlike motor oil, glycerin won't chemically attack soling material that isn't oil-resistant.)

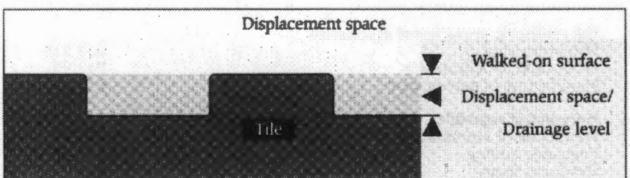
Three walkers each test a separate pair of the sample footwear. Each walker determines the acceptance angle three times, starting from the horizontal ramp position each time. The angle determines the slip-resistance category of the solings. If they have at least some slip resistance, the solings are categorized as either R1 or R2, with R2 being higher in slip resistance. For soling category R2, the acceptance angle on the lubricated steel must exceed 10 degrees. For category R1 it's between 4 and 10 degrees.

Spillage Displacement Volume of Flooring

Before we discuss the application of the ramp test results for flooring, we need to describe another test. This one has to do with the volume available to disperse spills on flooring that has a raised-relief surface.

Particularly in work situations, some areas will frequently have spillage on the floor. When you're manufacturing cooking oil, sausage, or mayonnaise, for instance, it's natural that some material spills on the floor and is walked on. It's helpful if the flooring has a raised-relief surface, so that spillage can disperse off the higher portions, leaving them uncovered. The photographs in Figure 5-4 on the next page show five relief surfaces. The more that spillage is likely to affect slip resistance, the greater should be the volume available (between the raised areas) for accepting spillage.

There's a standard laboratory test for determining spillage capacity. A four-inch-square sample of the flooring is weighed, then covered with a standard paste like peanut butter on bread. The paste must extend only to the topmost level of the relief surface, and the top of the paste must be level. The sample is weighed with the paste on it. From the difference in weight due to the paste, and the known



Displacement space/Minimum volume:		Displacement space/Minimum volume:	
V4	4 cm^3/dm^2	V6	6 cm^3/dm^2
V8	8 cm^3/dm^2	V10	10 cm^3/dm^2

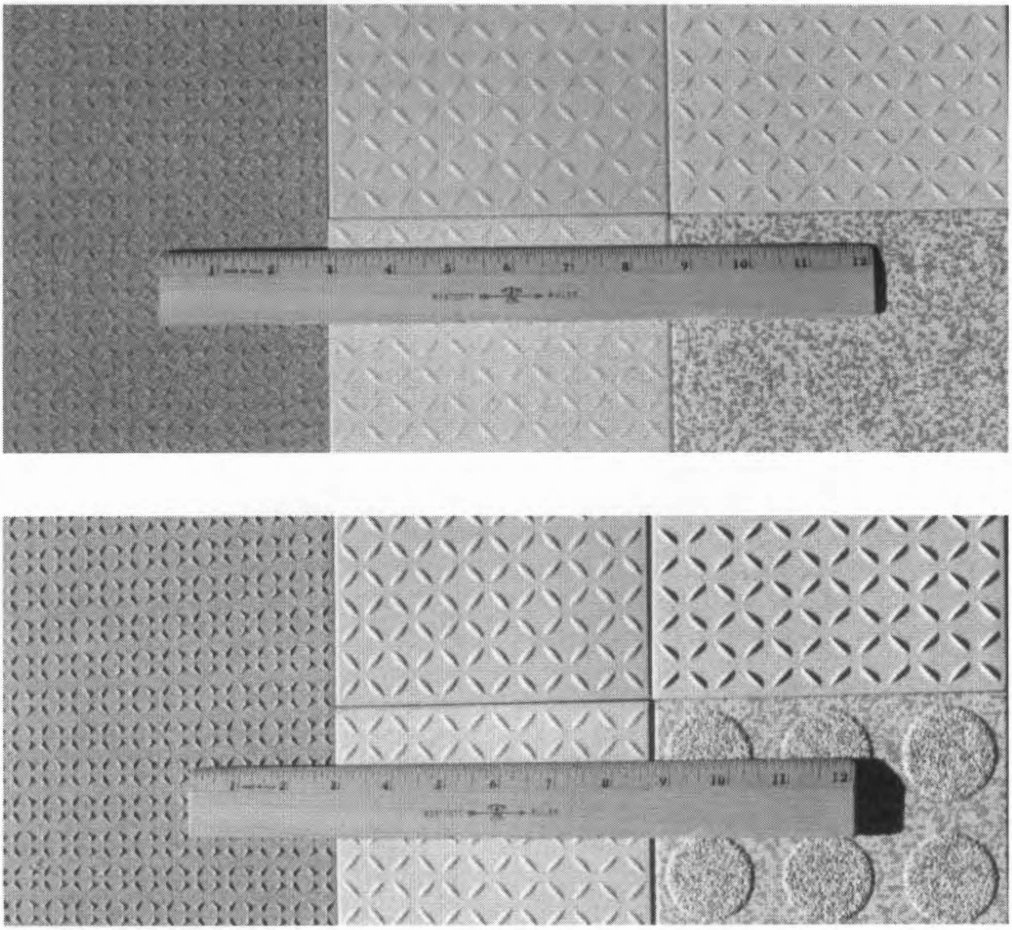


Figure 5-4.
Relief surfaces, with a one-foot ruler, in overhead sunlight (top) to show typical appearance and (bottom) in glancing sunlight to show relief features more clearly. Drainage of peaks, in addition to interlock with solings, enhances traction

density (weight per unit volume) of the paste, the spillage volume per unit area of the flooring is calculated. The sketch on the previous page illustrates the process.

The displacement is in volume per unit area. You can think of it as an equivalent spillage-containment depth in inches (or in millimeters) if the flooring were flat. The displacement volume category is V4, V6, V8, or V10. These numbers come from the equivalent depths being 0.4, 0.6, 0.8, or 1.0 millimeters. (One inch equals 25.4 millimeters.) The maximum category, V10, is equivalent to a spillage depth of 0.04 inches. Five examples of some of these categories are shown in the two photographs in Fig. 5-4 on the previous page. In the top photograph, sunlight from above shows the normal appearance of the flooring. Glancing sunlight from the side in the lower photograph makes the relief features easier to see.

Four of the samples shown have slip resistance R12 and volume displacement V4. The fifth sample, on top right of each photograph, has slip resistance R13 and volume displacement V10. Its higher volume displacement comes from higher ridges in comparison to the two other samples of similar relief pattern.

Flooring for most purposes doesn't require any displacement volume. However, for a cooking-oil refinery, the lowest category, V4, is appropriate. For a fish processing area, the maximum category, V10, is appropriate. (The subsection that follows this one gives detailed guidelines.)

Individual cases might require special consideration. For instance, if heavy trolleys with hard wheels need to be wheeled across the floor, some types of raised-relief surfaces might make this task difficult, and the surface might also tend to degrade quickly because of the high pressure from the wheels.

Finding the Right Slip Resistance for Your Application

Now we have enough information to select flooring that has the right traction properties for the new flooring application you may have in mind. (Farther on in this book, we'll also use ramp categories to help assess traction of your existing flooring.) There are standards for three types of flooring areas: residential, non-residential where footwear is used, and non-residential barefoot areas.

Residential uses. For floors inside and outside residential apartments, condominiums and houses, where the floor is likely to get wet or otherwise lubricated in use, R9 (or higher) is appropriate. Flooring you choose in category R9 should have ramp-test angles of seven degrees or higher. Slip resistance in residential areas is particularly important if elderly or disabled persons use the property.

A word of caution is needed about a different standard that's sometimes used. In the United States, a static-friction bath floor standard published by the American Society of Testing and Materials (ASTM) has been used at times to assess slip resistance of bathtub and shower surfaces. The threshold in this published standard is a rather low one, and some surfaces, even though they satisfy this criterion, can be slippery when wet and soapy. The low threshold was apparently accepted because the ASTM committee assumed that people would be standing still or moving slowly and carefully while bathing.

The result is that many such surfaces in the United States are slippery, even if they conform to the ASTM standard. This means no hanky-panky in the shower! Particularly when the shower is glass-enclosed, severe injuries may result. This book does not recommend use of that ASTM standard. Instead, use ramp-test category B or C as discussed farther on in this subsection.

When an existing bath, shower or laundry room is slippery, addition of adhesive strips or a bath mat is an easy and inexpensive way to make it safer. You should of course use an absorbent bath mat with a slip-resistant backing when stepping out onto a tile, stone or linoleum floor. Mats can help in residential kitchens, too.

Non-residential flooring where footwear is used. Professional trade associations for various industries have selected the traction properties that are most appropriate for the environments and activities in various areas. This work was originally done for the workers' compensation insurance industry in Germany, and the guidelines have been in use since at least 1993. Since people in most countries generally tend to walk and work similarly, we don't need to reinvent the wheel in every country of the world — we can take advantage of existing guidelines that are tried and proven in use. This set of standards is the only one that covers a large number of situations and is based on actual measurements of human traction.

Table 5-1, on the next page, shows a few samples of those standards for the most common situations. That Table, and the additional information that follows in this subsection, comprise the heart of this book.

Referring to Table 5-1, each situation has a category and class. For instance, Category 0, at the top left of the table, is "general work rooms and areas." Class 0.3, rest rooms, calls for slip resistance R9 and doesn't require any displacement volume. Classes that do require displacement volume are marked with an asterisk in this table.

For another example, food preparation kitchens in fast-food restaurants are Class 9.5. The standard is R12 for slip resistance, and a raised-relief surface. Again, in specific cases you may need to consider your special circumstances.

Class 28.1 is garages and car parks, which might be contaminated with oil and grease. The Table specifies slip resistance R10, with no displacement volume.

Class	Description	R
0	**General work rooms and public-accessible areas**	
0.1	Entrance areas likely to get wet	10
0.2	Stairs	9
0.3	Rest rooms	10
9	**Restaurants and other catering establishments**	
9.1	Kitchens in the catering trade (restaurant kitchens, hotel kitchens)	
9.1.1	Up to 100 meals per day*	11
9.1.2	More than 100 meals per day*	12
9.2	Kitchens catering for homes, schools, kindergartens, sanatoria	11
9.3	Kitchens catering for hospitals, clinics	12
9.4	Large kitchens catering for industrial and university canteens,	
	and contract catering*	12
9.5	Food preparation kitchens (fast food kitchens, snack bars)*	12
9.7	Coffee and tea kitchens, hotel garni kitchens and ward kitchens	10
9.8	Washing-up rooms	
9.8.2	Washing-up rooms for 9.2	11
9.8.3	Washing-up rooms for 9.3	12
9.9	Dining rooms, guest rooms, canteens, including serving counters	9
11	**Sales outlets, shops**	
11.7	Florist shops	11
11.10	Shops, customer rooms	9
11.12	Cash register areas, packing areas	9
11.13	Serving counters for bread, cakes and pastries, unpacked goods	10
12	**Health service rooms**	
12.6	Washrooms of operating theatres, plastering rooms	10
12.9	Operating theatres	9
12.10	Wards with hospital rooms and corridors	9
27	**Financial institutions**	
27.1	Counter areas	9
28	**Garages (with the exception of the areas specified under Number 0)**	
28.1	Garages, car parks	10
29	**Schools and kindergartens**	
29.1	Entrance areas, corridors, assembly halls	9
29.2	Classrooms, group rooms	9
29.4	Rest rooms, washrooms	10
	*Use raised-relief surface where indicated, for dispersal of liquid spills	

Table 5-1.
A few selected guidelines for floor slip-resistance rating R

Table 5-2, which covers six pages, includes the same information as Table 5-1, but adds more detail. It shows many more categories of situations, and includes the specific volume displacement ("Vol.") standard. The first page of the table is an index of the major headings. There are 141 standards listed altogether, and 38 (more than one quarter of them) include volume displacement specifications. The edges of the pages are grey so that you can always find this table for easy reference.

In most jurisdictions of the world, the specifications shown in Table 5-2 (and Table 5-1, which is just a brief extract from 5-2) are not legal requirements. In such cases, the Tables simply provide the best available information to use as a basis for selecting flooring. This doesn't prevent the use of good judgment to adjust the values according to specific situations. For instance, in certain fast-food restaurant dining areas the amount of floor lubrication may be greater than the industry average. Differences could be due to the amount of open deep frying, the quality of ventilation (lack of isolation of the kitchen air from the dining area), etc. It might then make good sense to increase the slip resistance specification from R12 to R13.

Barefoot areas. Flooring for barefoot areas is tested using the barefoot ramp test, with running soapy water on the flooring. The three categories A, B, and C have the following 16 application guidelines:

Category	Application
A	Barefoot passages that are nearly dry Individual and communal changing or locker rooms Pool floors in the non-swimmer (wading) areas, if the water depth is between 31 inches and 53 inches
B	Barefoot passages not classified in Category A Disinfecting spray facility area Ladders and stairs outside the pool area Ladders leading into the water Movable floors and toddlers' pools Non-swimmer sections of wave-action pools Pool floors in the non-swimmer areas, if the water depth is less than 31 inches in certain areas Relaxation steps and underwater steps, ledges, and benches Showers and pool surrounds Stairs leading into the water with a maximum width of 3 feet and handrails on both sides

continued on p. 58

INDEX OF MAJOR CLASSES IN THIS TABLE

Description	Class	Description	Class
Aircraft service and repair	24	Iron and other metals, treatment	21
Automobile service and repair	23	Kindergartens	29
Beverage production, wet areas	8	Kitchens, commercial	9
Bread production	4	Laundry	13
Cake production	4	Leather production	15
Car parks	28	Margarine, fats and oils, mfg.	1
Catering establishments	9	Meat processing	5
Ceramics industry	17	Metal processing & workshops	22
Cheese production	2	Milk processing	2
Chocolate production	3	Oils and fats, storage areas	20
Cold stores	10	Paint shops	16
Concrete, cast, factories	19	Pastry production	4
Confectionary production	3	Public-accessible areas	0
Deep freeze rooms	10	Restaurants	9
Delicatessen production	6	Sales outlets	11
Fast-food restaurants	9	Schools	29
Fats, storage areas	20	Sewage treatment plants	25
Financial institutions	27	Shops	11
Fire departments	26	Slaughtering	5
Fish processing	6	Sports stadiums	30
Fodder concentrate production	14	Stone polishing	18
Food production, wet areas	8	Storage areas for oils and fats	20
Garages	28	Supermarkets	11
General work rooms	0	Textile production	15
Glass and stone polishing	18	Vegetables, processing of	7
Health services	12	Vehicle repair	23
Hospitals	12	Work rooms, general	0

Table 5-2. **(continued on next five pages)**
Guidelines for flooring slip resistance where shoes are worn

Class	Description	R	Vol.
0	**General work rooms and public-accessible areas**		
0.1	Entrance areas likely to get wet	10	
0.2	Stairs in dry areas	9	
0.3	Rest rooms	10	
0.4	External walkways, pedestrian crossings and colonnades	10	
0.5	External ramps	11	
0.6	Internal ramps, dry	10	
0.7	Shopping center or mall	9	
0.8	Elevator lobbies above external entry level	9	
1	**Manufacture of margarine, edible fats and oils**		
1.1	Melting of fat	13	6
1.2	Cooking oil refinery	13	4
1.3	Margarine production and packaging	12	
1.4	Cooking fat production and packing, oil bottling	12	
2	**Milk processing, cheese production**		
2.1	Fresh milk processing and butter production	12	
2.2	Cheese production, storage and packaging	11	
2.3	Ice cream manufacturing	12	
3	**Chocolate and confectionery production**		
3.1	Sugar processing	12	
3.2	Cocoa production	12	
3.3	Production of raw mixtures	11	
3.4	Fabrication of chocolate bars and shells and filled chocolates	11	
4	**Production of bread, cakes and pastries (bakeries, cake shops, production of long-life bakery products)**		
4.1	Dough preparation	11	
4.2	Rooms in which predominantly fats or liquid mixtures are processed	12	
4.3	Washing-up rooms	12	4
5	**Slaughtering, meat processing**		
5.1	Slaughterhouse	13	10
5.2	Tripe processing	13	10
5.3	Meat sectioning	13	8
5.4	Sausage kitchen	13	8
5.5	Boiled sausage department	13	8
5.6	Raw sausage department	13	6
5.7	Sausage drying room	12	
5.8	Smoking room	12	
5.9	Salting and curing rooms	12	
5.10	Poultry processing	12	6
5.11	Gut storage	12	
5.12	Cold cuts and packaging unit	12	

Table 5-2. ***(continued)***
Guidelines for flooring slip resistance where shoes are worn

Class	Description	R	Vol.
6	**Fish processing, delicatessen production**		
6.1	Fish processing	13	10
6.2	Delicatessen production	13	6
6.3	Manufacture of mayonnaise	13	4
7	**Processing of vegetables**		
7.1	Production of sauerkraut	13	6
7.2	Vegetable canning	13	6
7.3	Sterilizing rooms	11	
7.4	Rooms in which vegetables are prepared for processing	12	4
8	**Wet areas in food and beverage production (if not specifically mentioned elsewhere in this table)**		
8.1	Storage cellars	10	
8.2	Beverage bottling, fruit juice production	11	
9	**Restaurants and other catering establishments**		
9.1	Kitchens in the catering trade (restaurant kitchens, hotel kitchens)		
9.1.1	Up to 100 meals per day	11	4
9.1.2	More than 100 meals per day	12	4
9.2	Kitchens catering for homes, schools, kindergartens, sanatoria	11	
9.3	Kitchens catering for hospitals, clinics	12	
9.4	Large kitchens catering for industrial and university canteens, and contract catering	12	4
9.5	Food preparation kitchens (fast food kitchens, snack bars)	12	4
9.6	Kitchens for heating up frozen meals	10	
9.7	Coffee and tea kitchens, hotel garni kitchens and ward kitchens	10	
9.8	Washing-up rooms		
9.8.1	Washing-up rooms for 9.1, 9.4, 9.5	12	4
9.8.2	Washing-up rooms for 9.2	11	
9.8.3	Washing-up rooms for 9.3	12	
9.9	Dining rooms, guest rooms, canteens, including serving counters	9	
10	**Cold stores, deep freeze stores**		
10.1	For unpacked goods	12	
10.2	For packed goods	11	
11	**Sales outlets, shops**		
11.1	Receiving of goods, meat	11	
11.2	Receiving of goods, fish	11	
11.3	Serving counters for meat and sausage, unpacked	11	
11.4	Serving counters for meat and sausage, packed	10	
11.5	Serving counters for fish	12	
11.6	Meat preparation rooms	12	8
11.7	Florist shops	11	
11.8	Sales areas with stationary ovens	11	

Table 5-2. ***(continued)***
Guidelines for flooring slip resistance where shoes are worn

Class	Description	R	Vol.
11	**Sales outlets, shops (continued)**		
11.9	Sales areas with stationary deep fryers or grills	12	4
11.10	Shops, customer-accessible rooms	9	
11.11	Preparation areas for food for self-service shops	10	
11.12	Cash register areas, packing areas	9	
11.13	Serving counters for bread, cakes and pastries, unpacked goods	10	
11.14	Serving counters for cheese and cheese products, unpacked goods	10	
11.15	Serving counters, except for 11.3 to 11.5 and 11.13, 11.14	9	
11.16	Supermarket aisles, except fresh food areas	9	
11.17	Shop and supermarket fresh fruit and vegetable areas	10	
12	**Health service**		
12.1	Disinfection rooms (wet)	11	
12.2	Pre-cleaning areas of sterilization	10	
12.3	Feces disposal rooms, discharge rooms, unclean nursing work rooms	10	
12.4	Pathological facilities	10	
12.5	Rooms for medical baths, hydrotherapy, fango preparation	11	
12.6	Washrooms of operating theatres, plastering rooms	10	
12.7	Sanitary rooms, ward bathrooms	10	
12.8	Rooms for medical diagnosis and therapy, massage rooms	9	
12.9	Operating theatres	9	
12.10	Wards with hospital rooms and corridors	9	
12.11	Medical practices, day clinics	9	
12.12	Pharmacies	9	
12.13	Laboratories	9	
12.14	Hairdressing salons	9	
12.15	Hospitals and nursing homes, dry areas	9	
13	**Laundry**		
13.1	Rooms with machines for washing of linen and clothes with water	11	
13.2	Ironing rooms	9	
14	**Fodder concentrate production**		
14.1	Dried fodder production	11	
14.2	Fodder concentrate production using fat and water	11	4
15	**Leather production, textiles**		
15.1	Wet areas in tanneries	13	
15.2	Rooms with skinning machines	13	10
15.3	Areas where leather scraps accumulate	13	10
15.4	Rooms for making leather impermeable by means of grease	12	
15.5	Dye mills for textiles	11	
16	**Paint shops**		
16.1	Wet grinding areas	12	10

Table 5-2. ***(continued)***
Guidelines for flooring slip resistance where shoes are worn

Class	Description	R	Vol.
17	**Ceramics industry**		
17.1	Wet grinding mills (processing of ceramic raw materials)	11	
17.2	Mixers; handling of materials like tar, pitch, graphite and synthetic resins	11	6
17.3	Presses (shaping); handling of materials like tar, pitch, graphite and synthetic resins	11	6
17.4	Moulding areas	12	
17.5	Glazing areas	12	
18	**Glass and stone polishing**		
18.1	Stone cutting, stone grinding and polishing	11	
18.2	Glass shaping		
18.2.1	Hollow glassware, container ware, glass for building purposes	11	4
18.3	Grinding areas		
18.3.1	Hollow glassware, flat glass	11	
18.4	Insulating glass manufacture; handling of drying agents	11	6
18.5	Packaging, shipping of flat glass; handling of anti-adhesive agents	11	6
18.6	Etching and acid polishing facilities for glass	11	
19	**Cast concrete factories**		
19.1	Concrete washing areas	11	
20	**Storage areas**		
20.1	Storage areas for oils and fats	12	6
21	**Chemical and thermal treatment of iron and metal**		
21.1	Pickling plants	12	
21.2	Hardening shops	12	
21.3	Laboratory rooms	11	
22	**Metal processing, metal workshops**		
22.1	Galvanizing shops	12	
22.2	Grey cast iron processing	11	4
22.3	Mechanical processing areas (turnery, milling shop, etc.), punching room, pressroom, drawing shop (pipes, wires) and areas exposed to increased contamination by oil and lubricants	11	4
22.4	Parts cleaning areas, exhaust steam areas	12	
23	**Vehicle repair workshops**		
23.1	Repair and servicing bays	11	
23.2	Working and inspection pits	12	4
23.3	Car washing areas	11	4
24	**Aircraft service and repair workshops**		
24.1	Aircraft hangars	11	
24.2	Repair hangars	12	
24.3	Washing halls	12	4

Table 5-2. ***(continued)***
Guidelines for flooring slip resistance where shoes are worn

Class	Description	R	Vol.
25	**Sewage treatment plants**		
25.1	Pump rooms	12	
25.2	Rooms for sludge draining facilities	12	
25.3	Rooms for screening equipment	12	
26	**Fire brigade buildings**		
26.1	Vehicle parking places	12	
26.2	Rooms for hose maintenance equipment	12	
27	**Financial institutions**		
27.1	Counter areas	9	
28	**Garages (with the exception of the areas**		
	specified under Number 0)		
28.1	Garages, car parks	10	
29	**Schools and kindergartens**		
29.1	Entrance areas, corridors, assembly halls	9	
29.2	Classrooms, group rooms	9	
29.3	Stairs	9	
29.4	Rest rooms, washrooms	10	
29.5	Instructional kitchens in schools (see also No. 9)	10	
29.6	Kitchens in kindergartens (see also No. 9)	10	
29.7	Machine rooms for woodworking	10	
29.8	Special rooms for handicrafts	10	
30	**Sports stadiums**		
30.1	Undercover concourse areas	10	

Table 5-2. ***(continued)***
Guidelines for flooring slip resistance where shoes are worn

Category	Application
C	Inclined pool edge designs Stairs leading into the water, if not classified in Category B Walk-through pools

Tests for other properties of flooring. There are many other special test data that you can request to assess whether a type of flooring is suitable for your specific uses. For instance, there are tests for resistance to wear, breaking strength, and resistance to stains and to chemical substances. In the United States, good sources of such tests include American Society for Testing and Materials (ASTM) Volume 15.02 (for ceramic tile) and 15.04 (for resilient floor coverings). ASTM is located in West Conshohocken, PA. The International Standards Organization (ISO) also has similar test methods, available from the American National Standards Institute in Philadelphia, PA (212-642-4900). You can obtain test data from the flooring manufacturer or by sending samples to commercial laboratories.

Slip Resistance in Adjacent Areas

If different work areas have different minimum slip resistance requirements, but workers frequently move between the two areas, use flooring of the higher slip resistance for both areas. In making transition to areas that have lower slip risk, change slip resistance by only one R value at a time, for example R11 to R10, then to R9.

Cleaning Slip-resistant Flooring

Most flooring manufacturers provide instructions for cleaning their products. It's prudent to have your plan for cleaning in mind before you buy and install the flooring. In areas that often get wet, provide floor drains (and appropriate grading of the floor) where practical.

Some flooring with higher slip resistance might require more intensive cleaning than slippery floors. In fact, even for slippery floors use of a soapy mop alone is not adequate to remove the grease or other lubricant that can make a smooth floor slippery. Mopping picks up some of the contaminant, but spreads the rest over a larger area than may have been contaminated in the first place. Proper washing of some floors is easier with a wet vacuum or a scrubbing machine.

Where appropriate, cleaning can be facilitated by using smoother flooring for the six inches closest to the walls. Visual signals (such as a different color and/or clearly different texture) should indicate that there's a difference in slip resistance. Rounded edges formed by cove skirting between walls and floor also make cleaning easier.

Hygiene doesn't have to be a problem with slip-resistant flooring. Local health inspectors shouldn't veto a flooring for a restaurant kitchen or a hospital on grounds of hygiene just because the flooring "doesn't look hygienic" to them. If there's doubt, you may need laboratory test data to assess whether the flooring can be properly disinfected for your application. Let the health inspector know that you need to consider both hygiene *and* safety. Testing has shown that slip-resistant floors can be hygienic. Don't accept a veto of safe flooring unless there's real evidence that it's not suitable for the application. If such a case occurs, look into requiring slip-resistant footwear in the area instead of more slip-resistant flooring.

Coefficient of Friction Testing

"Coefficient of friction" is the name given to the ratio between friction force and applied weight. There has been a lot of controversy regarding coefficient of friction testing, and over a hundred different methods have been used. However, one test is especially useful and inexpensive when combined with results of surface roughness testing. This particular coefficient of friction test method has a number of advantages:

- The American Society for Testing and Materials (ASTM) and the American National Standards Institute (ANSI) sanction the test

- It's the only slip-resistance test recognized by the ceramic tile industry of the United States

- It's the only field test recognized by the City of Los Angeles, which has been a leader in requiring good slip-resistance in areas accessible to disabled persons for many years. The City certifies qualified laboratories (regardless of location) to conduct this test, although this is not a requirement outside of Los Angeles

- It's the only ASTM floor-friction test that includes the use of a reference surface to check slider condition, and the test method, every time the test is conducted

- The equipment (see photograph on the next page) is simple and inexpensive

The test is ASTM 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." You can obtain a copy from ASTM in West Conshohocken, Pennsylvania. (610-832-9500; their Web address is www.astm.org.) Below is a summary of the procedure.

Procedure for the Static Coefficient of Friction Test

If you're not interested in how the test is conducted, you can skip this subsection and go on to "Application of Coefficient of Friction Test Results."

The ASTM's test C 1028-96 measures the frictional force between a flooring surface and a slider made of laboratory-grade Neolite, a synthetic rubber. The test result is a static coefficient of friction. The term "static" means that the two surfaces are at rest with respect to each other (rather than in motion) during the friction measurement. When the weighted slider is pulled, the coefficient of friction is equal to the friction force divided by the weight on the slider. The equipment is shown in Figure 5-5.

Figure 5-5.
Equipment for ASTM C 1028-96 static coefficient of friction is shown with one-foot ruler for scale. Clockwise from left: sanding block, slider mounted on wood, reference tile on slip-resistant pad, slider assembly with 50-pound weight, and dynamometer

The slider, three inches square, is mounted on an eight-inch-square piece of wood. Before a sample is tested, the slider is first calibrated using a standard reference tile. The slider is then placed on the sample flooring surface and a 50-pound weight is placed on on the slider. A dynamometer (force gauge), which measures force in pounds, is used to pull the weighted slider to initiate a small movement across the flooring. This pulling force is then divided by the weight on the slider, and the result — after correction using the slider calibration data for the reference tile — is equal to the static coefficient of friction.

As an example, if the friction force is 30 pounds and the total weight on the slider is 50 pounds, the static coefficient of friction is 30/50 = 0.60. If the friction force were 40 pounds, the static coefficient of friction would be 40/50 = 0.80. Since the friction force is higher (40 pounds) for the higher static coefficient of friction (0.80), the slip resistance to a stationary shoe is better when the static coefficient of friction is higher.

The flooring is tested both dry and wet with water. In each case, the coefficient of friction is measured 12 times and the results are averaged. The ASTM test method specifies that each flooring sample should consist of three pieces of the tile. (If fewer pieces are available for testing, the laboratory makes the same total number of measurements — 12. The test report should show that only one piece or two pieces were tested). For each of the three pieces, a pull is made in each of four directions, for instance north-east-south-west.

The test method also specifies that after this "as-received" testing, the flooring is cleaned with a specified powerful degreaser (Hillyard's Renovator) and tested again — both dry and wet. However, if contamination of the flooring sample was negligible, and the test temperature and humidity are unchanged, the results after degreasing are nearly the same as before. Now let's see how to use the results of this test.

Application of Coefficient of Friction Test Results

The coefficient of friction for wet flooring is often (though not always) lower than that for the same flooring dry, indicating less traction when it is wet. Applicable local safety regulations and legal requirements vary. If a floor remains dry in use, a high dry coefficient of friction may be adequate. An example of a "dry" floor might be one in an upstairs lobby that's under constant surveillance by a guard or receptionist who will act if there's any spillage. (If floor-care personnel walk the floor when it's wet and soapy, they should wear slip-resistant footwear.)

If parts of the floor might become wet in normal use — for instance, from dripping umbrellas or spilled beverage — it's important that the wet coefficient of friction also be high.

The Americans with Disabilities Act (ADA) requires that areas accessible to disabled persons be slip-resistant. The Department of Justice's Access Board, which administers parts of ADA, in its Bulletin #4 in the past recommended a minimum average static coefficient of friction of 0.60 for level floors and 0.80 for ramps. The Access Board eventually withdrew this recommendation in favor of making no specific recommendation at all.

The City of Los Angeles requires a minimum of 0.60 for level floors and 0.80 for ramps, with ASTM C 1028-96 being the only acceptable field test method. This requirement resulted from a lawsuit brought against the City by a group of organizations pressing the rights of disabled persons.

If the floor is used with a coating (sealer or wax) applied, it's essential that slip-resistance testing be conducted after the compound has been applied. Otherwise, the tests could be misleading if the compound changes slip resistance.

Quick, Which is Higher — 0.5 or 0.6? *[Is this a trick question?]*

There's been a lot of confusion over what the minimum static coefficient of friction should be for a level floor: 0.50, a limit used for the past 50 years by U.S. floor coating producers and quoted by OSHA; or 0.60, as discussed in the previous section.

High levels of the coefficient of friction help indicate good slip resistance. Is a 0.60 minimum too conservative and therefore possibly unfair to some types of flooring? The truth is paradoxical: the 0.60 value is *less* conservative than 0.50, and it's because of the way the static coefficient of friction is measured to see if it complies with one of these two minimum limits. It's like a comparison of apples and oranges.

The floor polish industry established the 0.50 minimum based on research in the mid-1940's, when Americans were jitterbugging to celebrate the end of World War II. Shoes with both heels and soles of leather were more common then, although rubber and synthetics such as light brown Neolite were widely used too. Because leather generally gives less traction, dry, than rubber and synthetics it was reasonable to test waxed floors using a leather slider to test for coefficient of friction.

The floor wax manufacturing industry used an apparatus called the James Machine for this measurement. The James Machine is strictly a laboratory device, since it requires a loose piece of flooring that's placed on the table of the machine. Research results (never published, and now long lost) showed that a static coefficient of friction of 0.50 or higher gave good traction (with a margin of safety) for pedestrians at walking speeds on level floors. This was adopted as part of an American Society for Testing and Materials (ASTM) standard (designated ASTM D-2047) and is still in use today. Since leather has variable and unpredictable properties when wet, the test is performed only on a dry surface. Wet tests with leather sliders wouldn't be trustworthy.

The ceramic tile industry has since established its own method for measuring coefficient of friction. It's also an ASTM standard — C 1028-96, discussed in the previous two sections — and uses the same general principle. The biggest difference is that in this method the slider is made of Neolite, a synthetic material. This makes it feasible to run tests both wet and dry.

When a floor is tested dry with both leather and Neolite sliders, the dry Neolite slider often gives a coefficient of friction that's higher by 0.2–0.5 than that measured using a leather slider. How much higher it is depends on the flooring and the test method or machine that's used. In some cases, a floor that has a coefficient of friction of 0.50 with dry leather will have a coefficient of about 0.65 to 0.75 with dry Neolite. Flooring assessed at 0.3 with leather might even be as high as 0.8 with Neolite, again both under dry conditions.

What does this mean to us as pedestrians? Well, we automatically and subconsciously *adjust our gait* depending on the traction we feel underfoot. In leather-soled dress shoes, we need to be, and are, a little more careful walking than we are when wearing rubber-soled shoes.

Is 0.60 "higher" than 0.50 when you're talking about coefficient of friction? It depends on how you define each one! As we've seen above, the 0.60 criterion, measured with Neolite, is often *less* conservative (or "lower") than the traditional 0.50 criterion as measured dry with leather. When applying static coefficient of friction measured using a Neolite slider, 0.60 is the proper minimum for a level floor.

Benefits and Disadvantages of ASTM C 1028-96 Static Coefficient of Friction Test

Benefits. The static test described by ASTM C 1028-96 is the only slip resistance test recognized by the ceramic tile industry in the United States. It's also the only field test method accepted by the trend-setting City of Los Angeles. While the test has weaknesses when used without a surface roughness measurement, the fact that it has had long use in commerce gives it a certain amount of credibility. Not that it's always favorable to ceramic tiles — many commercial floor tiles fail to achieve a coefficient of friction of 0.60 or higher in wet testing. Tiles that achieve 0.80 or higher (recommended for ramps) in wet testing are widely obtainable, but are a relatively small percentage of the floor tiles on the market.

Another attractive feature of the test is that it uses a standard reference tile to calibrate the test method every time tests are conducted. This may seem trivial. However, changes in results from periodic testing of the same surface over a period of time can reveal weaknesses or errors in testing that would not otherwise have been noticed. Other coefficient of friction test methods, because they don't have this calibration feature, may deceive the user by seeming to be more reproducible than they are in fact. Method C 1028-96, like any test method, may give *slightly* different answers each time it's used to test the same sample. However, use of a reference surface can indicate gross changes in the test that could otherwise lead to *large* errors.

If you want to conduct tests yourself, you can assemble the equipment for less than $400. The standard gives some examples of vendors for the components. The most expensive component is the dynamometer suggested *as an example* in the method. However, because it's a high-end digital model, this particular dynamometer is very costly. An analog dynamometer will give the same results. Range at full scale should be about 60 pounds. Davis Instruments (800-368-2516) has a dynamometer for under $180 that will do the job.

The test requires repetitive handling of a 50-pound weight, which must be lifted two or three inches each time. When conducting the test yourself, this is an advantage if you need a workout. However, if you don't have the strength needed, the weight is a big disadvantage! Sometimes this test is conducted by a two-person team.

Disadvantages. There are some minor weaknesses of this static method. First, the ASTM's written procedure leaves too much to the discretion of the test person, and this could result in deceptively high results if good technical judgment isn't used. In the next subsection, we'll tell how to avoid this problem while still adhering strictly to the written method.

Second, the method occasionally gives deceptively high results in the case of some porous natural stones (for example, granite or marble) that can form a suction between the Neolite slider and the floor when testing wet. Since these stones are normally very smooth, the problem can be circumvented by supplementing the static coefficient of friction with a surface roughness measurement as described farther on in this chapter. Generally, surfaces with a peak-to-valley total mean roughness of less than 10 microns are slippery when wet.

Finally, the static friction test results aren't sufficient to divide flooring into the five categories R9–R13 specified in Tables 1 and 2. However, you can use the static coefficient of friction *when combined with surface roughness data* to estimate the slip resistance R rating or the barefoot ratings A, B and C.

The conclusion from all this is that the static coefficient of friction determined using ASTM C 1028-96 can be very useful when it is combined with a surface micro-roughness measurement as described later in this chapter. All flooring that's used when wet by pedestrians should, when tested with this method, have a static coefficient of friction, wet, of 0.60 or higher. Test results of typical tiles, wet, are in the range 0.40–0.90.

If You're Conducting the Coefficient of Friction Test Yourself

If you want to conduct the coefficient of friction test yourself, proceed as specified in the ASTM Standard. Unfortunately, the standard leaves a number of things unsaid, so that different people could follow slightly different procedures and still be in conformance with the Standard. Here are some recommendations for you to use to fill the gaps in the Standard and still be in complete conformance with it. These recommendations are good scientific practice and will make your data more credible in a lawsuit as well as useful for accident prevention.

Have the dynamometer calibrated at least once a year. Calibration should be by a certified calibration laboratory, and include at least four points across the range of the instrument. Have it calibrated when it's brand new, too. The actual procedure takes a few minutes and cost is usually less than $50. If you're not close to a calibration lab, you can mail the dynamometer to them for a few dollars. During the year, if you have any reason to doubt the condition of the dynamometer, you can at least calibrate it at one point near the high end. Use your 50-pound weight (required for the coefficient of friction test) suspended from the dynamometer by a few links of chain. You can use a postal scale to weigh the chain, remembering that there are 16 ounces in a pound. (The chain's weight will probably be negligible compared to the 50 pounds.)

Reference tile. After receiving the test method's reference tile (see the ASTM Standard for suppliers), clean it with Hillyard's Renovator as specified in the Standard. Rinse thoroughly with tap water, then once with distilled water. After that, allow nothing to touch its top face except a clean plastic storage bag, clean sliders and distilled water. No fingerprints! Handle the reference tile by its edges. If the top face becomes contaminated, clean it again with Hillyard's Renovator. Store the tile in a non-biodegradable plastic bag.

Sliders. Compounds such as Neolite and rubber deteriorate over time. Store the Neolite slider assemblies in the dark below 75 degrees Fahrenheit and away from circulating air. If they're stored in plastic bags, don't use biodegradable bags or any other plastic that decomposes by outgassing — this could contaminate your sliders with a layer of plastic. Don't use the sliders for longer than one year after shipment to you by the manufacturer.

Preparing the slider. After sanding the slider as directed by the ASTM Standard, remove any dust using a clean paintbrush or a terry cloth towel that's been washed and double-rinsed. If you prefer, use plain white paper towels. Don't use facial tissues or paper napkins — they might contain a lubricant to make them kinder to the skin.

Applying the weight to the slider. Think of the slider as a potential suction cup. Conduct the test in such a way as to avoid inducing suction between the slider and the flooring. If you wanted a suction cup to form a suction bond onto a horizontal surface, you'd slam the cup onto the surface, or else let a weight stand on it for a time. This is what's to be avoided in floor friction testing, since it induces a suction bond that's unlike the bond that the heel of your shoe forms with the floor in walking.

Here's how to avoid inducing suction. First, lower the 50-pound weight onto the slider assembly. Then tilt the assembly back a few degrees so that the slider rests on its rear edge. Gently lower the slider onto the floor and make the pull within one or at most two seconds. Make sure the pull is straight. If the slider assembly should twist when you pull, tilt it back on its rear edge as before and start again.

If you're testing pieces of flooring on a table or workbench, you'll need a lip on the bench, or else a slip-resistant rubber pad (perhaps aided by your thumb on the edge of the tile), to prevent tiles from moving. When testing in-situ on the floor, be sure to wear kneepads to avoid excessive stress to your knees. For transporting the equipment from one location to another, you can use a strong box (an eight-gallon plastic Igloo brand box is satisfactory, for instance) mounted on a dolly or folding luggage cart.

For dry tests, results may show some effect of relative humidity. The reference tile-Neolite combination is somewhat "stickier" when the relative humidity is over 55 percent. If the tile you're testing doesn't show this same effect (compared to the reference tile), the measured coefficient of friction of the test tile may be slightly lower when humidity is high. This usually isn't critical, because the dry test results are over 0.60 for almost any clean flooring. For wet tests, both the reference tile and the test tile are saturated with water and the relative humidity has no effect.

Surface Roughness

It's not surprising that surface micro-roughness has proven to be helpful in evaluating floor slip resistance under wet or otherwise lubricated conditions. If there's anything that the average person is sure about regarding slip resistance, it is that most very smooth floors can be slippery, particularly when wet. (They may also be slippery to some soling materials when dry.)

Of all the portable instruments for testing floors, the Taylor-Hobson Surtronic 10 has shown the best correlation of test results with human traction as measured by the variable-angle ramp test. Specifically, the Surtronic 10 measures peak-to-valley surface micro-roughness over an 0.8-millimeter path length, using a stylus of about 5 microns radius. For brevity, we'll call this measurement "surface roughness." (A new model, the Surtronic Duo, might soon replace the Surtronic 10).

Separate research programs in the United States, Australia, and Great Britain have shown that Surtronic 10 readings can correlate, to some extent, with human traction measurements made using the variable-angle ramp. In fact, the Surtronic 10 is the only portable instrument to show reasonable correlation with slip resistance as measured by the variable-angle ramp. The Surtronic 10 must always be used together with a direct measurement of friction, like the one discussed previously, though. The Surtronic 10 measures the difference in height between microscopic peaks and valleys. It doesn't tell whether the peaks are bumps or "teeth". Rounded peaks or bumps on flooring can be slippery, something like ice-capped peaks on a mountain range.

The Surtronic 10, shown on the next page, costs about $1200 and is very easy to use. Thus if you want to conduct tests yourself, for a total of less than $1600 you can get equipment for static coefficient of friction by ASTM C 1028-96 and for surface roughness. Both tests combined, including data reduction, take a total of roughly 40 minutes per sample "as found" (that is, without removal of any lubricants that might be present on the sample). Though the test is run on a dry sample, the results of the surface roughness test apply only to slip resistance of wet or otherwise lubricated flooring. They don't apply to dry slip resistance as measured using synthetic rubbers such as Neolite or Four-S rubber.

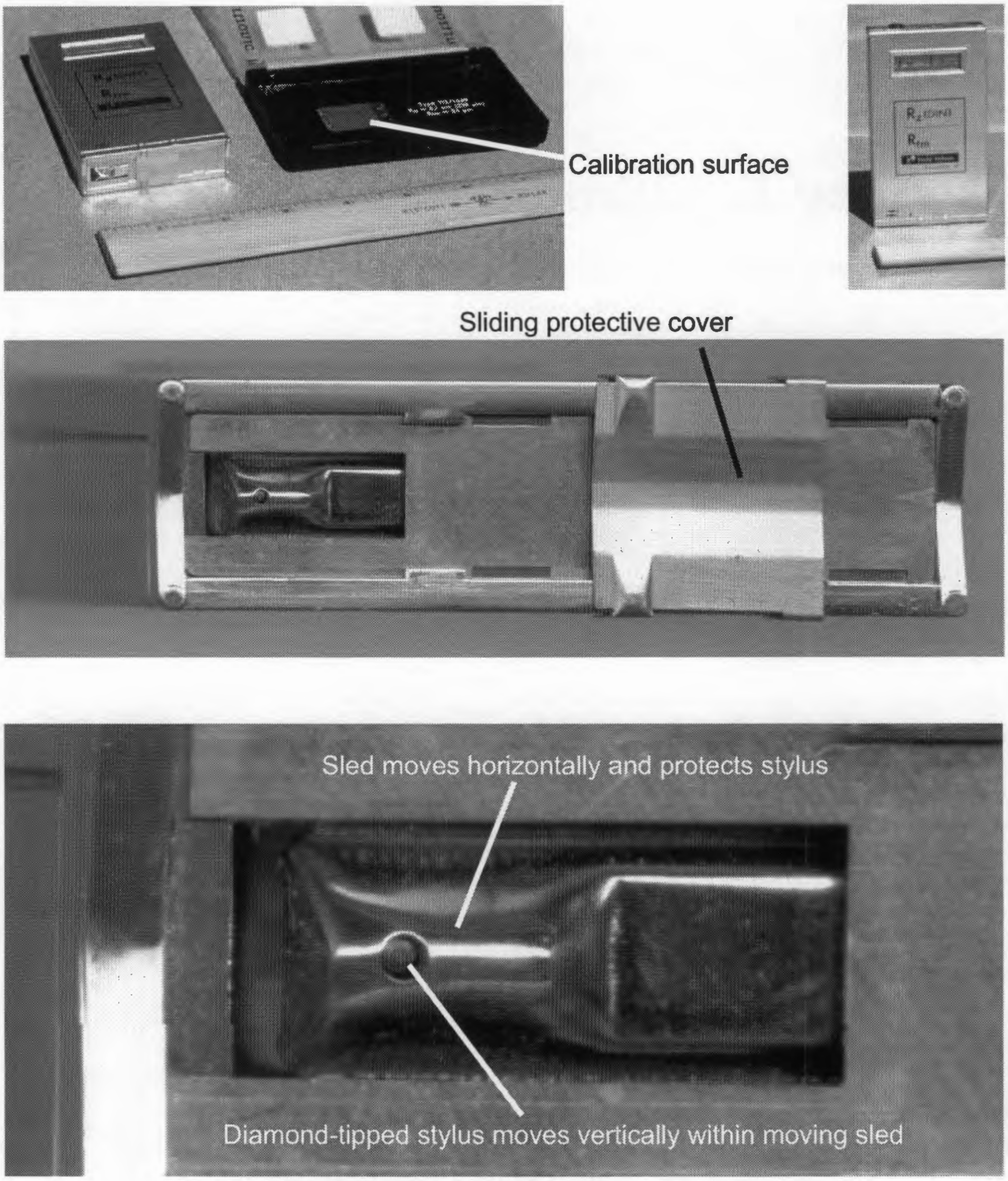


Figure 5-6.
Surtronic 10 surface roughness instrument. Case (see top left photo) includes calibration surface. Top right shows operating position. Center and bottom photographs show worm's eye view detail of base through clear glass surface that's being tested

The Surtronic 10 is an indirect measurement — it measures only surface roughness, not slip resistance itself. Use the Surtronic 10 only in combination with another test — static coefficient of friction by ASTM C 1028-96, discussed earlier in this Chapter.

Unless you're responsible for safety of a large amount of property, you'll find it more economic to obtain test data in other ways rather than testing yourself. The easiest way may be to get the data from the flooring manufacturer. If you need to send a sample to a test laboratory yourself, you can probably get static coefficient of friction and surface roughness data on one sample for a total charge well under $200. You might be able to negotiate an even lower price if you're willing to supply the tile or stone sample in a degreased condition — that is, removing any contaminants by washing with Hillyard's Renovator as specified in the Standard. That procedure takes ten minutes and a few cents' worth of Hillyard's Renovator.

Procedure for the Surface Roughness Test

Research in Britain, Australia and the United States shows that the surface total mean peak-to-valley roughness (Rtm) can be a helpful indicator of traction of ceramic tile flooring surfaces when those surfaces are wet or otherwise lubricated. The portable instrument used in this research is the Taylor Hobson Surtronic 10, which is also used in machine shops worldwide (Web site: www.taylor-hobson.com). Roughness is expressed as the maximum peak-to-valley height difference, in micro-meters (25.4 micro-meters equals one-thousandth of an inch). Roughness is measured on dry samples, but the test results apply to wet slip resistance.

The Surtronic 10 has a rounded diamond stylus of radius approximately five micro-meters. (It's similar to a phonograph needle, if you're old enough to remember what they were.) The stylus traverses a path of 0.8 millimeters and measures the height difference between the lowest valley and the highest peak. The instrument makes five such evaluations and averages the results to yield a single reading on its digital display. It's calibrated on-site in a few seconds for each use.

Make a minimum of 10 such readings, dry, to evaluate Rtm for a flooring material. (Since each reading represents five paths averaged, the 10 readings actually represent 50 determinations of local micro-roughness.) In cases where increased accuracy of the average roughness for a sample is desirable, make and average 30 readings. Making and averaging 30 readings requires less than ten minutes.

For reference only: approximate Rtm surface roughnesses of some materials commonly available at low cost in hardware stores —

Material		Roughness, microns
Clear window glass		0.1
Picture-frame non-glare (lightly frosted) glass		3
Silicon carbide abrasive paper,	1500 grit (extremely fine)	13
	400 grit (super fine)	30
	320 grit (extra fine)	46
Emery cloth, industrial grade, 150 grit (fine)		85

Checking the feel of these materials next time you're in the hardware store will give you an idea of the range of surface roughness of interest. The materials listed cover the range of roughness commonly found in flooring. The first two (both glass) are in the roughness range of slippery flooring, while the remainder are slip-resistant when wet with water. The paper that this text is printed on has a surface roughness of about 17 microns, but the outside cover has a roughness of about three microns. Please wet your finger tip and see if the cover is slippery to your moving finger.

Like other precision instruments, the Surtronic 10 should be checked periodically by the manufacturer or an independent calibration laboratory. Check the performance of the instrument yourself periodically by using three reference surfaces: window glass for a near-zero reading; and two rough ceramic tiles that you've checked (by averaging at least 10 readings) when you knew the instrument was in good calibration.

Every time you use the instrument, check the instrument's reading for the calibration patch that's supplied with the instrument. However, the instrument's traverse time can be out of adjustment without affecting the reading for the calibration patch. That's why it's important to also check the instrument periodically on ceramic tiles of known roughness that you keep on hand for that purpose.

Examples of Surface Roughness Test Data

Flooring that's rated above seven degrees on the variable-angle ramp test also has a wet static coefficient of friction, SCOFw from ASTM C 1028-96, that's above 0.60. Let's look at some typical values of total mean surface roughness, Rtm, for the various ramp categories. For areas where footwear is used, here are some approximate sample roughness and minimum wet static coefficient of friction (SCOFw) data.

For areas where footwear is used

R category	Typical Rtm, microns	Minimum SCOFw
9	12	0.60
10	20	0.60
11	30	0.60
12	45	0.60
13	90	0.60

Some R9 surfaces have an Rtm of less than 10 microns. However, as we've already said, some researchers believe the lower range of R9 (below seven degrees ramp test angle) is not slip-resistant enough. Ten microns seems to be a good minimum for slip-resistant ceramic tiles under wet or otherwise lubricated conditions.

The typical values above are for conventional ceramic tile, not for either chemically-etched, laser-etched, or raised-relief tiles.

For ceramic tile in barefoot areas, some sample roughnesses and minimum static coefficients of friction for ceramic tiles in the three barefoot categories are:

For barefoot areas

Barefoot category	Typical Rtm, microns	Minimum SCOFw
A	20	0.60
B	30	0.60
C	50	0.60

The roughness of the paper this book is printed on is approximately 17 microns. Wet your finger tip and check whether this paper is slippery wet. Although it's paper and not ceramic tile, it has roughness typical of some ceramic tiles that are slip-resistant wet.

Roughness data can be helpful for estimation, but are not infallible. Roughness data are useful mainly for assessing existing ceramic tile installations, where a ramp test isn't feasible. (More about assessing existing floors in Chapter 11.) For new flooring, it's best to obtain the R category or ramp angle from the manufacturer or from a laboratory ramp test. If it's not feasible to get either one, at least get the static coefficient of friction and Surtronic 10 surface roughness. Every United States flooring supplier (whether domestic or imported flooring) can and should supply the static coefficient of friction data, and you can obtain a laboratory test of surface roughness from a commercial laboratory for $50 or less. If combined with a static coefficient of friction test, the surface roughness test might cost as little as an additional $30.

The wet static coefficient of friction and surface roughness data don't definitively place ceramic tiles in a given ramp-test category. However, if static coefficient of friction is below 0.60, it's unlikely that the tile would reach even the lowest variable-angle ramp-test categories R9 or A. If a tile has a surface roughness of only 10 microns, it's clearly not suitable for a situation in which R12 or R13 is appropriate. Roughness data can also be helpful for quality checks of flooring that's slip-resistant wet.

Quality Control of the Flooring You Buy

When you buy flooring, make sure that the supplier will guarantee the slip resistance level. That means his manufacturing quality control is adequate to make sure the product you actually receive reaches the promised specification.

The raw materials the manufacturer uses, and the manufacturing processes, can vary from day to day and even from morning to afternoon. For instance, ceramic tile is said to be made from "dirt and fire." The manufacturer mixes clay and other natural materials, forms them, and bakes them in a furnace. The particle size and composition of natural materials can vary from one part of the quarry to another. The temperature in the furnace may change, too, for instance from startup on Monday to shutdown on Friday. However, these variations should be the manufacturer's problem, not yours. His job is to control quality so that you get the product you need.

A manufacturer may have sent a sample of a certain tile to a laboratory three years ago and determined the slip resistance of that sample. The tile shipment you receive, though it looks the same, could have different slip resistance because of the factors mentioned above. Your supplier needs to do better than that.

Ceramic tile isn't the only product that can vary. Many types of flooring — natural stone, wood, etc. — can vary in surface characteristics enough to change their slip resistance as supplied. This need not concern you, though, if the manufacturer's quality control is good enough so that the manufacturer or the supplier will guarantee that your purchase will meet your specification.

You should always keep some "attic samples" (so-called because they can be stored in the attic) in case there's breakage or other damage to small areas of flooring. If, within months after starting to use the floor, you suspect it isn't up to the slip resistance specification, you can send a sample to an independent laboratory for a check. Laboratory tests of coefficient of friction and surface roughness are much cheaper than field tests. (The *ramp* test is only conducted in a laboratory, not on site, and requires a nine-square-foot sample.) If you supply the sample degreased (cleaned with Hillyard's Renovator as mentioned in the test description earlier in this chapter) you may be able to get a static coefficient of friction test (without degreasing by the laboratory) for about $100 plus postage to send the sample to the lab. (Be sure to tell the lab if you want the sample back; most are discarded after testing.)

If you don't have attic samples, get a coefficient of friction and surface-roughness field-test on a part of the flooring that gets little or no traffic. This might be immediately adjacent to the wall, in a corner, under a bench or table, etc. Since it's had no wear, after cleaning with Hillyard's Renovator (as specified in the ASTM standard) it should be in mint condition and suitable for comparison with the manufacturer's specification.

Maintain Slip Resistance of Flooring Over Time

We'll talk about floor care in a later chapter. For now, let's just note that having slip-resistant flooring at one point in time is necessary, but not sufficient, to maintain safe conditions long-term. What can happen?

- New floor-care contractors may use different chemicals and machines for cleaning and finishing floors
- Even if the contracting company remains the same, personnel turnover, plus inadequate training and supervision, may result in changes in floor maintenance

- Floor-care personnel, in a well-intended effort to make the floor look more glossy, might apply a compound that destroys the floor's slip resistance.

- Wear in high-traffic areas can decrease slip resistance by breakdown of abrasive particles, or can increase it by scratching smooth surfaces

- Lubrication can change due to contamination by mud, dust, or (around cooking) long-term buildup of oxidized fats, or change of the commercial or industrial materials being used (and spilled) in the work area. Some detergents can leave a slippery residue if not rinsed

The effects of these changes will become noticeable more quickly when the flooring didn't have good slip resistance in the first place.

In a restaurant that does grilling or deep-frying, airborne grease may constantly be deposited throughout the kitchen and dining room. Make sure the ventilation system is designed and maintained so as to minimize intrusion of kitchen air into the dining room. If you can't avoid deposition of airborne grease, consider specifying a static coefficient of friction of 0.80 or greater for the area as well as adequate surface roughness.

CHAPTER 6

The Other Partner: Footwear

Just as you can't have a wedding without two people to form the marriage, you can't have pedestrian traction without a walking surface and a shoe (or boot or other footwear) or a bare foot. For maximum safety in our personal activities and work, we need to have appropriate traction from our footwear — not just in the shoe store, but in the conditions of everyday use.

Use Solings Appropriate to the Situation

Philip Morris Inc.

We already know that sports footwear manufacturers produce different models for different sports: basketball, baseball, tennis, etc. Non-sports activities have different requirements too. Ballroom dancing requires rather low traction so the feet can glide over the floor. Construction work calls for high traction, and treads that can easily freed from the mud and pebbles that may get caught in them. People in a work environment that includes petroleum products need oil-resistant soling. Note that "oil-resistant" doesn't mean "slip-resistant" — it only indicates that the shoe material will not undergo chemical attack by oil, causing it to dissolve or otherwise deteriorate.

Our feet give feedback to our brains when we walk, indicating to us when small slips are occurring — meaning we're not getting good traction. If we pick up these signals

"Yo Adrienne —"

In the original *"Rocky"* motion picture, Sylvester Stallone's character jogged beside his new girlfriend Adrienne on an ice rink while she tried ice skating for the first time. We can walk or jog on ice and other slippery surfaces if we take small steps. Shoes with good treads help on ice too.

fast enough and quickly adjust our gait, we can usually avoid falling. However, good slip resistance enables us to move and work with greater speed and confidence. As we age, our reflexes slow and our bones may grow brittle, and slip resistance becomes even more important.

Your Personal Footwear — Get a Grip!

Many manufacturers of everyday shoes are just beginning to wake up to the fact that the slip resistance of their product often leaves a lot to be desired. Some manufacturers of work shoes have been offering slip-resistant solings for many years. Designers of high-quality athletic shoes must assure appropriate slip resistance if their product is to be competitive. For general pedestrian use, though, it's up to the consumer to be the expert. The street shoe styles you see in the store have probably not been checked for slip resistance, and may in fact be hazardous even if very expensive. What can you do about this?

In Chapter 3, we talked briefly about good soling design. Softer materials can provide better traction, wet or lubricated, than hard ones, but soft solings should have micro-roughness built into them (like polycellular urethane does, for instance). Also, they must have adequate *tread,* or they can be *treacherous* on a wet floor. Farther on in this Chapter, we'll talk about the features of good tread designs.

Stiletto heels tend to have very hard material in contact with the floor, in order to avoid rapid wear from the tremendous stress caused by the wearer's weight being concentrated in a very small contact area. Use extra care if you wear them.

It's difficult to judge slip resistance when trying on shoes in the store. If the store owner is thinking, the area for customers trying out shoes has a slip-resistant carpet or other flooring suitable to the task. This is essential because some solings can be especially slippery when they first come out of the box. They may have a very smooth thin outer skin, plus a lubricant that the manufacturer applied to the mold when the soling was made, so that the soling wouldn't stick to the mold. Both the outer skin and the lubricant might wear off after a few minutes' walking on a rough, dry floor or sidewalk, but that doesn't help you in the shoe store.

When you're testing solings for slip resistance, you must test them under wet conditions. *Dry slip resistance tells us nothing about wet slip resistance!* Some solings give excellent traction dry, and yet are treacherous when wet.

For a meaningful test of your new shoes, you need to scuff one shoe on a wet, smooth floor while holding on to something to keep you from falling. You could try this more conveniently at home if you can return the shoes when you find them unsatisfactory. It's unfortunate that you have to do what should be the shoe manufacturer's job. Things will be different after the revolution!

Employee Footwear

In a work situation where good traction is needed, appropriate solings can be a great asset. Not only are accidents avoided, but workers can move with greater efficiency and confidence.

Professional basketball players in the NBA wouldn't dream of playing a game in shoes with worn-out or dirty solings. Their footwear receives a great deal of attention from players, from footwear manufacturers, and from consumers. But basketball's just a game — the footwear of workers in other businesses can be far more important. Working around deep fryers or other hot equipment, working at height, or having bones that are weak from osteoporosis, can make the consequences of a fall more disastrous for ordinary folks than for a young professional athlete.

Professional basketball players normally wear their playing shoes only on court, and they clean their solings carefully (by stepping on sheets of sticky film) immediately before every game. The floors are smooth, and when wet with perspiration from dripping or falling sweaty players, can be very slippery. Good tread design and good care of solings help minimize risk of slipping under these circumstances.

Employers in some situations can exert either influence or control over footwear. Varying stages of this are, for instance:

- Supplying employees with information to help them choose safe footwear
- Inviting vendors of slip-resistant shoes to visit the work site in a shoemobile to sell to employees
- Buying a new employee's first pair of slip-resistant work footwear
- Having a shoe repairer make pickups and deliveries at the work place so that worn-out solings will be replaced in time to prevent accidents
- Helping employees make timely shoe purchases by offering a payroll deduction plan to spread out the cost of shoe purchases
- Contributing toward the cost of replacement footwear

DANGER - Safety Shoes

"Safety shoes" are not necessarily slip-resistant shoes. The term "safety shoes" usually means that a steel cap is included in the toe to prevent crushing of the toes by falling objects. Other features might include solings that are puncture-resistant or electrically insulating. Knowing that the shoes are "safety shoes" tells us nothing about slip resistance.

Where very heavy objects might fall on the foot — for instance, a 500-pound beam — having a steel toe cap may be a disadvantage. When the toe cap collapses it can trap the toes inside, and sometimes this cuts off the toes like a guillotine or leads to the emergency medical procedure of amputating the toes in order to remove the shoe.

In some work situations, use of dedicated footwear — worn at work only — makes sense. For instance, in manufacture of pharmaceuticals workers in some areas must wear paper overshoes for hygienic reasons. Use of dedicated footwear that is confined to that work area can in some circumstances eliminate the need for the overshoes. Workers simply leave their clean work shoes in a locker and change to street shoes when they leave the restricted work area. This also helps extend the lifetime of the work shoes' solings.

Slip-resistance Testing of Footwear

There are two ways of scientifically testing footwear for traction. One way is using the variable-angle ramp test described in a previous chapter. The other way is by using mechanical shoe-test devices.

Shoe manufacturers who don't have their own traction test equipment have access to shoe traction test laboratories. One such laboratory is that of SATRA (formerly Shoe and Allied Trades Research Association), available to United States manufacturers through the Footwear Industries of America. If your company has influence over the purchase of a large number of work shoes, your suppliers should be willing to provide you with slip-resistance test data. If you make a decision to buy based on that data, make sure that the manufacturer will guarantee to maintain the slip resistance throughout the time span when you're buying the shoes.

For your personal footwear, you'll probably have to do some testing yourself, since traction ratings unfortunately aren't available to U.S. consumers. If you do such a test, use great caution. For wet traction testing use a smooth floor, perhaps a glossy ceramic tile or vinyl surface. Wet the floor and the soling with water, making sure no one else steps on the wet area of the floor. Hold on to something stable so you can't fall, and scuff the shoe on the wet part of the floor. Scuff the trailing edge of the heel first, since that's the most critical part. Keep the heel at a small angle to the floor, as if you were leaving room for an imaginary pencil underneath the sole.

Next, try the sole for wet traction. Then try the whole shoe-bottom. Always hold on to something stable so you can't fall. When you've decided whether the shoes have good enough traction for your purpose, take off (or dry off) the wet shoe and make sure you remove all traces of water from the slippery floor surface.

The next two sections of this chapter tell you what the general characteristics of slip-resistant solings are, and this will help you to select safe footwear. The principles come from scientific testing of solings.

Surface Roughness of Solings

When we say "solings" in this book, the term includes both heels and soles. Some solings that are slip-resistant under wet or otherwise lubricated conditions have surfaces that are rough on a nearly microscopic scale. Because of their structure, which may be polycellular or foamlike, they stay rough even if worn on smooth floors.

In the previous chapter, we talked about use of the Surtronic 10 instrument to measure peak-to-valley total mean surface micro-roughness of flooring. This instrument can also be used on solings as long as there's sufficient flat surface on the cleats or lugs for the instrument's short traverse.

Surface roughness of typical solings in use generally ranges from 10–70 microns (less than three thousandths of an inch) peak to valley. This is similar to the range of roughnesses for slip-resistant flooring. As with flooring, the higher values of surface roughness are associated with improved slip resistance under wet or otherwise lubricated conditions. Increased roughness doesn't eliminate the need for tread, though.

"Fine texture" on a shoe soling is of a scale in between that of micro-roughness and tread. It might be in the form of a fabric-weave pattern, lettering, or small bumps on the soling, for instance. You should avoid solings with fine texture such as this because it's counterproductive. It reduces the amount of surface in contact with the floor without having the wet-traction advantages of micro-roughness and tread.

How to Look for a Good Tread Pattern

Tread on shoe solings is just as important to pedestrian safety as tire treads are to road safety. In both cases, tread is of little or no value under dry conditions, but is *vital under wet conditions.* Some racing tires have no tread because they're only used on dry race courses.

Figure 6-1 (next page) shows the types of features that most good shoe treads have. The figure shows the general rules for good tread — your solings don't need to look exactly like the one shown at the top. The main idea is to have lots of squared-off leading edges in all directions to cut through lubricants. An infinite number of tread patterns are possible while following the general rules shown in Figure 6-1.

The channels in between cleats should be at least three millimeters wide — that's a little more than 1/16 inch, or the thickness of a United States penny. For situations where you're likely to get mud or other materials caught in the treads, up to 20 millimeters (about 3/16 of an inch, three pennies' thickness) might be easier to clean.

It's especially important to have good tread at the trailing edge of the heel, because that's the most common source of pedestrian slips. When you look at shoes, you'll find that many models have tread everywhere except there — the place where you need it most (see Figure 6-2, at right).

Figure 6-2.
These comfortable $180 boots have tread everywhere except where it's most needed — the trailing edge of the heel.

A soling that follows most of the SATRA principles of Figure 6-1 is shown in Figure 6-3. (The tread doesn't wrap around the trailing edge of the heel, though.) It was designed for work shoes marketed under the name, "Shoes for Crews," (telephone: 1-800-218-4770, ext. 301; www.shoesforcrews.com) originally for workers in fast-food restaurants. The soling is soft and has cleats roughly 1/4-inch square, separated by channels 1/16-inch wide and 1/8-inch deep. Slip-resistant solings are also offered by other manufacturers, such as Iron Age (telephone 1-800-223-8912; www.ironageshoes.com); North Safety Products (1-800-777-9021); and Grainger Industrial Supply (outlets nationwide in the United States and in several other countries: www.grainger.com).

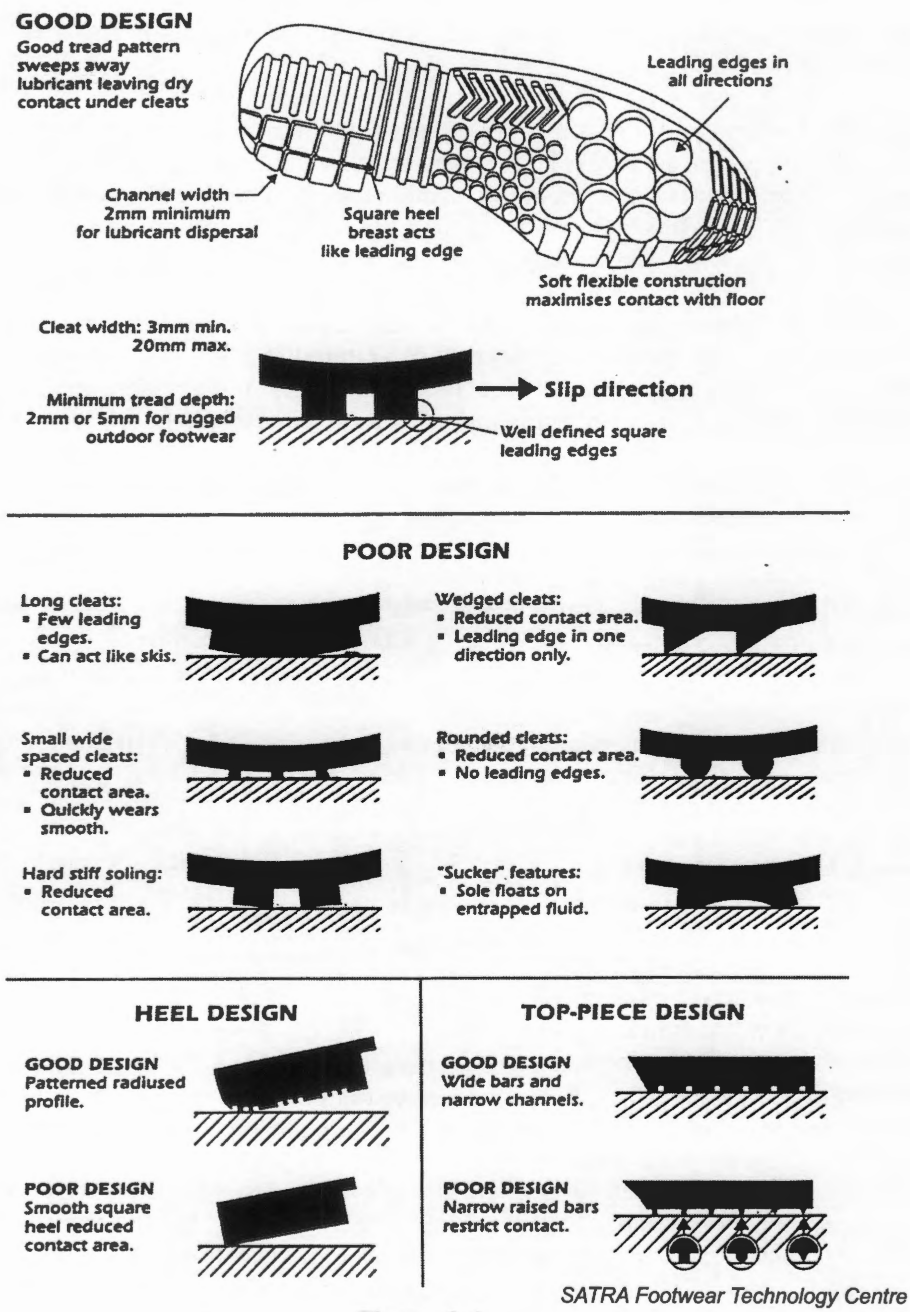


Figure 6-1.
Features of tread design for good wet traction

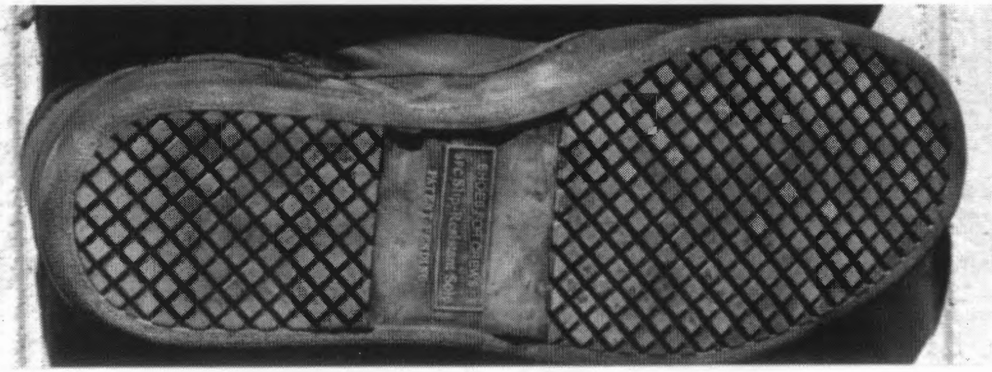


Figure 6-3.
Shoes for Crews tread

Slip-resistant solings are generally fairly soft. This helps with wet and dry slip resistance, *as long as there's adequate tread.* If tread is absent, soft solings can be treacherous on a surface that's wet or otherwise lubricated.

Lack of Toe Spring Can Trip You Up

Footwear should have built-in clearance between the toe of the soling and the floor. Known as "toe spring," this clearance helps avoid trips. Figure 6-4 shows that even very simple, low-cost sandals with recycled tire-tread solings can have toe spring. Figure 6-5 (next page) indicates what can happen when footwear without toe spring encounters a tripping hazard.

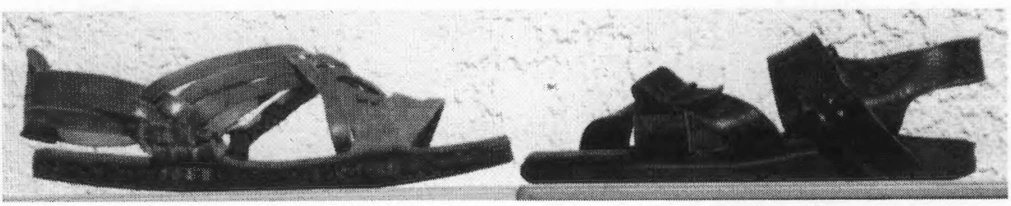


Figure 6-4.
"Toe spring" (left) gives clearance between toe and floor and can help prevent tripping, which is much more likely without toe spring (right)

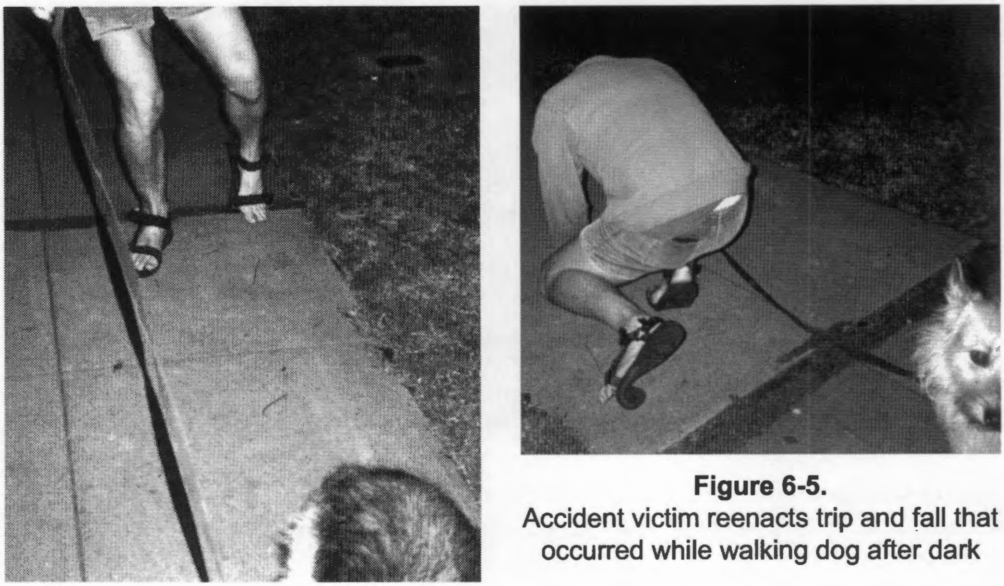


Figure 6-5.
Accident victim reenacts trip and fall that occurred while walking dog after dark

Keeping Solings Clean

In some situations the lubricants that sometimes are on the working surface can stick to the solings and overwhelm slip-resistant features of solings and floor. This is one reason for having doormats at homes. Brush-type cleaners are also effective at removing mud and other sticky substances from solings. Slip-resistant overshoes can also be helpful in protecting solings. For instance, steel erection workers must often slog through mud at construction sites to get to their work area, where there may be no mud on the steel components on which they'll be walking. Protection of their solings with galoshes or rubber overshoes until they get to their work area can help.

Slip Resistance of Solings Can Change Over Time

Once you've selected slip-resistant footwear, it's important to remember that the condition of the solings is important. When the tread is lost from slip-resistant solings they can become treacherous in a lubricated situation. The tread at the trailing edge of the heel is often the first to go, and is the most crucial because that's where slips most often begin. Check your solings periodically to make sure tread remains in the contact areas. If not, have the heels and/or soles replaced or replace the shoes.

Don't expect warnings in the form of little slips as your solings lose their tread in the critical areas. You might still have excellent traction *under dry conditions* even when the tread is completely gone. It's when you walk on a wet or otherwise lubricated smooth floor that you can suddenly discover that your shoes' slip resistance is gone.

Figure 6-6 shows a shoe from which the tread is gone in the contact areas. An elderly man was injured and narrowly avoided being run over by an automobile when this shoe's traction failed on a concrete parking lot in a light rain. The slip resistance of the roughened (broom-finished) concrete was not at fault.

Figure 6-6.
This soling, bald in the contact areas, caused an accident on a wet parking lot

Stairs, Ramps and Other Elevation Changes

CHAPTER

7

Stairs have been useful for thousands of years, and for able-bodied pedestrians are still the quickest, shortest and most comfortable and cost-effective routes between elevations. Ramps take more space for a given change in elevation, but are more convenient for many disabled persons and for wheeling heavy loads.

Both stairs and ramps have their hazards. We can alleviate these hazards to some extent by using properly constructed handrails and other precautions.

Other elevation changes can present tripping hazards. This chapter also shows you how to detect such hazards so you can remedy them.

Stairs

Because stairs accidents can cause especially severe injuries, building codes for stairs are very stringent. Even for properly constructed stairs, it's also essential that the nosing of each step be clearly visible, so that people don't become confused when they're looking for the next step. Confusing carpet patterns, for example, can make nosings harder to locate. On wet outside steps, visibility is even more critical.

In addition to safety, efficiency of stairs use is also improved by keeping to the high standards. When we use stairs that are properly constructed, we can walk with ease and converse at the same time, nearly unaware that our feet are performing a rather complex operation.

Nosings on stairs are sometimes rounded (see Figure 7-1), and the radius of the rounding is not mentioned in most building codes. If this radius is too large, people may step far out on the nosing where the slope is steep, and slip although the stairs are dry. The Americans with Disabilities Act states that the radius of curvature at the leading edge of the tread shall be no greater than one-half inch. Risers must be sloped

Figure 7-1.
These entry stairs, accessible from outdoors, have a nose radius of 7/8 inch — greater than the 1/2 inch ADA maximum. In addition, the surface is smooth and is slippery when wet, which caused a woman to fall while descending on a rainy day.

or the underside of the nosing must have an angle not less than 60 degrees from the horizontal. Nosings must project no more than 1-1/2 inch.

Under the Americans with Disabilities Act (ADA), stair treads in areas accessible to the disabled must be no less than 11 inches wide, measured from riser to riser. The Act doesn't permit open risers.

Ease and safety of stairs depend on each step in the stairs being the same in height (rise) and length (run). Building codes can vary between jurisdictions, but in many areas of the United States the variation between the rises must not exceed 3/8 inch *between any two steps in a flight.* The two steps *don't* have to be adjacent to one another. The same tolerance applies to the runs: no more than 3/8-inch variation between any two steps. Some codes are even more stringent, requiring no more than 3/16-inch variation between rises or runs of any two steps. (You can find out what building code applies in your area by contacting the municipal or county building department.) If we were to start with some lumber and a hammer and saw, most of us would find it extremely tedious to make even a simple 14-step stairs that conformed to these standards. Relaxing the tolerance can make building a stairs less expensive, but at a cost in safety that might be unacceptable. Figure 7-2, which covers pages 90–91, illustrates how bad stairs can be in an extreme case.

When we use stairs, in the first few steps we mentally store information on the rise and run, and subconsciously use that information as we walk the rest of the stairs. Because we are accustomed to a high standard in stairs, a change in dimension of one rise or run can upset the walking process and cause a misstep, leading to serious injuries or death.

If an accident occurs at or near a stair-step that is out of building code specification, the law might attribute the cause to *negligence per se*. In this way, the person or company in charge of the property may become liable for a fault they never realized was there.

Rises of stairs can be checked using a compound square, as shown in the photographs in Figure 7-3 below. The instrument can be assembled for about $15 from two adjustable squares from the hardware store.

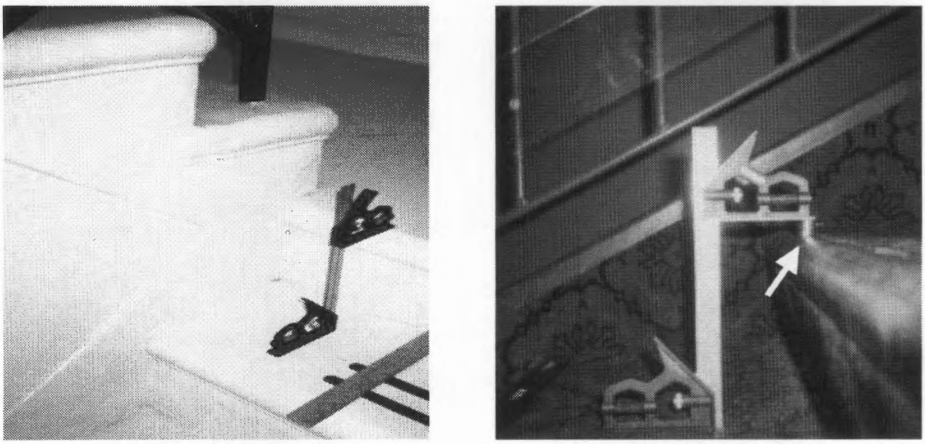


Figure 7-3.
The compound square measures rise of steps. Stack of pennies in photograph on right (see arrow) illustrates height difference from rise of step immediately above.

Measuring stairs this way can be somewhat tedious, and might be unnecessary if there's been no reported problem and no one suspects that there's anything wrong with the stairs. Fortunately, there's a way to check stair dimensions that takes very little time.

The Five-second Check of Stair Rise and Run

This technique would hardly qualify as primary evidence in court, but it can be a useful means of quickly finding dimensional faults in straight flights of stairs. Because the building codes' dimensional tolerances are so tight, a step that's out of specification can in some cases stick out like a sore thumb.

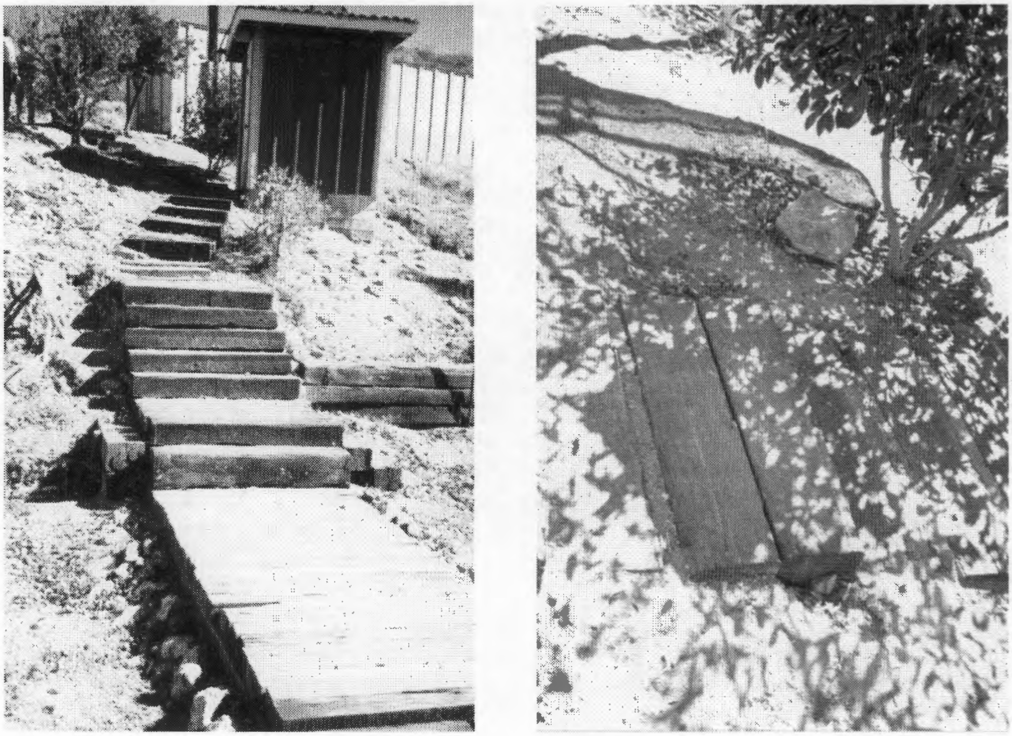
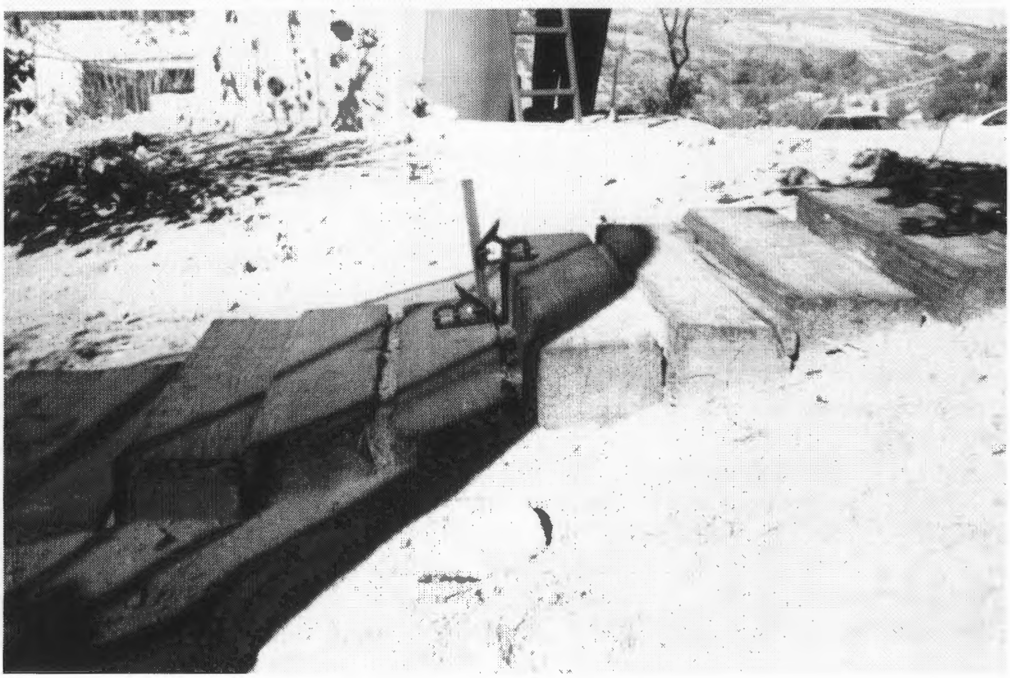
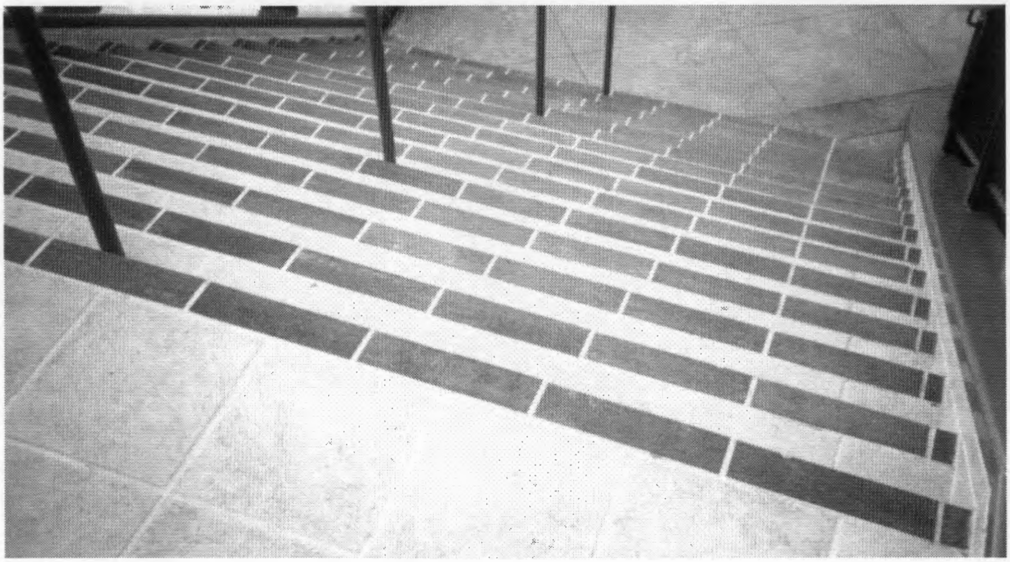


Figure 7-2 (see also facing page).
This accident scene illustrates many features of hazardous stairs: lack of handrail, nonuniform rises and runs, leading edges sometimes difficult to discern, confusing lighting, and potentially slippery surfaces. Railroad ties may be impregnated with creosote and should not be used for stairs.


FOS



Stand at the top of the stairs, a few feet back from the first step so that your eyes are nearly lined up with the nosings of the steps. Actually, your eyes need to be slightly above the line of nosings so that you can see each nosing; see the photograph below.



If you can't see each nosing from that position, for instance if you can see all except one, that's an indicator that something is wrong. If you can see each nosing, but one of them appears to be different in relative location from the rest, that's also an indicator. Now please look at the photograph in Figure 7-4 (next page) and before reading the caption, see if you can tell where the problem is.

Once you've located a potential problem on your stairs, you may need to use the compound square (shown back in Figure 7-3) to confirm the rise and/or run to be out of specification. However, after you've practiced your visual check on a few flights of stairs, you may be ready to spot a problem in about five seconds.

In some cases, the stairs could pass this test and still be faulty. This could occur when the rise and run are both out of spec, and compensate for each other so that the nosings still line up. It's also harder to detect a deviation when the code only allows 3/16-inch variation between any two rises or runs in a staircase. But in many cases, the five-second check of every staircase in a building is a great way to find major stair dimensional faults before an accident happens.

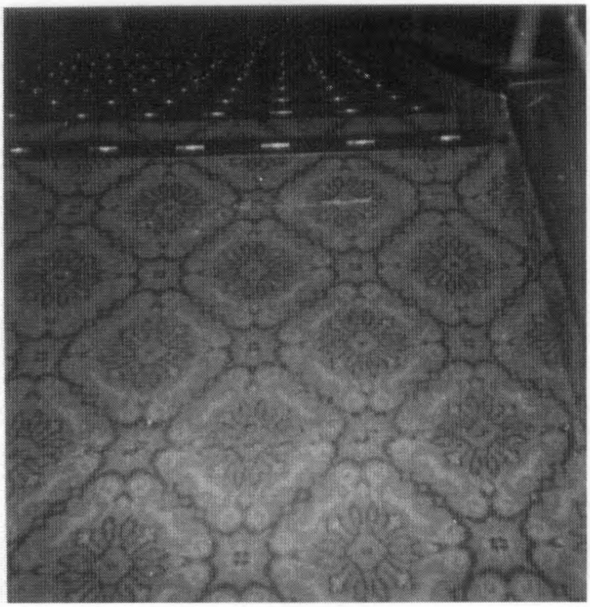


Figure 7-4.
What's wrong with this cinema stairway? An injury occured when a schoolteacher stepped down to the second and third steps, assuming their rise and run were the same as those of the first step down — but they weren't

Visibility of Steps

Pedestrians, including those who are visually impaired, need to be able to distinguish the leading edges of steps. This is particularly important on outside stairs, which will be walked wet with rain or dew. Place a 2-inch wide, slip-resistant contrasting-color strip parallel to and not more than one inch from the step nosing. Even a single step must be clearly marked, since it's very likely to go unnoticed otherwise.

Figure 7-5 shows an example of how steps can seem to disappear under some conditions. The problem in this case could be cheaply solved by striping on the leading edges of the steps. If the steps are slippery, abrasive strips are helpful.

Handrails on Stairs

Building codes also provide details on handrails for stairs. Handrails need to be accessible to and easily grasped by any adult, regardless of the size of the person. Wide stairs need to have multiple handrails so that everyone using the stairs can use at least one.

Handrails serve several functions. First, they provide a visual indicator that the stairs are there. This can be especially valuable if there are only one or two steps. Second, they provide a stable anchor for us to hold onto when we lose our footing. Third, they are a safety barrier when there's no wall along the side of the stairs. Fourth, they

Figure 7-5.
These outdoor stairs at a civic building are quite easy to see when ascending (top photo); however, under some lighting conditions the leading edges are difficult to locate when descending (lower photo).

are a support for a person on crutches using the stairs and holding both crutches on one hand so that the other hand can grasp the handrail.

The Americans with Disabilities Act requires that the clear space between handrails and wall be 1-1/2 inches. The top of the gripping surface must be mounted between 34 inches and 38 inches above stair nosings.

Free Insurance!

Accidents on stairs can be serious and even fatal. Handrails are provided to help prevent these accidents. Yet, millions of people of both sexes and all ages walk stairs with one or two hands free, but without touching — or even staying near — the handrail (Figure 7-6, on page 96). Use of the handrail is free insurance against injury from stair accidents, whether the accident is caused by a fault in the stairs or by a human error made by the pedestrian. Let's all resolve to use the handrail whenever we can! In buildings used by many people, it can be helpful to post signs as reminders that the handrails are there to help prevent falls.

Slip Resistance of Stairs

Stairs must be slip-resistant, particularly near the nosing. Generally, a rating of R10 for the whole tread (see Chapter 5) is adequate for dry steps with handrails, R11 for wet steps with handrails, both where shoes are worn. A fast, inexpensive way to remedy slippery stairs is to add adhesive strips of abrasive near the nosing. These strips are available in hardware stores at about $1–5 per foot, depending on type and width.

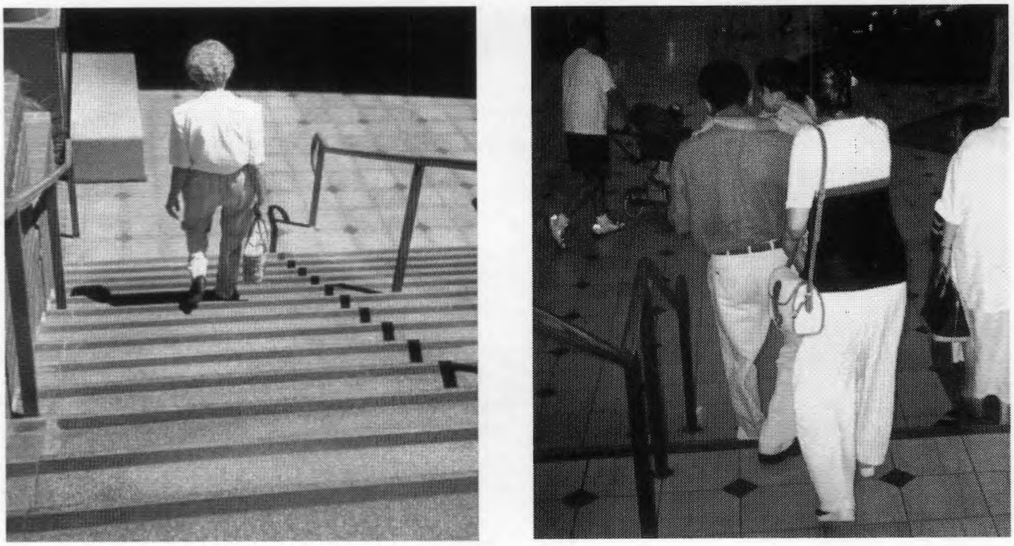
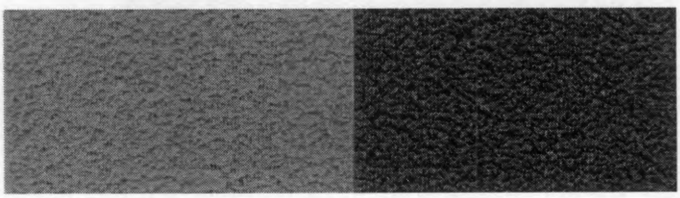


Figure 7-6.
Hold the handrail and prevent a serious accident.



Samples of two such tapes (3M brand, 2 inches wide) are pictured, near actual size, at right. The gray tape is intended for medium duty, the black one for heavy duty. A white tape is offered for light duty. It has a peak-to-valley roughness of about 85 microns.

Pedestrian Ramps

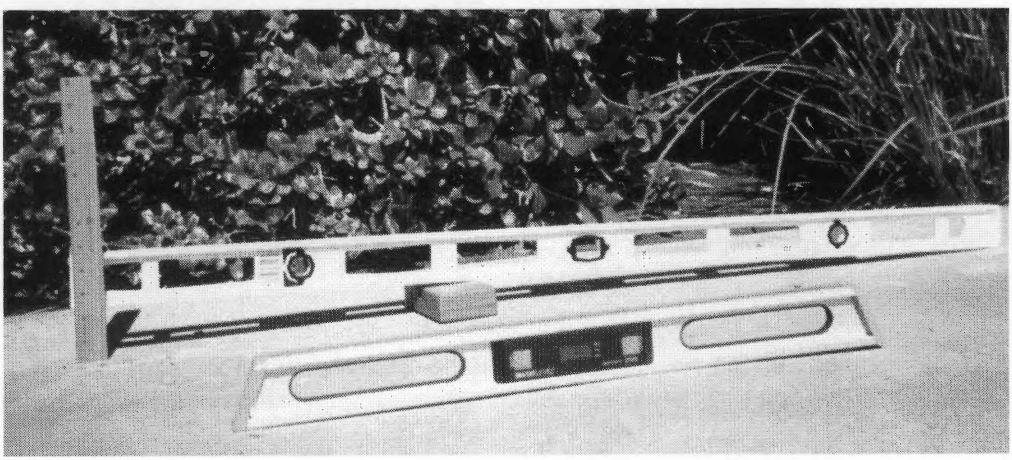
A pedestrian "ramp" has a slope greater than one inches of vertical in twenty horizontal inches. This is a five percent grade, or an angle of 2.9 degrees from the horizontal. Most building codes require that ramps have a slope of no more than one in eight (12.5 percent grade, an angle of 7.1 degrees). The next page lists some slopes as defined by the Americans with Disabilities Act (ADA). They're expressed in three equivalent ways: slope, as in "1:50," meaning one inch of rise in 50 inches run; rise/

run, which is simply slope expressed in decimal form (when multiplied by 100, it's "percent grade"); and the angle, in degrees, that the slope makes with the horizontal. Pick the one you like best.

Slope	Slope	Rise/run	Angle, Degrees
Maximum cross-slope for wheelchair ramp	1:50	0.02	1.2
Minimum at which pedestrian surface is considered a "ramp"	1:20	0.05	2.9
Maximum for new construction			
30-inch maximum rise	1:12	0.08	4.8
6-inch maximum rise	1:10	0.10	5.7
3-inch maximum rise	1:8	0.13	7.1

For comparison, a relatively steep flight of stairs in a public building might have a 7-inch rise for an 11-inch run, which is a rise/run of 0.64, or 32.5 degrees. Stairs need much less space than a ramp for the same change in elevation.

You can measure the rise and run of a ramp by using a carpenter's level and a ruler, or measure the angle in degrees using a digital level, for example SmartLevel. Both are shown below. The digital level is more expensive (roughly $100) but is a more accurate method.



The minimum clear width of a ramp must be three feet. Ramps and landings with drop-offs must have curbs (at least 2 inches high), walls, railings, or projecting surfaces that prevent people from slipping off of the ramp. If a ramp run has a rise greater than six inches, or a horizontal projection greater than six feet, it must have handrails on both sides. Handrails aren't required on curb ramps (see Figure 7-7 below) or adjacent to seating in assembly areas.

Slip Resistance of Ramps

Because of a ramp's slope, the potential for slipping on a ramp is greater than on a level floor unless the minimum requirement for slip resistance is increased. This has led to the adoption in some jurisdictions of a requirement that the minimum static coefficient of friction for a ramp be at least 0.80, as compared to 0.60 for a level floor. The City of Los Angeles, for example, uses this requirement. It's applied to a "ramp" regardless of how steep the ramp. This is generally a fairly stringent requirement,

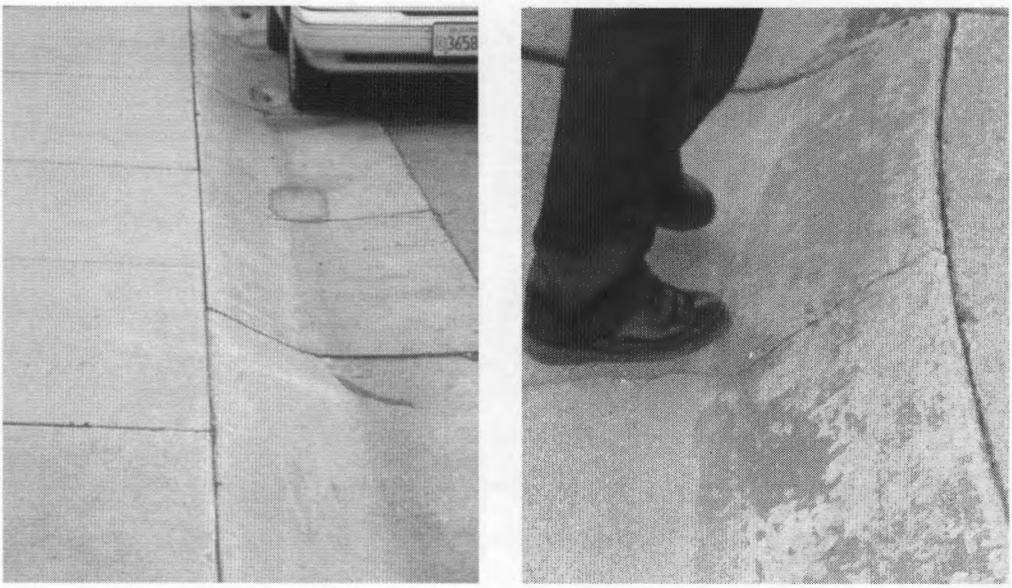


Figure 7-7.
Sloping curbs (or long curb ramps) need to be clearly visible to visually impaired people. Paint (right) can help, but only if it's in reasonably good condition and the resulting walking surface is slip-resistant.

particularly for a ramp with a slope of only 1 in 20. Relatively few floorings in a typical flooring outlet have a static coefficient of friction as high as 0.80, but nevertheless they are widely available.

The surface roughness for a ramp that gets wet should depend on how steep the ramp is. Here's an example. In Chapter 5, Table 5-2 indicates that for Class 0.1, Entrance Areas, the minimum slip resistance on a level floor should be R9. Using the modified R9 guideline also specified in Chapter 5, the variable-angle ramp test rating minimum for R9 is seven degrees. If, however, an entrance area had a six-degree ramp, the ramp itself should have a variable-angle ramp test rating of about 7+6, or 13 degrees. This puts it into the next higher ramp category, R10 (10–19 degrees, as shown in Figure 5-2).

For a less extreme case, let's assume the entry ramp has an angle of only three degrees. In this case the laboratory ramp rating would only need to be about 7+3, or 10 degrees, at the top of the R10 category (which ends at 10 degrees).

How would we assess the slip resistance of an existing ramp that gets wet or otherwise lubricated, assuming that we know only static coefficient of friction and surface roughness? First, the wet static coefficient of friction should be 0.80 or higher. Second, the minimum surface roughness Rtm should be appropriate according to how steep the angle of the pedestrian ramp is.

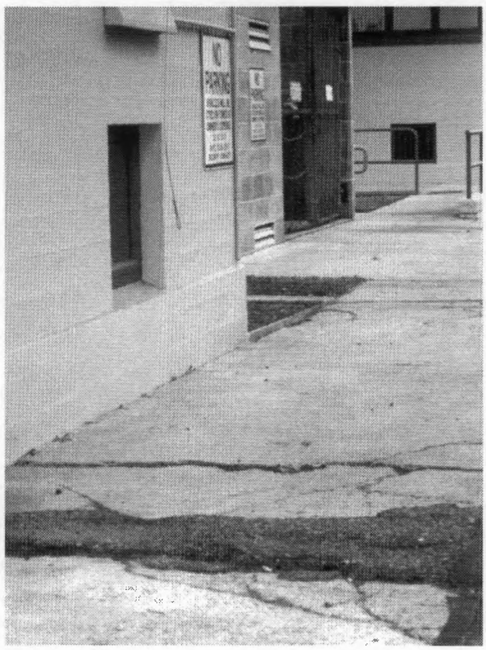
The table below gives some suggestions for minimum ramp roughness of ceramic-tiled ramps that get wet. We've assumed a minimum of 10 microns for R9, 15 microns for R10, and 25 microns for R11 categories. Here's what the minimum roughness should be for ceramic tiles on various pedestrian ramp angles:

Pedestrian ramp	Minimum surface roughness, microns		
Angle, degrees	for R9 area	for R10 area	For R11 area
0 [level floor]	10	15	25
3	13	19	28
4	14	20	29
5	16	21	30
6	17	22	31
7	18	23	32

Again, roughness guidelines aren't infallible, since they're not a direct measurement of slip resistance. They can be useful, though, to help detect a potential problem with slip resistance of existing floors.

Finally, let's clarify once more the difference between "pedestrian ramps" and the "variable-angle ramp test" described in Chapter 5. The variable-angle ramp test ranks flooring according to relative slip resistance when walked by humans in a laboratory test. The ramp angle test results don't apply directly to pedestrian ramps at the same angle. As discussed previously in this section, a seven-degree pedestrian ramp that gets wet or otherwise lubricated needs flooring that's rated much higher than seven degrees in the variable-angle ramp test.

Other Changes in Elevation



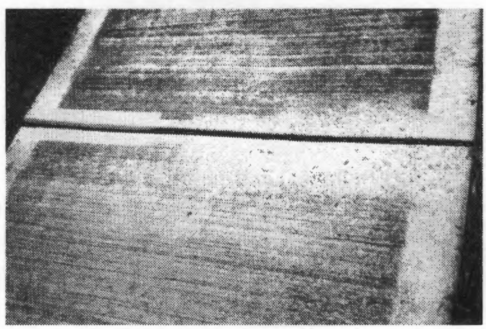
Small changes in elevation can be tripping hazards. Sometimes it's necessary to cut out a repaired section and start again, as in the case shown at right.

Edge treatment isn't essential for changes of elevation that are less than one-quarter inch in height. Changes in level between one-quarter and one-half inch should be beveled, with a slope no greater than 1 inch of rise per inch of run (that is, no steeper than a 45-degree angle). Provide a ramp or stairway for transitions of greater than one-half inch.

It's preferable to avoid having a single step down, since a pedestrian might fail to notice it. If there is a single step, a handrail is a helpful visual signal as well as an aid to the disabled. The leading edge must be clearly visible, too. The two photographs at the top of the next page show a single step to a restaurant entry that was made safer by adding handrails and yellow striping.

Where is a tripping hazard not a tripping hazard? On public sidewalks, a looser standard often applies. A step rise of three-quarters of an inch or less might be considered trivial unless there are other factors that increase the risk. The taxpayers like to give themselves a break, and do not consider smaller defects to be negligence in some cases. Changes in sidewalks due to the growing roots of trees or the settling of soil can make it costly to maintain a tighter standard.

Some fixes can be done at low cost, though. The two photographs below show how yellow striping and grinding away of some concrete has helped remedy changes in walkway levels at two locations in a seaside municipal park.



The Penny Ruler — Measure Accurately for Five Cents

The "penny ruler" can be a useful way of measuring the heights of elevation changes. Since a United States penny is 1/16 inch thick, a stack of four pennies represents the maximum height of step change that's not considered a tripping hazard on private property. A five-penny stack indicates a tripping hazard. A torpedo level (see Figure 7-8 below), available in any hardware store, can help you make this measurement more accurately.

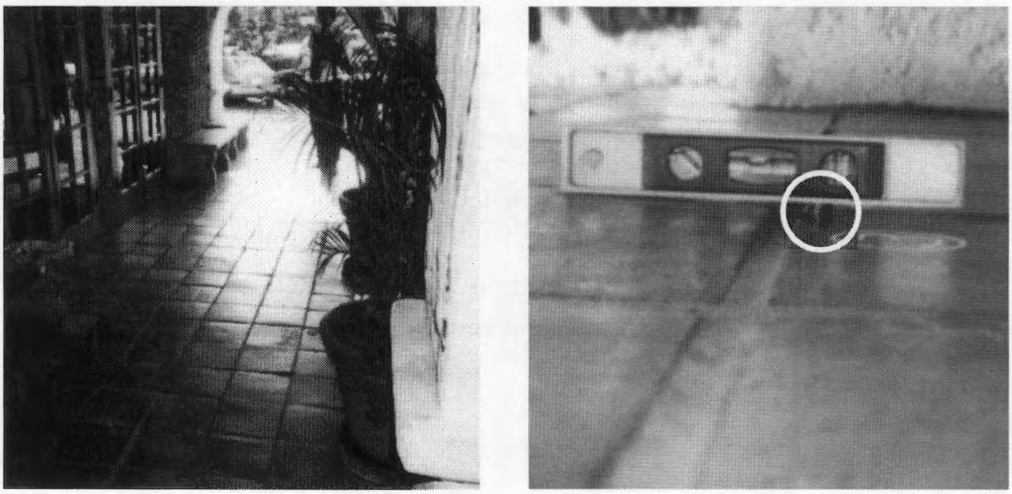


Figure 7-8.
A retired woman tripped and was injured walking across this rustic-style ceramic tile toward the parking lot at a Mexican-style restaurant. The penny ruler (circled at right) indicated that several of the tile edges were tripping hazards — the one shown rises approximately the height of six pennies, or 3/8 inch

Outdoor Slips, Trips and Falls

CHAPTER 8

Outdoor slips deserve special consideration because both the activities and the environment can be significantly different from what they are indoors. We include special problems in the construction industry in this chapter because the outdoor environment affects much of construction work.

Outdoor Activities

We already instinctively react to the fact that slip resistance of outdoor surfaces tends to be more dependable than that of indoor surfaces. A person might feel comfortable jogging on a black-top road that's wet with rain, but would not want to run on the polished marble or granite lobby of an office building on a rainy day.

The fact that people are more likely to run outdoors means that designers and building owners must be extra careful not to use slippery surfaces outdoors. Ornamental tiles set into a concrete surface can make a big improvement cosmetically, but it's important that the tiles have roughness and slip resistance comparable to that of the concrete. (The concrete needs to be rough, of course, or it too can have poor wet slip-resistance.)

Some occupations require outdoor work on surfaces not designed for safe walking. Farm and construction work and trucking are examples. Workers may need to pay special attention to having well-designed footwear treads when they must work on vehicles, farm machinery or unfinished construction surfaces that can be slippery when wet or otherwise lubricated. Caution about the effects that weather can have is also necessary.

Maintenance work on sloping roofs (Fig. 8-1) can be very hazardous, especially for people who seldom work on roofs and don't have special equipment or experience to protect themselves from falls. Use shoes with good treads; see Chapter 6. Try to avoid walking on roofs when they're wet, even with dew. Restraining devices to prevent falls off the roof can help avoid fatalities. Plans for a new building should include provisions for safety of anyone who needs to work on the roof after the building is completed.

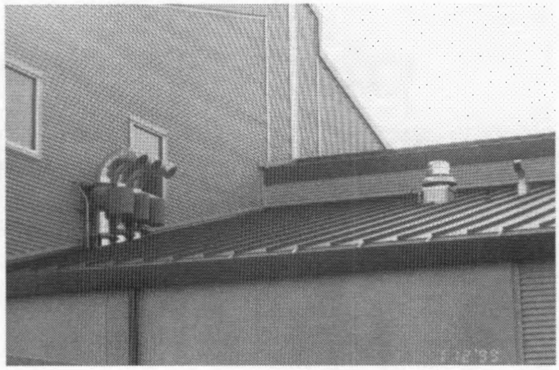


Figure 8-1.
The exhaust fans mounted on the duct at left will need maintainence throughout the life of the building. Workers should wear solings with good treads and have fall protection

Weather

Weather can contribute to slip-and-fall accidents or to other accidents that are sometimes mistakenly attributed to slips. Rain, snow and ice are obviously hazards. Mud can have varying consistencies depending on soil particle sizes and moisture content, and can cause slipping.

Some other weather effects are less obvious and are worth discussing here. They are dew, which can cause an unexpected hazard on some walking surfaces; heat, which can affect people's behavior and reaction times; and wind, which can supply a time-varying force that may result in foot traction and/or balance being lost.

Dew

It's generally impractical to expect outdoor workers to wait to start work until there's no dew on walking/working surfaces. But many (though not all) walking surfaces are more slippery wet than dry, and patches of dew that remain as the day progresses can cause a continuing slip hazard.

The importance of dew can vary considerably with the locality, as well as day to day. This is because the amount of dew that falls, and the time needed for the dew to evaporate, are functions of temperatures, sunlight, and relative humidity.

The maximum amount of water vapor that air can hold increases strongly with temperature, as shown by these examples:

Temperature, °F	Saturation water vapor content, pounds of water per 100 pounds of dry air
50	0.8
70	1.6
110	5.8

The examples show that dry air at 110 degrees Fahrenheit can absorb over seven times as much water vapor as it can at 50 degrees. When the water vapor content (absolute humidity) of air reaches the maximum possible (saturation) at a given temperature, the relative humidity is 100 percent. If the air is not saturated its water vapor content is less than the theoretical maximum, and relative humidity is correspondingly less than 100 percent.

At night, the temperature can drop enough that the humid air cools below its saturation point, and water condenses as dew. The table above indicates that in hot, humid weather with cool nights much more dew can form than in cold, dry weather. (Dew doesn't fall at all if the nighttime temperature doesn't drop sufficiently.)

When the temperature rises again the next morning, the dew can't evaporate unless the relative humidity is less than 100 percent. If it's even close to 100 percent, evaporation can take a very long time. When clouds obscure the sun, evaporation can take even longer because less radiant heat from the sun is available to speed the process.

The result is that in a hot, humid climate dew can persist on walking/working surfaces well into the working day. In a dry climate (for example, Phoenix, Arizona) or a humid area with hot nights (Houston, Texas), there might be no dew on surfaces when the work day starts. Therefore, the importance that dew-moistened surfaces have to workers varies, depending on the locale of the work and time of year.

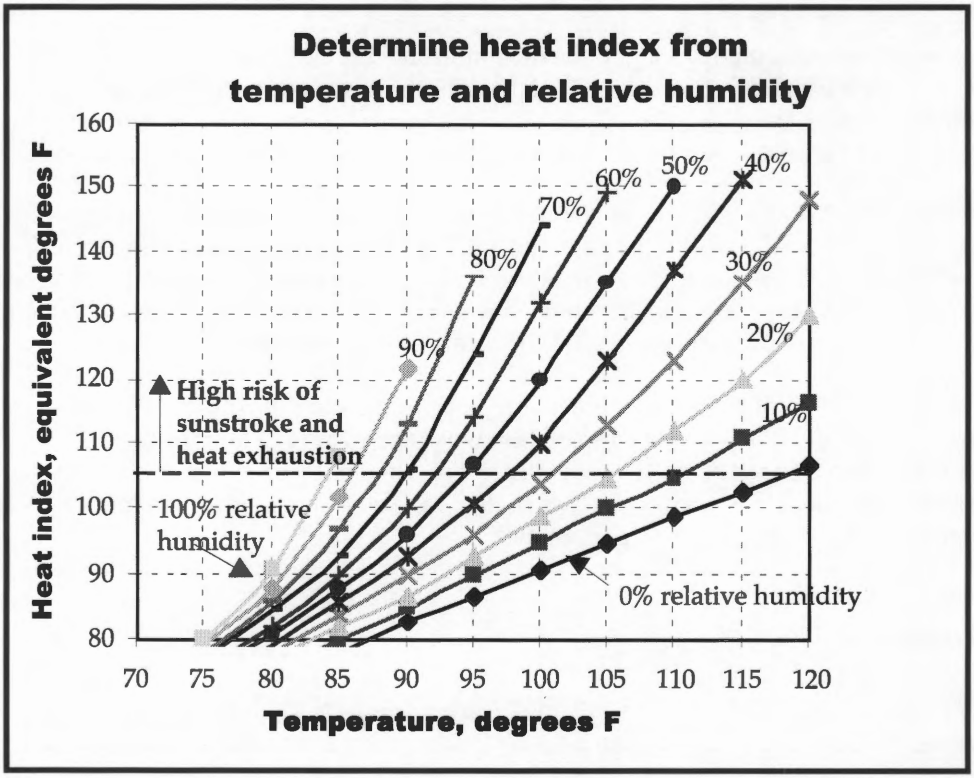
Regardless of the locale, when there is some dew remaining it's more likely to be present in shade. Examples in construction work are an area of floor or beam that's in the shadow of a column, or on a sheet of steel roofing that's been under other sheets in a bundle. The persistence of patches of dew can cause a risk of an unexpected and therefore hazardous drop in slip resistance.

Heat

"It's not the heat, it's the humidity," an old saying, reflects the fact that our bodies' evaporative cooling system is much less effective when the humidity (evaporated moisture) in the air is so high that sweat can't evaporate quickly. When the relative humidity is 90 percent, the effect of 90-degree temperature on a person is greater than it is for a temperature of 110 degrees at a relative humidity of 20 percent or less.

"Heat index," or temperature-humidity index, is an *apparent* temperature that's a measure of the combined effects that heat and humidity have on people. For example, at an air temperature of 95 degrees Fahrenheit and a relative humidity of 70 percent, the apparent temperature is 124 degrees. Sunstroke and heat exhaustion are likely when the heat index is 105 degrees or higher.

The graph below shows how heat index varies with temperature and humidity. For values above the heavy dashed horizontal line, there is high risk of sunstroke and heat exhaustion for the general population. For people on reflective surfaces such as light-colored sand or concrete, this threshold may be even lower than 105°F because of the added effect of reflected sunlight in heating the body. Below the threshold, mental alertness deteriorates as the heat index increases.



To use the graph, find the temperature on the horizontal scale at the bottom and read vertically up to the point corresponding to the relative humidity. Then look horizontally to the left to read the corresponding heat index.

High heat index (also known as temperature-humidity index, THI) increases the likelihood of all types of accidents in which fatigue or reduced mental alertness can play a role, and this includes slipping accidents. The U.S. National Weather Service issues the THI between June 15 and September 15. However, it can be determined more accurately at the work site using a battery-powered digital temperature-humidity instrument (hygro-thermometer) that costs less than $60. Some are pocket-sized, not much larger than a pen. There are many suppliers of this type of instrument; an example is Davis Instruments (telephone: 800-368-2516).

Wind

When heat index is high, a cool breeze is usually welcome — but a hot breeze can further aggravate the effects of heat. At any temperature, strong winds can exert significant forces on a person's body, affecting balance and calling for more traction than walking or working in still air.

Wind at height is usually stronger than it is at ground level. In the lee of steep hills or tall buildings, wind is likely to be gusty, changing unpredictably in both speed and direction. Gusty wind exerts varying forces on the human body, calling for increased traction and quickly adjusted balance to counteract those forces. We must lean into the wind to keep our balance. If the wind speed suddenly changes, we must react just as quickly as the wind does to maintain our balance. This is especially critical when working on a roof or narrow walkway at height and without fall protection.

Wind can also exert large and varying forces on large pieces or bundles of plywood, roofing, and other materials that can contribute to falling accidents. Risk is higher when a person is carrying, lifting, dragging, pushing or throwing those materials. When someone carries a large sheet of material by hand, the sheet can act as a sail with a wind force on the sheet much larger than that on a human body alone. In fact, a large sheet of building material can experience wind forces comparable to the wind forces on a small sailboat.

The wind's force is proportional to the square of wind speed. This means that when wind speed doubles, for instance from 10 to 20 miles per hour, the force on a roof sheet or a human body increases by a factor 2 x 2 = 4. If the wind speed triples, increasing from 10 to 30 miles per hour, its force increases by a factor 3 x 3 = 9.

Because of this, sudden variations in wind speed can create a hazardous situation for an outdoor worker.

Construction Sites

Workers in construction are particularly vulnerable to injuries from slips, trips, and missteps. They work in an environment that is constantly changing and often has far more hazards than would be considered acceptable in most other work environments. And even on a sunny day, construction workers may have to deal with mud and rainwater from the day before (see Figure 8-2) — not to mention ice and snow.

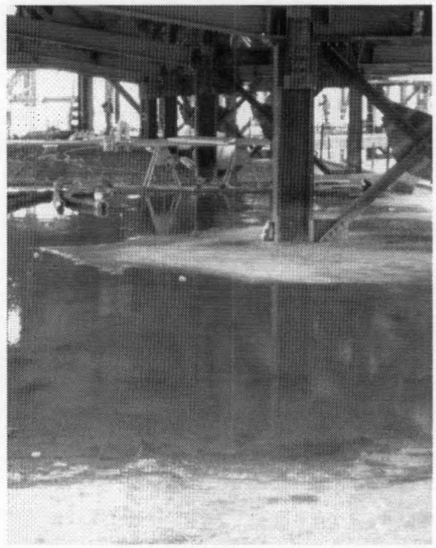


Figure 8-2.
Construction workers must often ford lakes like this one on the way to their work area. The water might contain mud, cement dust, and other substances that can make it very slippery.

The occupation, "construction laborer" is the most dangerous in the United States — it's in the top ten in fatality rate and is in the top five in injury rate. In an average week five construction laborers are killed, mainly in falls or vehicular accidents, and one thousand are injured. Structural metal workers (including ironworkers) and roofers also rank in the ten occupations having the highest fatality rates. In these occupations, falls are the most common cause of fatal accidents.

Let's look at some case summaries as examples of the types of things that can go wrong to cause construction accidents involving slips, trips, or missteps. Then we'll discuss preventive actions in general construction and in steel erection.

Construction Case Summaries

Table 8-1 (pages 110-111) gives brief summaries of 50 court cases involving slips, trips and missteps that were involved in some way with construction. These cases all occurred in one state in a period of five years. In general, they involved a defendant other than the accident victim's employer.

Damages, listed from the highest down in the Table, were as high as $2,754,000. Since the verdict was sometimes for the Defense, the Table shows that in Cases 32–50 there was no award of damages.

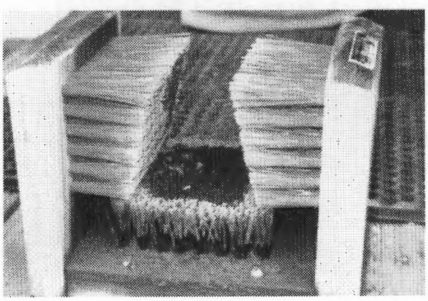
In other cases, the Plaintiff was partly responsible for the accident, as noted in the last column. For instance, in Case 1, "Construction contractor [was] 75 percent negligent." In this case, the Plaintiff had to absorb 25 percent of the total cost. A few of the cases were settled outside the courtroom during the trial but before a verdict was returned, and the Comments column notes, "Settlement."

In several of the fifty cases listed, the accident victim was not directly involved in the construction work. For example, in Case 9 a secretary tripped on walkway planks. In Cases 20, 21, 24 and 26–31 the victims were also passers-by or residents who fell on walkways that had hazards on them as a result of construction activities. In other instances an employee of the facility being renovated was the accident victim: for example, in Case 23 the victim was a hospital worker who was using a stairway in the hospital.

Footwear for Construction Work

Construction workers should maintain footwear solings that have good tread (see Chapter 6) from heel to toe. Consider tread on your solings to be just as important to your walking/working safety as tire treads are to road safety. In both cases, good tread is indispensable when the walkway or road is wet or otherwise lubricated.

When a site is muddy, consider using rubber overshoes to protect the treads of your primary work footwear. If the work area isn't muddy but the path leading to it is, you could remove the overshoes after slogging through the mud. Mud can have an infinite number of different compositions, and it's probably unrealistic to hope that any tread can always be self-cleaning.



The channels between tread lugs should be relatively wide to make it easier to remove mud and other contaminants. A portable fixture that has brushes mounted on it (see photograph at left) can make cleaning treads

Case	Damages	Accident	Age*	Comments
1	$2,754,000	Railroad engineer slipped on grease; improperly constructed derail	52	Constr'n contractor 75% negligent
2	$1,098,428	Drywall worker slipped on material he had scraped off drywall; fell 10 ft		Protective barrier removed
3	$1,000,000	Painter slipped on solvent applied on concrete floor by janitorial agency	49	No safety warning
4	$870,000	Carpenter killed when slipped and impaled on steel rebar	26	Survived by 2 minor children
5	$840,000	Ironworker slipped and fell on scrap piece of electrical conduit	40	Dark, messy room with debris
6	$795,000	Managerial employee slipped or tripped in plant in construction area	52	Channel iron or conduit was hazard
7	$612,245	Drywaller slipped on wet cement	37	Employers 95% negligent
8	$500,000	Paper roofing helper slipped while carrying hot tar		Workers comp paid $25,000
9	$492,783	Secretary tripped when heel caught in gap between walkway planks	48	Metro-Rail construction project
10	$475,000	Drywaller tripped over exposed rebar and sustained brain injuries		Victim's view blocked by insulation
11	$350,000	Worker tripped while moving work area (under construction)	63	Settlement
12	$295,501	Ironworker slipped carrying rebar into trench	45	Employer 40% negligent
13	$285,000	Carpenter foreman slipped on sand on makeshift board ramp rising 32"		No employer safety meetings
14	$282,600	Wood frame wall slipped while being raised after built on ground	36	Plaintiff 10% negligent
15	$200,000	Painter fell off ledge from 5-ft height while wearing dress shoes	38	Settlement (no verdict required)
16	$198,000	Worker helping carry wooden form fell on dirt-covered plastic sheeting	48	Plaintiff 5% negligent
17	$178,800	Electrician tripped over empty conduit that should have been removed	34	
18	$175,000	Laborer slipped and fell on stairs that had no railings or barriers	30	
19	$175,000	Laborer slipped on stairs without rail or barrier at construction site	30	Stairs violated building code
20	$143,237	Passer-by tripped and fell on sidewalk construction zone	43	Workers had quit for the day
21	$142,000	Retired woman slipped on gravel on sidewalk at construction site	67	Token defense
22	$127,696	Carpenter slipped and fell on piece of discarded pipe	50	Inadequate cleanup of worksite
23	$125,000	Hospital worker fell down stairs during remodeling of hospital	50	Debris on stairs
24	$120,000	Sand on sidewalk at construction site caused passing jogger to slip	27	Settlement (no verdict required)
25	$105,000	Bricklayer fell from scaffolding that was strewn with rubble	34	
26	$100,102	Hairdresser tripped on plywood covering hole at construction site	70	

27	$85,000	Retiree tripped on hose on sidewalk	89	Settlement (no verdict required)
28	$80,000	Schoolteacher fell in sewer trench depression on home site	59	Hole had sunk since construction
29	$52,000	Secretary fell on newly constructed stairs at work	35	
30	$47,900	Retired carpenter fell in parking lot at Builders Emporium (remodeling)	74	Black tarp obscured ramp edge
31	$34,241	Shopper tripped on construction debris protruding from under dumpster	38	Plaintiff 70% negligent
32	$0	Carpenter slipped on piece of tile on scaffold, fell two stories	29	No notice, defendant not responsible
33	$0	Electrician/foreman slipped on wet stairs outside of construction trailer	29	Open, obvious condition. No rain.
34	$0	Carpenter fell on a slippery steep hill at construction site	50	Plaintiff negligently took short cut
35	$0	Tool slipped out of sheet metal apprentice's hand	32	Not a foot slip/trip or falling accident
36	$0	Ironworker tripped on a piece of conduit while pulling welding machine	42	Concrete floor
37	$0	Hardwood floor installer slipped on frost on exterior stairs of home	56	Handrail missing due to construction
38	$0	Plumber's ladder slipped on hydraulic fluid that came from man-lift	51	Defendant had no notice of hazard
39	$0	Refrigeration contractor slipped on fat or water at Nabisco train dock	60	Another contractor caused hazard
40	$0	Shoe store owner slipped and fell on new stairs having no handrail	62	No negligence in not blocking stairs
41	$0	Asbestos remover slipped on air conditioner drainage from discon. hose	45	Hazard's existence disputed
42	$0	Physician slipped on construction debris on hospital floor	45	No negligence of builder
43	$0	Taco Bell employee slipped outdoors on dirt area under construction		Offer was $1500, demand $250,000
44	$0	Shopper tripped on driveway during mall remodeling	78	Plaintiff didn't follow walkway
45	$0	Female pedestrian tripped on plywood on sidewalk construction area	63	Broken plywood but obvious hazard
46	$0	Shopper tripped and fell on expansion joint in store under remodel	56	Plaintiff ignored obvious hazard
47	$0	Legal secretary fell on Las Vegas Hilton stairs during remodel	73	Dangerous condition not proven
48	$0	Passerby tripped on hose on sidewalk at construction site	53	Open, obvious condition.
49	$0	Woman tripped and fell in hole in asphalt pavement	60	Contractor unaware of hazard
50		Ironwork foreman tripped on unfinished metal stairs	49	Hung jury, 6-6; no decision
	$259,990	**< Average of available data >**	**49**	
		* Age of victim at the time of the accident		

Table 8-1.
Sample court case summaries: construction-site accidents

easier. If no such fixture is handy, a scrub brush, welding rod, or other implement might do the job.

For footwear in construction work other features such as ankle support, resistance to punctures, and electrical resistance, might also be considerations.

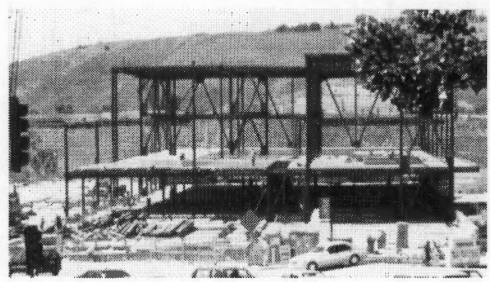
Tripping Hazards

It's a time-consuming job keeping a construction site free of unnecessary tripping hazards. All sorts of materials are constantly being unpackaged or cut to fit, and scraps dropped on the floor in the work area. Unfortunately, the fact that the cleanup is time-consuming is not an adequate excuse. Construction sites even at their best can include many hazards that can easily make even a short fall fatal. All workers need to make sure that tripping hazards do not collect in their work area, and general contractors need to enforce this requirement vigorously.

Roofing

Roofers (see Figure 8-3 opposite) must contend with slippery, highly-pitched surfaces, wind, heat, and fumes. In too many cases, there is no fall protection. On average, one roofer is killed in a work accident every week in the United States. There are many additional accidents in the "construction laborer" category that involve roofing work but are not included in the "roofer" occupational category.

Steel Erection



A few steel erection activities are shown in Figure 8-4 overleaf. Safety in steel erection, or ironwork, is the subject of existing and proposed revised regulations by the United States Occupational Safety and Health Administration (OSHA). In connection with this a steel industry association, the OSHA/ SENRAC Steel Coalition, conducted steel-erection site research on the potential for slips, trips and falls during steel erection. This study is probably the most comprehensive published research conducted to date on slips and falls in any single occupation.

Figure 8-3.
Roofers face a variety of hazards, and fall protection should be used whenever possible. Throwing a bundle off the roof is one activity that puts extra demands on balance and on soling traction

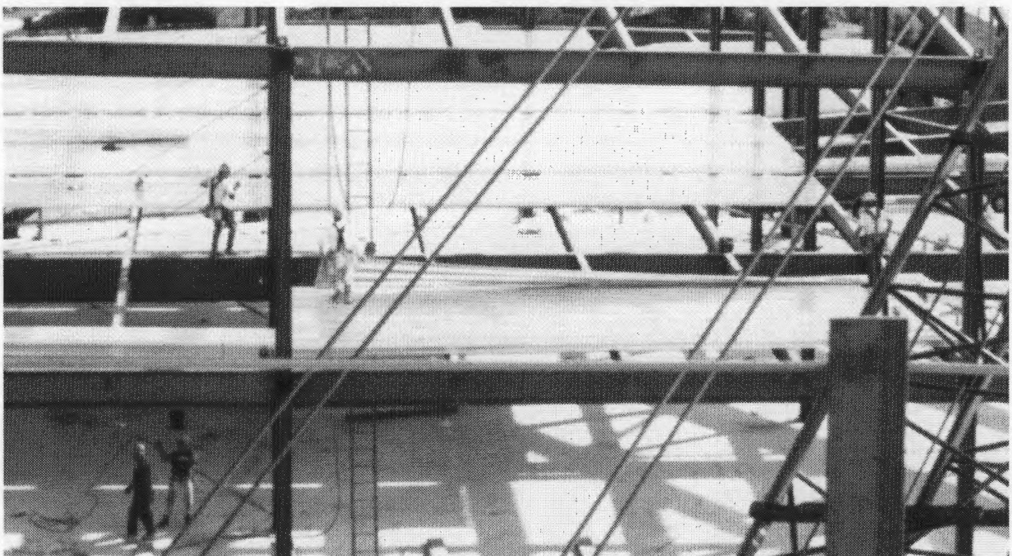
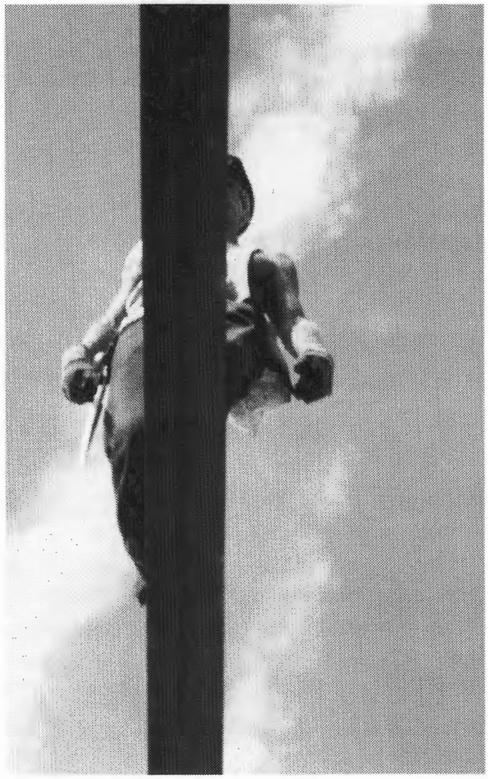


Figure 8-4.
A random sampling of steel erection activities. Photograph at top right of facing page shows worm's-eye view of iron worker walking horizontal beam



A 174-page report presented at an OSHA hearing in 1999 summarized the results. Included were 29 recommendations for decreasing slips, trips and falls in steel erection. We won't repeat them all here, but some of the ones of immediate interest are worth mentioning.

Workers, supervisors and managers in steel erection must treat workers' boot treads as being as important to work safety as tire treads are to road safety. Many workers at present wear bald solings — they have no tread at all. Eliminating this hazard is a fast and cost-effective means of improving safety. Steel erection workers and their loved ones should always make sure that the worker is using comfortable footwear with adequate tread. This must be a top-priority item in the family budget.

Improve housekeeping at steel erection sites, with daily cleanup of debris at every site to reduce slipping and tripping hazards. Remove lubricants such as dust, debris, ice, snow, water, etc. from walking/working surfaces by pickup, sweeping, blowing, before workers walk the surfaces.

Steel erection workers need to lower their risk tolerance and take better account of normal human error. Steel erection companies should make greater efforts to supply their workers with fall-protection equipment that is both effective and user-friendly. Workers will then be more enthusiastic about using it as well as safer and more productive in operations that require fall protection.

Steel erection companies should consider extending special protective measures to roofs with slopes as low as 2 in 12 or 3 in 12 whenever the roof has unprotected sides and edges six feet or more above lower levels, including ground level. Such measures include guardrail systems with toeboards, safety net systems, or personal fall arrest systems. Federal regulations require such measures when slopes are greater than 4 in 12.

Hiking

In casual hiking, don't go beyond the capabilities of your footwear. Use footwear that gives ankle support and has suitable treads that are in good condition. If you don't have good treads, don't walk on sloped or moist rock surfaces. See the U.S. National Park Service warning in Figure 8-5.

When fording streams, the risk of slipping is very high. Algae might cover water-polished underwater rocks, and the force of the current can help overcome friction to cause a slip and fall that in shallow water might cause severe injuries.

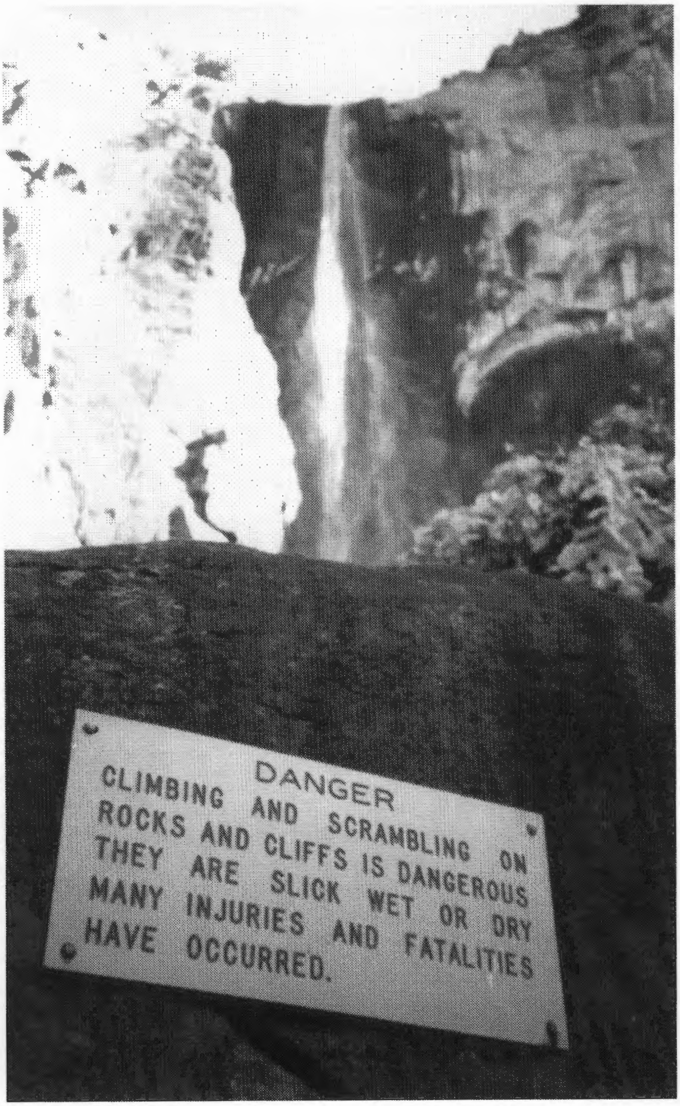


Figure 8-5.
Bridal Veil Falls in autumn, Yosemite National Park

Visual Effects: Illumination, Distractions, and Warnings

CHAPTER 9

Pedestrians usually avoid a hazard if they see it. For people who aren't visually impaired, seeing the hazard is often the last line of defense against falling accidents. Despite the best efforts of employees in places like supermarkets and ice cream stores, the customer is often the first person to see (or fall victim to) a hazard.

For pedestrians to detect hazards readily, they need adequate illumination of the area. Even with good lighting, though, the pedestrian might not notice the hazard if there are distractions. It's not always possible to avoid having distractions, but in important areas like stairs it's worth considering whether distractions can be relocated or eliminated.

Illumination

The amount of light on a surface is called the *illuminance* and can be measured in foot-candles. A *foot-candle* is the amount of light cast on a surface by a standard tallow candle at a distance of one foot from the surface. It's not very much light.

Instead of expressing illuminance as foot-candles, you can also express it as *lux;* take your pick. One foot-candle equals 10.76 lux, so one lux is even less light than one foot-candle. As an example, the illuminance from the sun around noon in the southern United States in summer can be about 1400 foot-candles, or roughly 15,000 lux.

Portable instruments are available for measuring illuminance, and many are very simple to use. An inexpensive digital meter sells for about $130, and has a switch to change from foot-candles to lux. (You might not need one of these instruments unless you suspect there are areas where some money needs to be spent to improve lighting.) If you do use a light meter, consider having it calibrated at least once a year — including before (or very soon after) its first use. A typical meter is shown in Fig. 9-1.

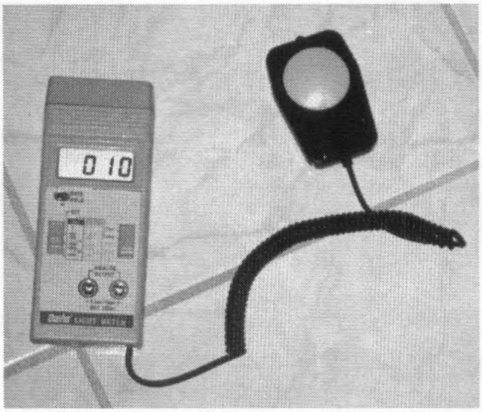


Figure 9-1.
Light meter for reading luminance in either foot-candles or lux

How Much Light is Enough?

Building codes in some cases specify minimum levels of illuminance for various environments. Unfortunately, in some cases these minimums are not adequate. It's important to know that building codes tend to give *minimum* standards for safety, not optimum recommendations. For instance, some codes require a minimum of one foot-candle, measured at the floor, for means of egress, including stairs and ramps. A much more prudent minimum for stairs is eight foot-candles — which is eight times the minimum amount of light allowed by some codes! Visualize a stair step illuminated by a single candle at one-foot height, compared to eight candles at that height, and you have an idea of the difference.

The Illuminating Engineering Society of North America (IESNA, New York, telephone: 212-248-5000) recommends illuminance values, in their *Lighting Handbook,* that are much more helpful than those in building codes. The handbook specifies nine illuminance categories, denoted by the letters A through I. Categories A, B, and C have the lowest ranges of illuminance, and are for "general lighting throughout spaces." They're the ones of most interest here. Categories D, E and F are for illuminance on task. Categories G, H and I are for visually demanding tasks (for example, Category F is recommended for hospital scrub rooms) and are generally obtained by a combination of general lighting and local supplementary lighting.

Table 9-1 shows the illuminance values for the interior categories A through D. Ranges are rounded off, and the approximation 1 foot-candle = 10 lux is used for the table. Each category has a target value and recommended minimum and maximum. For example, for Category C, working spaces where visual tasks are only occasionally performed, the target value is 15 foot-candles (or 150 lux) and the recommended foot-candle deviations are bounded by 10 and 20 (100 and 200 lux). For electric lighting, excessive illumination implies excessive costs of lighting equipment and its operation.

Illuminance category	Type of activity	Illuminance range	
		Footcandles	Lux
A	Public spaces with dark surroundings	2-3-5	20-30-50
B	Simple orientation for short temporary visits	5-7.5-10	50-75-100
C	Working spaces where visual tasks are only occasionally performed	10-15-20	100-150-200
D	Performance of visual tasks of high contrast or large size	20-30-50	200-300-500

Table 9-1.
Illuminance categories and illuminance values for generic types of activities in interiors

A few examples of the categories the *Lighting Handbook* recommends for specific situations are as follows:

Banks		
	General lobby area	C
	Writing area	D
Dance halls and discotheques		B
Health care facilities (including hospitals)		
	Lobby	C
	Nursing areas – day	C
	-night	B

Health care facilities (including hospitals) *(continued)*			
	Nursing stations		
		Corridors – day	C
		Corridors – night	A
	Patients' rooms-general		B
		Observation	A
		Toilets	D
	Stairways		D
	Toilets		C
	Waiting areas – general		C
		Local for reading	D
Hotels			
	Bathrooms, for grooming		D
	Lobby, general lighting		C
		Reading and working	D
Locker rooms			C
Office lobbies, lounges and reception areas			C
Residences-general lighting			
	Conversation, entertainment		B
	Passage areas		B
Service spaces			
	Stairways, corridors		C
	Toilets and washrooms		C
Transportation terminals			
	Boarding area		C
	Rest rooms		C
	Waiting room and lounge		C

Please refer to Table 9-1 for the illuminance ranges that correspond to these categories. The *Lighting Handbook* is revised periodically, and a new edition will be published early in 2000.

Glare can defeat otherwise adequate lighting because the pupils of our eyes contract to accommodate the glare. For instance, bright sunlight coming through a window at a staircase turn landing could, on a bright day, cause decrease visibility of the stairs.

This might be true even if the stairs have adequate lighting for night or for any other time when the glare is not strong.

Distractions

Visual distractions, and sometimes noises, can prevent people from paying the attention they should to obstacles, spills, and stairs. For instance, stairs are inappropriate places for advertisements, displays (see Figure 9-2 below) or mirrors.

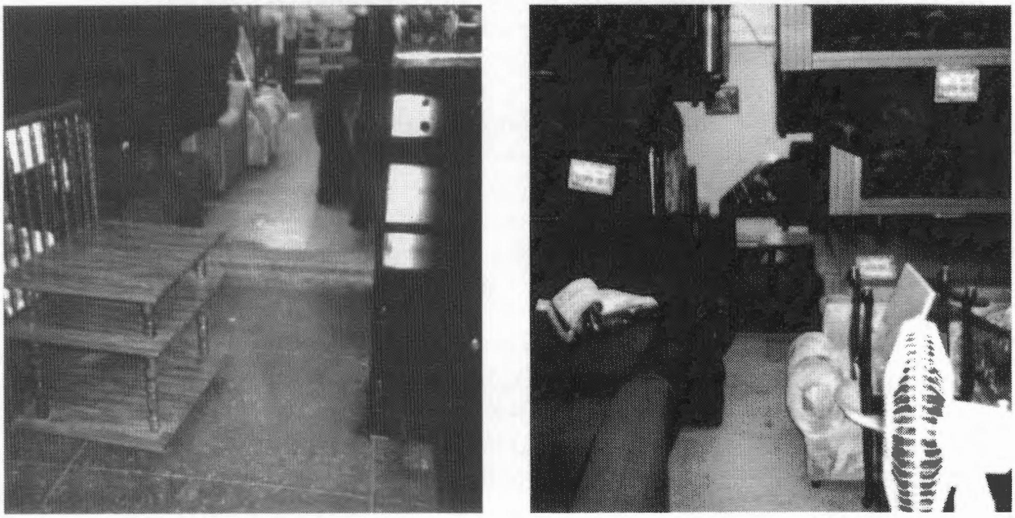


Figure 9-2.
Furniture store's single step up, shown in center of photograph at left, went unnoticed by shopper approaching from the other direction through narrow aisle (photograph at right) because of distraction by the display. An injury resulted.

In a "rich view," many objects, conditions, or people attract the attention of pedestrians. There's some evidence that a rich view on only one side of stairs can be more dangerous than rich views on both sides.

Rich views can be most hazardous when combined with other factors that change abruptly. These include direction changes, changes in views, and changes that require gait alteration, such as at top, bottom, and landings of stairs.

Warnings

Warnings can help people to avoid tripping hazards, spills, and other hazards or to modify their gait or other behavior to help compensate for increased risk. Sometimes it's best to station a person at a hazard (such as a spill) to warn people until further action is completed. However, warnings are generally in the form of signs.

The closer the sign is to eye level, the more effective it will be. When you use warning signs on the floor, make sure there are enough signs to mark off the area that the pedestrian needs to avoid. One sign in the middle of a large wet area won't do the job.

It's preferable to remove the hazard rather than to use warnings alone to prevent accidents. People may be involved in conversation as they walk and don't always notice warning signs, particularly when many other people are walking close by. Sometimes pedestrians see the signs and still ignore them, walking through an area of wet floor to save a few steps. If a hazard is to persist for hours or days (for instance, during renovations) it's best to have a physical barrier to prevent people from crossing the area.

Warnings must be clear, comprehensible, and adequate to place the user on notice of the danger involved. Signs are readily available from hardware stores and other sources to warn of wet, slippery floors and other hazards. Signs are even more effective if they are connected to each other by yellow chains or tapes to form an easily-seen barrier.

Warnings that use pictographs are more reliable than those that require reading. In the United States, millions of adults are not literate in English. The world's most common language by far is Mandarin Chinese, followed by English, Hindi Indian, Spanish, and Russian. A posted warning in English and Spanish languages doesn't begin to cover the possibilities, even for literate persons.

Floor Care: What Can Go Wrong?

CHAPTER 10

A prime objective of floor care should be to maintain safety. Floor care contractors or in-house floor care people need to know that safe conditions are every bit as important as the appearance of the floor.

Floor care personnel clean floors using a combination of chemical, heat and agitation. Keeping the floor clean enhances both appearance and safety. Removing mud, dirt and grease helps to maintain slip resistance. On rainy days, keep mats at the entries — and change them as they become saturated with water, mud or soil.

Some slippery deposits can dull the finish. However, a floor can look clean and still be covered by a thin film of slippery deposit such as grease, phosphate, or detergent. After cleaning, rinse with fresh water if a floor detergent's instructions require it.

Some detergents are more slippery than others during washing of the floor. This can be a hazard to floor care personnel and pedestrians. Look for a detergent that isn't slippery in use, but make sure floor care personnel wear slip-resistant solings. If pedestrians are present when someone is washing the floor, make sure warnings are visible and adequate to keep passers-by off the wet area. Give pedestrians a dry path to use rather than making them walk over a wet or soapy floor.

Certain substances on the floor can oxidize over a period of weeks and build up a hard, slippery layer on the floor that takes extra strong detergent, and possibly deck-brushing or machine-scrubbing, to remove it. An example is fats in a kitchen. You may need to make special provisions for periodic removal of these deposits, but it's better if you can clean vigorously enough to prevent them from forming in the first place.

Replace mop heads frequently or they will contaminate the floor rather than clean it. Floor cleaning personnel must also change washing solution and rinse water often enough so that they are actually cleaning the floor, not just spreading grease and other lubricants. Avoid cross-contamination between floor areas.

Don't use wax or other finishing compounds on ceramic tiles unless you're sure that the compounds won't destroy slip resistance. Most ceramic tiles are intended to remain uncoated — this is one of the attractions of this type of flooring, since it reduces maintenance cost. Some well-meaning floor-care personnel coat ceramic tile to make it nice and shiny, but this can create a dangerous situation. A shiny floor doesn't look so good when you're lying on a wet one, waiting for the paramedics to show up.

On resilient floors such as vinyl composite, the buffing or burnishing pad may do more than just polish the floor-finishing compound ("wax"). Most compounds used today are not really waxes, but plastics that need to cure to set properly. Friction from burnishing may supply the heat needed to speed up the chemical reactions that cure the compound. Improper buffing pads or speeds could prevent the compound from setting properly, so you should make sure to follow the manufacturer's instructions. If there's a language barrier, use an interpreter when necessary to make sure the floor-care employee understands what's needed.

Some burnishing equipment leaves a powdery residue on the floor that needs to be vacuumed, dry-mopped, or swept away. The powder can act like thousands of tiny ball bearings to cause a slipping hazard, particularly at a store's or office's opening time. To see if this is happening, dim the lights and place a lighted flashlight on the floor early in the morning before others use the floor. Sight along the beam, and if such a powder is present, it should be easy to see.

Because today's floor-care compounds for cleaning and for restoration have sophisticated chemistry, it's important not to use one manufacturer's chemical together with another's that might not be compatible. For instance, in a supermarket, when an employee grabs the nearest cleaner off the shelf to clean up a spill, this can lead to an invisible slippery spot being left on the floor.

Over long periods, minerals from hard water can build up on a floor. Special cleaning compounds may be needed occasionally to remove these deposits.

Overspray of furniture wax can leave slippery deposits on floors. This is less of a problem if flooring is slip-resistant.

Cautions About Floor Finishing Compounds

Some floor care compounds for vinyl or other resilient floors are labeled "slip-resistant" based on a dry test conducted using the James Machine and a leather slider. We don't need to go into detail on this test — you just need to know that the results are often misused.

In the good old days, when waxes rather than plastics were used for floor finishing, manufacturers needed a way to tell whether the wax was setting up firmly enough so that it wouldn't be slippery when dry. The James Machine test was devised for this purpose, and is still useful today even for compounds that aren't waxes. Since it's a dry test, though, it doesn't tell us a thing about slip resistance when the flooring is water-wet or otherwise lubricated. Thus, a smooth floor that's maintained with these "slip-resistant" compounds might be slippery when floor or solings are wet!

There should be a big market for a floor-care compound that can add wet slip resistance to smooth vinyl floors and still provide a smooth, glossy appearance. Unfortunately, there doesn't seem to be such a compound available today. The price of having smooth, glossy vinyl or linoleum floors is eternal vigilance — employees must constantly be on the alert for spills, and make sure pedestrians are warned of them and that any spills are cleaned up as soon as possible.

Supermarkets are an example of a situation where this is vital. It's an axiom in the supermarket business that if the floors and ceiling (lighting) look good, customers will forgive a lot of what happens in between. Many vinyl areas are kept to a high gloss, and this is only safe if they are free of spills, condensed water, melting ice, rainwater tracked in by customers, sprays tested by customers, inappropriate cleaning compounds, foodstuffs, and other lubricants.

Slip-resistance Testing to Check Floor Care

Routine testing of floors to show that slip resistance is being maintained can not only prevent accidents, but provide evidence of due diligence if an accident does occur. It's particularly valuable when floors are subject to lubrication by oil, grease and other slippery deposits. Preventive testing also provides a method of checking floor care contractors to make sure they are maintaining the floor's slip resistance as well as providing a good appearance.

Even those floors that are not slip-resistant wet can be kept in their safest condition by making sure they are clean, dry, and properly maintained. The instrument that's best for checking floor maintenance seems to be the Tortus, but it should be used only for dry tests. Since this test requires a rather expensive (over $7,000) instrument, it's usually best left to a specialized contractor.

The Tortus Method has been used internationally for many years to evaluate the dynamic coefficient of friction of flooring materials. This test is used to measure the frictional force between a flooring surface and a moving slider made of "Four S" (Standard Shoe Sole Simulating) rubber, a synthetic rubber specially formulated for measuring slip-resistive properties of pedestrian flooring.

The slider, 3/8" in diameter, represents the trailing edge of a shoe heel as it first lightly touches the floor. The slider is mounted on the Tortus (see Figure 10-1) — a machine roughly the size of a bathroom scale — which crawls across the floor surface at 3.3 feet per minute (2/3 inch per second). The Tortus measures dynamic coefficient of friction continuously and records it using an on-board computer. The term "dynamic" means that the two surfaces were in motion with respect to each other (rather than stationary) for the friction force measurement. The weight on the Tortus slider is 200 grams, approximately a half-pound. On tile and stone floors, special software is necessary to eliminate the effect of grout joints in the data.

A minimum dry dynamic coefficient of friction of 0.5, as measured by the Tortus method, is advisable for slip resistance of a level pedestrian walking surface. On a wet smooth floor, the Tortus sometimes gives over-optimistic results and this book doesn't recommend it for wet tests.

The Tortus test is strictly to check floor *maintenance;* it doesn't assess whether the floor has adequate wet slip resistance. For that job, use the static coefficient of friction and surface roughness tests described in Chapter 5.

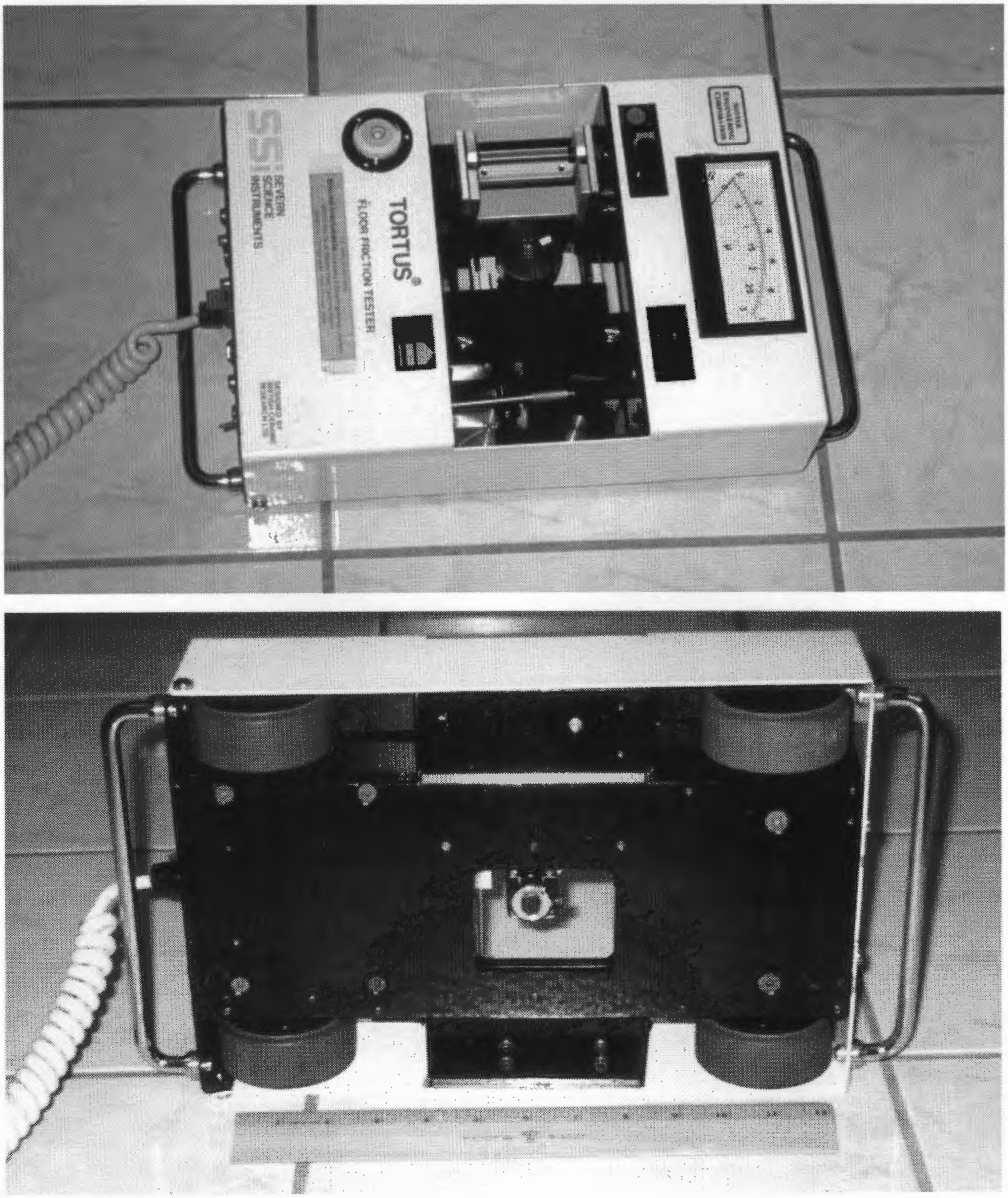


Figure 10-1.
Top photograph shows electrically-driven Tortus moving from left to right while continuously recording dynamic coefficient of friction. Round, black Four-S rubber slider is seen in center of lower photograph

Part III:
Play Defense!

What's in this part —

Now we're ready to talk about the nuts and bolts of a risk reduction program for slip and fall accidents. First, identify and quantify the risks on your property. Then methodically implement cost-effective remedies where they're most needed. Most important, don't buy new problems by installing slippery floors in renovations or new construction.

Assess Risk of Your Existing Flooring

CHAPTER

11

If you're responsible for premises that have multiple slip-and-fall losses each year, you have an immediate financial incentive for improving the situation. You should keep track of where the accidents are occurring to see whether certain areas or types of flooring are responsible for most of the falls.

Some properties with high foot traffic, such as busy subway stations and large malls, have so many falling accidents each year that a study of the records will show where the problem areas are. On properties where there are fewer accidents, though, random variations can play a larger role and make a difference between a bad year and a good year. For the accident victims, unfortunately, one accident can make a bad year or can even change lives forever — or end them.

An assessment of the slip resistance of the various types of flooring on a property can help to determine the likelihood of an accident occurring there. In some instances, it's not the flooring itself that's the main problem, but a nearby source of contamination that's being brought in on shoes, in the air (grease from cooking), or by other means. When the flooring checks out as being suitable for the activity, but accidents are still occurring, that's a hint to look for other problems.

In Chapter 5, we showed how the combination of static coefficient of friction (using ASTM Method C 1028-96) and surface roughness (by Surtronic 10) can help characterize the slip resistance of flooring. You may find that several areas of flooring have less than the ideal slip resistance for the purpose. In that case, it may be useful to have guidelines for deciding what area should have the highest priority for acting to correct the problem, and what remedy might be most cost-effective.

Table 13-1 (next page) shows some suggestions for prioritizing risks due to the flooring in level areas (not ramps) where shoes are warn. The table applies to flooring that may get wet or otherwise lubricated in use. To use the table, you need test data for the wet static coefficient of friction *and* the surface roughness of the flooring. Use the surface roughness with the information in Table 13-2 to estimate what the R category of the flooring is *if* the static coefficient of friction is 0.60 or greater.

SCOFw	Total mean roughness, Rtm	Risk
≥ 0.65 *and* ...	At or above minimum ramp test category	Negligible
≥ 0.65 *and* ...	≥ 10 microns but one category too low	Mild
Any value	Three or more categories low	High
Any value	Less than 10 microns	
≤ 0.55	Any value	
SCOFw: static coefficient of friction using ASTM C 1028-96, wet Neolite slider Rtm: peak-to-valley total mean surface roughness using Surtronic 10 profilometer ≥ "Greater than or equal to ..." ≤ "Less than or equal to ..."		

Table 13-1.
Suggested risk priorities for level floors based on static coefficient of friction and total mean peak-to-valley surface roughness

Surface roughness, microns	R category equivalent
10–15	9
15–25	10
25–35	11
35–55	12
Over 55	13

Table 13-2.
Approximate surface roughnesses (Rtm) for typical ceramic tiles of slip resistance categories R9 through R13 if SCOFw is greater than 0.60

Now you know both the *roughness* corresponding approximately to an R category, and the wet static coefficient of friction. (Remember that the R category estimate only applies if the wet static coefficient of friction is 0.60 or higher.) To use Table 13-1, find the line in which both the first two columns correspond to measured data for the flooring. The combination of the first two columns governs the risk level, which is shown in the third column. Let's look at some examples.

Example 1. Rest room with wet static coefficient of friction of 0.68 and surface roughness of 12 microns. Refer to Table 5-2, where rest rooms are Class 0.3 and the recommended slip resistance is R10. Table 13-2 shows that 12 microns corresponds to R9. This is one category low compared to R10.

Entering Table 13-1, we see that since wet static coefficient of friction (SCOFw) is equal to or greater than 0.65 and roughness (Rtm) is over 10 microns but one category too low, the second line below the "Risk" heading, "mild" risk, applies.

Example 2. Kindergarten kitchen with wet static coefficient of friction of 0.53 and surface roughness of 30 microns. In Table 5-2, Class 9.2 calls for R11 for kindergarten kitchens. The estimated risk corresponds to the fifth line (below the heading) in Table 13-1, SCOFw less than 0.55. Risk is high because, regardless of peak-to-valley roughness, the surface has no "teeth."

Example 3. Parking structure surface with static coefficient of friction of 0.76 and surface roughness of 110 microns. Table 5-2, Class 0.4, calls for R10 for external walkways and pedestrian colonnades. Table 13-1 indicates that the measured roughness, 110 microns, corresponds to the R13 category, well above the R10 minimum. Since the static coefficient of friction is greater than 0.65, the first line of Table 13-1 applies and the risk of pedestrian slipping at normal walking speeds is probably negligible. A parking structure floor with good wet slip resistance is shown in the photograph on the previous page. Pedestrian slip resistance is important here because of rain brought in by tires and wind, and because oil and grease can drop on the walking surface.

These guidelines are far from infallible and mustn't be abused. The information in Table 13-1 does not represent legal requirements and is offered here only as a rough guide to help assess priorities for remediating your slip hazards. Use judgement to account for other risk factors too, as discussed below.

Other Risk Considerations

Figure 13-1 below shows an example of a case that Tables 5-2 and 13-1 don't cover. In the location pictured, a ski area, it's not feasible to keep an outdoor stairway free of ice and snow by cleaning — snowfall averages more than 20 feet per year, and daytime temperatures often remain below the freezing point. The open structure of the stairs assists in shedding rain and snow, and short, peaked protrusions on the stair treads give good interlock with most solings.

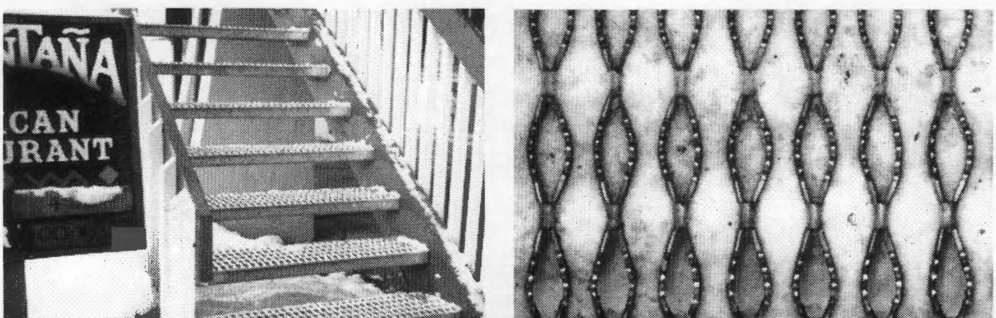


Figure 13-1.
Restaurant stairs in a Rocky Mountain town that averages more than 20 feet of snowfall per year. The surfaces offer little traction from the *adhesion* of classic friction; in this case the dominant mechanism is *interlock* with soling material.

When risk due to the flooring itself is low, we need to consider other factors:

- How many people use the floor on a typical day, and who are they? A subway concourse floor that's used by 10,000 people each weekday is much more likely to have an accident than a lobby walkway that's used primarily by the same 15 employees each weekday.

- How often does tracked-in rain, snow or sleet affect the floor area? Table 13-2 gives an example of some of the extremes of precipitation in U.S. cities in a single year. Other factors being equal, an entrance lobby floor that's mildly slippery when wet could pose a higher risk in Minneapolis (132 days of precipitation) than in Phoenix (31 days). In both areas, though, awareness of the hazards is important. Don't let lack of rainfall for months lull you into thinking there's no potential problem.

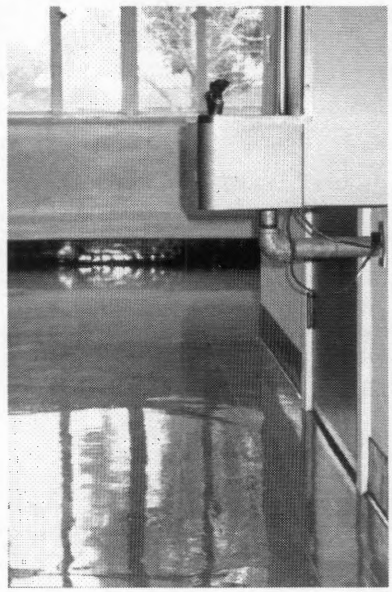
Station	Total precipitation, inches	Sleet or snow, inches	Days of precipitation
Barrow, Alaska	2.8	24.0	51
Indianapolis, Indiana	35.5	29.7	119
Marquette, Michigan	39.0	223.6	173
Minneapolis-St. Paul, MN	25.7	40.3	132
New Orleans, Louisiana	65.3	0.0	101
New York, New York	40.4	26.2	118
Phoenix, Arizona	9.5	0.0	31
San Diego, California	17.0	0.0	47
Seattle, Washington	42.6	0.2	144

Table 13-2.
Examples of precipitation in U.S. cities in 1995

- Are oil and grease tracked in from the parking lot? This problem can be worst in normally dry climates when there's rainfall. Oil and grease may have accumulated for weeks or months, then they're spread around the parking lot by the first rain. Clean the parking lot when you see patches of greasy deposits.

- Is footwear controlled? If all employees are wearing slip-resistant solings, it might be feasible to have slightly lower floor slip resistance without slipping accidents. In a 50,000 square foot warehouse with only ten workers, it could be more feasible and cost-effective to control footwear than to remedy the flooring.

- Are there potential problem areas that deserve special attention? The flooring shown at right is far from outdoor entrances and is normally dry, but the water fountain on the right side of the photograph is a potential source of water on the floor. The flooring is slippery when wet.An absorbent mat at the fountain might be appropriate.



- Are there complaints about the area being slippery? Complaints can indicate that the activity (for instance, rushing or pushing heavy loads), people (retirees) or environmental effects (tracked-in mud or grease) make the area particularly sensitive to the floor-footwear combinations there.

Risk assessment can help you to establish priorities, find reasonable remedies, and set budgets for reducing risk. The fact that risk of an accident was relatively low won't necessarily help you if there is an accident. In a lawsuit you might be found negligent if you could have eliminated the risk at reasonable expense. If the loss is covered by worker's compensation, the employer ultimately pays the cost regardless of fault. In either case, it's better to prevent the accident.

Other Portable Test Devices for Floor Slip Resistance

No one could possibly keep track of how many portable slip resistance test machines, methods and gadgets people have used in court cases, research, and routine field testing, but the number is certainly well over one hundred. They cover a wide range in cost and ease of use, and they give different answers. When faced with a choice between more than one hundred test methods, how do we decide which to use?

The answer is that we need to assess flooring using the method that *best corresponds to human traction.* We want to assess potential for slipping of people, not the slipping of test machines.

Everyone would like to have a device that gives consistent results no matter who uses it, is accurate and easy to use, and is readily portable. All this is true of a digital wristwatch, but a wristwatch doesn't measure potential for pedestrian slipping accidents. We need proof that a test device is suitable for our intended use. We know from human walking tests that, for instance, flooring classified as R13 has much higher slip resistance than that of flooring classified as R9. A portable test method needs to be able to distinguish between these categories.

In research in the England, Australia, and the United States, surface roughness measurements by the Surtronic 10 have shown the best correlation with human traction as measured using the ramp test method. However, this is only true of flooring for which the wet static coefficient of friction exceeds 0.60. That's why this book recommends the *combination* of the Surtronic 10 and wet static coefficient of friction as measured using ASTM Method C 1028-96. The Surtronic 10 measures peak-to-valley roughness but doesn't determine whether the peaks are bumps, suction cups, or "teeth," as discussed in Chapter 5. Since bumps don't give a high wet static coefficient of friction, we must use the static friction measurement to supplement the Surtronic 10.

There are two much more expensive test devices that many workers in the field have bought and used more than most of the other methods. They are the so-called "British Pendulum," which was invented in the United States, and the English XL, also invented in the United States. Let's look at the backgrounds of these two instruments.

The "British" Pendulum

Sigler invented this type of pendulum device decades ago at the United States National Bureau of Standards. The pendulum was devised for the purpose of evaluating pedestrian slip resistance. A pendulum with a spring-loaded slider on one end is released from a horizontal position and swings down so that the slider slides or bounces along the walking surface.

Few people use the Sigler pendulum in its original form now, but British researchers modified it and increased its speed by using a longer pendulum (20 inches in length). The British researchers wanted the new pendulum to simulate the sideways skidding of an automobile traveling around a curve at 30 miles per hour. Because it models sideways skidding, the speed of the pendulum when it strikes the floor is only eight miles per hour. The modified pendulum became an American Society of Testing and Materials standard for evaluating road slip resistance.

Some time after this modification, British workers started using the high-speed pendulum for assessing pedestrian slip resistance. They use it despite the fact that the slider speed, eight miles per hour, is much greater than the speed of a person's heel when it strikes the floor in walking. Australia and New Zealand also use the British Pendulum for assessing pedestrian slip resistance. However, research at RAPRA (formerly Rubber and Plastics Research Association) in England indicated that the Surtronic 10 was superior to the British Pendulum for predicting pedestrian slip resistance as measured by people walking in the ramp test.

Efforts are proceeding to improve the reproducibility and repeatability of the pendulum so that it will give the same results regardless of whose pendulum is used or who operates it. However, the high-speed pendulum appears to have a basic deficiency for modeling human traction: it's too fast. It seems almost like using a moose to model the behavior of a mouse.

It might seem acceptable to use an ultra-conservative method (a fast-moving slider) where safety is concerned. The problem with that is that based on slip-resistance test results, people make decisions totaling billions of dollars every year. Many of these decisions involve lawsuits, some of which individually run into several millions of dollars. Other decisions involve the purchase of flooring for new and renovated residential, commercial, industrial and governmental buildings. Because the stakes are so high, we must have a rational, reliable method for making sound decisions. Even when an amount less than a billion is at stake, if it's your money, you will appreciate the problem. An unfair outcome of a lawsuit, or an investment made (or rejected) in flooring that is incorrectly rated for safety, can result when the test method used doesn't correlate well with human traction.

Research and testing with the British Pendulum continue, and include efforts to achieve a better correlation with direct measurements of human traction. The pendulum might eventually become a more widely accepted test method.

The English XL

William English of William English, Inc. invented the English XL and manufactures it. It's easy to transport and to use. However, there are problems in relating it to human traction.

When the English XL was known by its former trade name, Ergodyne, the British Government's Health and Safety Executive had the device tested on three occasions. The conclusion was that the device was "not sensitive enough to evaluate wet flooring materials." The device did not agree with results of ramp tests using human subjects.

In work related to OSHA proceedings, in 1999 Dr. Paul Kyed of Bethlehem Steel evaluated the comparison between English XL measurements and human traction on a ramp. Kyed reported, "This study suggests that a valid correlation between [English XL] measurements and human traction on steel surfaces does not exist. ... Claims of a valid correlation between [the English XL] measurements and actual human traction must be viewed with skepticism. ... The relative ranking of the slip resistance of different surfaces using [English XL] measurements may not correspond well with the relative slip resistance rankings of those same surfaces in actual human traction tests."

Research and testing with the English XL continue.

Risk Reduction Techniques

CHAPTER

12

There's risk in nearly every human activity. For instance, just traveling to work can involve considerable risk. Lying in bed can be risky when an earthquake, lightning, or a hurricane strikes. Our objective should be to reduce risk to reasonable levels while still being able to lead normal, productive lives. Slip and fall risk can't be reduced to zero, but using the principles in these pages can result in a drastic reduction in the probability that slip and fall accidents and injuries will occur.

The most obvious step is to avoid spending your money on any new flooring that has needless slip-and-fall risk. From architect to designer to buyer, everyone involved in the selection of flooring for new business premises, new residences, and renovations must realize that accident prevention for many years into the future is at stake. Slip and fall prevention should be considered from the beginning.

Next, evaluate and prioritize existing risks. Then remedy the risks according to what's reasonable and cost-effective.

New Flooring

Use the information in Chapter 5 to establish slip resistance specifications for any new flooring. The preferred method is to have the supplier tell you R ratings (R9 through R13) from a ramp test. If this isn't feasible, the next best thing is to apply the combination of static coefficient of friction and surface roughness that's discussed in Chapter 5.

Make sure the flooring you receive — which could be different from the sample that was tested — is going to have the specified slip resistance. If the manufacturer has adequate quality control, he should be able to guarantee this.

It's important that the flooring be slip-resistant *as used,* not just as it came from the manufacturing process. For instance, if you'll be applying sealer after installing tile or stone, test slip resistance on a sample that's had the sealer applied. If you'll be using a floor finishing compound on vinyl-based flooring, test the flooring with the compound on it.

New Glossy Ceramic Tile and Stone

Many glossy flooring surfaces, as manufactured, are slippery when wet. The desire to have high gloss on flooring is, unfortunately, one reason that there are so many slip and fall accidents. Until recently the only solution to this problem has been light chemical etching of tile and stone floors, or use of an abrasive coating. These sometimes have a noticeable effect on the appearance and cleanability of the flooring. In the case of a few natural stones, chemical etching doesn't produce the desired slip resistance.

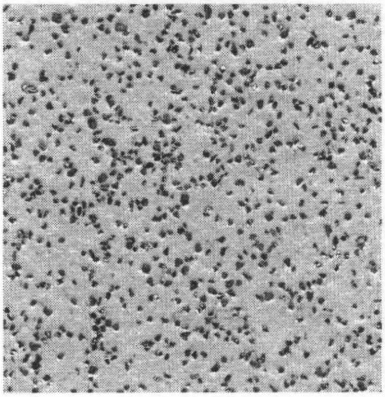
Now there's another way to solve this problem. A process is applied to ceramic flooring or natural stone after it's been made into tiles but before the tiles are delivered and installed. A laser burns "divots" in the flooring that are typically 30 microns (0.001 inch) deep and 200 microns (0.008 inch) in diameter. The divots are typically spaced 0.020 inch apart or less, depending on the desired level of slip resistance. Slip resistance ratings of R10 (with a static coefficient exceeding 0.60) for areas where shoes are worn, and barefoot ratings of A, B and C, are achievable. Cleaning and maintenance must be conducted as directed. It's still necessary for pedestrians in leather solings to use care on these floors, especially when wet.

The process has been applied to large areas of flooring in a number of countries, and at this writing is being introduced into the United States. The process is owned by SafeStep, located in Walls, Mississippi and headquartered (as Renosa Steintechnik Gmbh) in Boltersen, Germany. More about this in the next chapter.

New Vinyl Composite Flooring

Use vinyl-based flooring with included studs or abrasive, rather than smooth vinyl, where the floor is likely to get wet. Follow the manufacturer's directions for maintenance so you don't destroy the slip resistance.

Durability is important in slip-resistant vinyl-based flooring. Altro Floors (800-565-4658; web site www.altrofloors.com) offers seven lines of vinyl-based flooring that include abrasive. The surface pattern of one of their most heavy-duty line is pictured,



at actual size, at left. This particular line, which includes three types of abrasive, is available in seven color schemes. Altro recommends this type (Stronghold 30) for commercial kitchens, fast food kitchens, supermarket meat preparation areas, and several other industrial and commercial applications. Special improvements make this flooring easier to clean.

New Concrete

It might seem strange to think of a concrete walkway or floor being slippery when wet, since outdoor sidewalks are commonly made of this material and can give very good traction when wet. But left to its own devices, concrete can be very smooth, and can be slippery wet. To prevent this problem, and at practically zero cost, the concrete must be roughened after pouring — preferably before it cures. Concrete contractors often use a broom to accomplish this. Another technique is to spread rock salt on the surface; the salt leaves indentations in the dry concrete and is later removed by hosing it off with water.

Sometimes builders omit the roughening step, and that can create a hazard. However, you can have the surface roughened later by muriatic acid etching or by grinding. The acid is very inexpensive but to avoid the chance of injury to people or materials it's often best to employ a specialized local contractor to do this work. Once you've roughened the concrete surface, it's of course important not to apply any dressing to it that will bury the roughness or otherwise destroy the wet slip resistance.

New Wooden Floors

The slip resistance of wooden floors can vary widely depending on the roughness of the finish, the preservative or polish that's used, and the direction of walking relative to the orientation of the grain. If the finish is quite grainy, slip resistance parallel to the grain may be lower than it is across the grain. Consult Chapter 5 and select slip resistance appropriate to the application. There are finishing compounds available that contain abrasive for applications in which wet slip resistance is required. Ask your supplier of wooden flooring.

New Steel and Aluminum Walking Surfaces

Diamond-plate metal surfaces can be slippery when lubricated. Their slip resistance depends to some extent on the depth and sharpness of the "diamonds" embossed on the surface, but there are more effective ways of making metals slip-resistant.

Plasma-sprayed slip-resistant surfaces are available in stainless steel, mild steel and aluminum from the W.S. Molnar Company in Detroit, Michigan (Tel.: 313-923-0400). Other companies make metallic bolt-on surfaces for metal grating, stairs and ladders that are coated with a slip-resistant abrasive compound. Trowel-on coatings are also available.

New Rubber Flooring

Rubber flooring can give good wet and dry slip resistance, as well as being easy on the feet. If it's combined with other flooring, prevent or minimize tripping hazards encountered in going from one type of flooring to another.

Remediation of Existing Slip Hazards

On an existing floor, slip resistance can often be increased at relatively small cost and with little or no time lost in use of the floor. The remedies discussed below include chemical etching, abrasive coatings, carpeting, and rugs or mats.

Chemical Etching of Tile and Stone

For slippery ceramic tiles and natural stones such as granite and marble, a light etching with a properly formulated chemical solution can often significantly increase the wet static coefficient of friction, improving slip resistance without necessarily increasing surface roughness.

There are two general methods of doing this. One method involves a strong acid, and is best performed by a competent, experienced and responsible contractor. The other method uses a milder chemical and can be performed by the layman on some floors if care is used. It is more suitable for flooring (such as fast-food kitchens) where little harm is done if the appearance of the tile suffers from any nonuniformity in the treatment.

Neither of these processes normally involves applying a *coating* to the flooring, although a sealer may be recommended to improve appearance and cleanability after the etching. The etching chemicals react with the flooring material, dissolving a thin layer. The improvement in traction can be quite noticeable and seems to result from suction between footwear and the etched surface under wet conditions. Under dry conditions, there is little or no change in traction, but dry conditions are not usually what need to be improved.

When considering chemical etching, it's advisable to have a sample of the flooring etched and tested for coefficient of friction. Inspect the sample to see if its appearance is acceptable after etching. If you don't have spare tiles ("attic samples") to use as samples, pick a portion of the installed flooring that's inconspicuous — for instance, under a table or bench. You might also want to test the etched sample (and an untreated sample, for comparison) for cleanability of common stains that you expect in the floor's environment. For instance, a restaurant might want to stain the samples with one-inch-diameter spots of ketchup, mustard, red wine, and salad oil and leave the stains sit overnight (one set covered, another set uncovered) before cleaning.

Etching with strong acid. Persons not trained in safe use of strong chemicals shouldn't handle the acid used for this treatment. Even some contractors who offer the etching service are not competent in its use and sometimes damage irreversibly the appearance of flooring. Especially where the appearance of the flooring is critical, use care in selection of a contractor. The Ceramic Tile Institute of America (Culver City, California; telephone 310-574-7800) may be able to name some contractors of known experience.

Etching can be helpful both for areas where footwear is used and for barefoot areas. Varying the strength and period of application of the etching chemical controls the extent of the etching. Usually the aim is to perform the minimum amount of etching that will give the traction improvement needed. This has the least impact on the appearance of the flooring and on its cleanability. After etching it's of course necessary to keep the flooring reasonably clean so that the microscopic "suction cups" in the floor will not be filled with grime, grease, etc. and lose their effectiveness.

If you have etching performed by an outside contractor, make sure that the process was applied vigorously enough to give the results you require — for instance, a wet static coefficient of friction of at least 0.60. This might require a field test by a third party.

The cost per square foot of floor of chemical etching by a contractor depends largely on travel and labor time. Getting a small residential bathroom etched could have a very high cost per square foot if the contractor needs to travel a long distance. For a larger commercial or industrial job the charge is usually of the order of $1 to $2 per square foot, with the lower number applying for areas of 20,000 square feet or more.

For tile and stone, sandblasting is usually not as satisfactory as chemical etching. Sandblasting or shotblasting is often more aggressive to both tile and grout.

Microscopic surface texturing by in-house personnel. Other chemicals are available commercially that are not as aggressive and can be handled by in-house personnel. It's important to read labels carefully, follow manufacturer's instructions, and be familiar with the product's Materal Safety Data Sheet (MSDS) report. Some fast-food restaurants apply this process to quarry tile. Although the necessary safety precautions are less stringent than when strong acid is used, it's important to use care. For instance, if an employee were to get one of these weaker chemicals in his or her shoes and let it remain there for several hours, damage to the toenails might result.

Products for microscopic surface texturing by in-house personnel include S.C. Johnson's Stop Slip (1-800-558-2332), Quarry Grip by U.S. Chemical (1-800-558-9566), and Sure Trac Ultra by Drackett Co (1-800-242-1677).

You shouldn't consider microscopic surface texturing by in-house personnel if the cosmetics of the flooring are sensitive (for instance, a hotel lobby).

Abrasive Coatings

The abrasive coating technique is often an instinctive solution: broadcasting some sand onto a painted floor as the paint is drying, for instance. Alternatively, mixing sand in with the paint before painting the floor.

This process is not as foolproof as it might seem. Tiny paint-covered bumps on the floor don't necessarily increase the slip resistance, and exposed sharp particles that break down or abrade under wear from shoes soon lose their effectiveness.

The greatest wet traction increase from abrasive particles comes from sharp points that can dig into solings through a lubricating layer, interlocking with soling material. Burying these sharp points under paint can destroy their effectiveness. Even adding *pigment* to a thin, clear floor coating that contains abrasive can decrease the effectiveness of the abrasive!

Applying an abrasive-laden coating in too thick a layer can also defeat the object. The abrasive may sink to the bottom of the liquid layer during drying and, completely masked by the coating on top of it, lose all effectiveness. If polyurethane or another *thin* coating is put on top, make sure it won't destroy the slip resistance.

The most durable system seems to be an epoxy-type coating plus durable aluminum oxide (alumina) particles. Make sure that a thick layer of coating that robs them of their effectiveness doesn't mask the particles. Preferably, a skilled, experienced contractor who understands these principles should apply the coating.

The grit size is also important. Grit size indexes have to do with the fineness of the screens used to size the grit. The smaller the grit, the higher the grit size number is. As with flooring selection, the solution needs to fit the problem. Here are some examples of grit sizes that have been used:

Application	Grit size
Food processing	36-60
Manufacturing work stations	16
Restaurants and food preparation	60–80
Vehicle ramps	8-12

You can use abrasive paints or other abrasive coatings on a number of types of floors. Clear abrasive coatings especially for wooden floors are also available.

Carpet

A rather drastic method of remediating a slippery floor is by covering it with carpet. Although it's sad to see an expensive, beautiful hard floor covered with a thin carpet, this can be a quick solution.

Flooring accessible to disabled persons should be firm, meaning that thick carpet-pad combinations aren't appropriate. Carpet is more difficult to keep free of stains and allergens than are hard and resilient (vinyl) flooring, and doesn't last as long.

Pay attention to the condition of carpet in order to prevent and eliminate tripping hazards. An Atherton, California commercial building owner and its property management company decided to pay a $525,000 settlement to a 37-year-old man who tripped on a loose carpet seam after exiting an elevator. The settlement included compensation for injuries and to the man's wife for loss of consortium.

Mats for High-risk Areas

One way of saving an expensive existing slippery floor is to add area rugs or mats to the portions where slips are most likely to occur. Building lobbies are one example. Giving people a chance to dry their solings when they enter is helpful. Three feet of matting is not generally adequate, though. Matting should be long enough so that everyone's solings can be dried (not just those of the first few people to enter), and should be replaced with a clean, dry mat if it gets near saturation.

Remember, too, that solings aren't the only source of water on a rainy day. After people get past a mat, their raincoats may still be dripping. Then they start to shake their umbrellas! When rainfall is expected, it can be helpful to have a container handy near the door to shake or store umbrellas, or to supply plastic bags for umbrella storage. Use enough length of absorbent matting at entrances (e.g., 10–15 feet), turns, and other likely slip areas to reduce slip hazard to negligible levels. How much is "enough" depends on conditions such as amount of foot traffic, mud, and snow.

Tripping can be a hazard with mats if they are not properly designed, or if they become distorted. A jury awarded $680,900 to a 53-year-old law librarian whose foot became stuck on a bulging rain mat inside the door of 55-story Arco Plaza in Los Angeles. She suffered multiple fractures and sprains and needed a hip replacement. The defendants were the investment company that owned the building, and three subcontractors.

Warnings

Take all reasonable steps to eliminate hazards. If you've done that and a hazard remains, reduce risk by warning the pedestrian. Warning signs and cones are readily available commercially. Whenever possible, warnings should use pictographs so that persons don't need to be literate in English or any other language to understand. They should be conspicuous (preferably near eye level) and should be simple enough for rapid perception. When a spill occurs, warn people verbally until signs are in place.

Surveillance to Detect Hazards

Surveillance of floors to detect spills, dropped produce, and other hazards is an important part of many safety plans, particularly on floors that have poor wet slip resistance. This includes most floors in customer areas of supermarkets. In one supermarket case involving Safeway Stores, a court ruled that inspections every 12 minutes were necessary in certain areas of the store. Supermarkets use signed "sweep sheets" to document their inspections.

Your safety plan might include formal, documented surveillance of floors as an alternative to having floors of increased slip resistance. If so, don't assume that surveillance has no cost just because workers who are already on the payroll conduct it. What, your employees don't have anything else to do?

Remember also that some lubricants might be present in such thin layers that they're very hard to detect visually. Examples include spray products tested in the store by customers: WD-40 lubricant, Armorall, silicone spray polishes, perfumes, etc.

Let's assume that your uncle manages a Wal-Mart Supercenter that has five acres of floor under one roof. He needs a good contractor to conduct routine surveillance on his floors for spills and other hazards, and he suggests that you bid on the job. The only snag is that if you miss an inspection and an accident occurs, you are liable for the losses. How much would you want to be paid for that job?

Getting back to your real-life situation, don't forget to assess the cost of formal floor surveillance if it's part of your safety plan. Keep that cost in mind when you weigh the cost of remediating the floors so that they're not slippery when wet with water or with other reasonably expected contaminants. Better floors might save you money. If you rely on regular walk-in customers, you might also enjoy higher sales if customers feel more secure on your floors than on your competitor's floors.

Confirm and Document Your Risk Reduction

The fact that you're reading this book proves that you're concerned about potential slip and fall accidents. When you act to reduce risks, you should keep paperwork in your file to prove your diligence. Flooring test reports, specifications for applied slip-resistant coatings, and receipts for purchase of mats, chemical etching, etc. can be helpful later to demonstrate that you've been following a reasonable path to improve pedestrian safety.

Testing performed by you or other in-house personnel can be helpful if properly documented. For greater credibility, consider having qualified outside testing laboratories conduct some or all of your tests.

In large properties or companies, records of accidents and reported "near-misses" can help indicate progress. Just the number or cost of accidents alone may not be sufficient to demonstrate progress, though. Remember that the frequency of incidents can be affected by business conditions (number of people entering the premises, work pace, hours worked per day, etc.) and weather conditions (number of days of rain, snow and ice), for example. Accounting for these factors will help you to determine whether you're achieving genuine progress.

Your Program for Cutting Risk

CHAPTER 13

Organizations or people who have many floors under their responsibility should have a formal slip and fall risk management policy. This involves several operations:

- Management commitment and employee involvement
- Site assessment
- Hazard prevention/minimization
- Training for employees, supervisors and managers

We'll discuss risk reduction further in this chapter. First, let's take a minute to review some of the highlights of what the preceding pages have said that can help you in your efforts to stop slip, trip and misstep accidents.

We discussed the fact that slips, trips, and missteps account for millions of injuries every year and contribute to about 15,000 deaths — nearly 300 deaths in an average week — in the United States alone. Single cases have had $10,000,000 or more in damages.

Complaints, near misses, and accident histories can help you to find slip, trip, and missteps hazards. Using the penny ruler, five cents can help you to measure tripping hazards in the form of vertical rises that are more than one-quarter inch (a four-penny stack) in height.

Although some flooring is slippery to certain shoe solings even when dry, most slip hazards occur when walking surfaces are wet or otherwise lubricated. We define *lubricants* to mean *any substance between walkway and footwear (or bare foot) that reduces slip resistance* — and that includes water. Dry slip resistance is very different from wet (or otherwise lubricated) slip resistance. Knowing dry slip resistance tells us nothing about wet slip resistance. Many floors have excellent slip resistance dry, but are treacherous when wet. On the other hand, floors can be chosen (or treated) and maintained so they are not slippery when wet.

Both flooring and footwear should be *appropriate to the activity and to the environment.* Table 5-2 in Chapter 5 will help you to select flooring for areas where footwear is used. The text immediately preceding Table 5-2 gives similar guidelines for barefoot areas. The variable-angle ramp test is used to classify flooring in categories R9 through R13 (with R13 having the highest slip resistance) for areas where footwear is used, and A through C (C having highest slip resistance) for barefoot areas. For some types of work areas, flooring should have a raised-relief surface (characterized by spillage displacement volume V4, V6, V8, or V10) as specified in Table 5-2. Get the test data and/or the rating in writing from your flooring vendor before you order flooring. Many overseas flooring manufacturers have the data readily available. United States manufacturers may need to have a sample tested. If your vendor won't supply ramp test data, insist on having, in writing, at least the static coefficient of friction *and* peak-to-valley surface roughness before you buy any flooring. Keep this information in your file.

Figure 6-2 showed you characteristics of solings that have good wet slip resistance. Squared-off cleat leading edges in all directions cut through lubricants to grip the floor underneath. You should review Figure 6-2 whenever you're ready to buy new shoes. When the tread of your shoes starts disappearing in floor-contact areas, replace the solings or the footwear. If the occasion, or fashion, demands that you wear solings that aren't slip-resistant, be extra careful.

You can assess existing flooring using the *combination* of static coefficient of friction (using ASTM Method C 1028-96) and peak-to-valley total mean surface roughness (measured by the Taylor-Hobson Surtronic 10). Both tests together take less than an hour per sample, including washing the flooring if necessary to degrease it. If you use a commercial laboratory for this data, make sure they follow the test procedure outlined in Chapter 5.

Falls on stairs can be cause very severe injuries, and are too often fatal. It's vital that stairs comply with the local building code. Uniformity of rise and run helps prevent missteps, and building codes are strict in these requirements. You can do a quick check for uniformity by standing at the top and sighting down the nosings. This helps detect gross problems, but you'll need to measure carefully if you want to confirm compliance.

Chapter 14 lists some things that you need to do immediately following an accident. Chapter 15 helps you protect yourself against fraudulent accident claims. The most important safeguard against fraud is to maintain your property for safety so that scamsters can't show that your demonstrated negligence could have caused the alleged accident.

It's helpful to remember that not everyone has the visual acuity, physical fitness and coordination, and awareness that you may be fortunate enough to have. What may not seem a problem to one person can cause a serious accident for another.

Your Program Plan

The beginning of this chapter mentioned four steps in a risk reduction program. The discussion below outlines these steps. You should document your program continuously to demonstrate your good faith in reducing risks.

Management Commitment and Employee Involvement

The first step in an effective program is the decision to start *now.* Management must make it clear that they are committed to taking cost-effective action to reduce slip-and-fall risk. Decide who in your organization is the most appropriate person to manage your slip-and-fall risk reduction program. Have this person develop an action plan for the program. This includes identifying the person who will take responsibility for each action. Include periodic reviews to make sure the program is advancing as intended. As the program proceeds, establish objectives and budgets for each year.

Consider separately employee and visitor (including customer) safety. It may be feasible to take special actions to protect employees through such methods as training and slip-resistant footwear. Remember that your employees are valuable assets, and in a healthy business, their loss from injury can cost you a lot more than medical expenses. In addition, when your employees get hurt, you pay through workers' compensation (and through your productivity-related losses) no matter whose fault it was.

For areas to which visitors have access, normally your plan must provide safety under conditions of little or no training, and uncontrolled footwear.

Site Assessment

Review several years of accident and complaint records to see if they indicate problems that you need to address. Talk to floor care personnel to learn their concerns. Since they walk on the floor when it's wet and soapy, make sure they understand the importance of good treads.

Walk through each site and decide whether you need testing to evaluate certain floor areas. At the same time, visually inspect stairs and ramps for proper design and construction according to your local building code. Check for distractions (by mirrors, posters, displays, etc.) for pedestrians who are using stairs. Make sure lighting is adequate in pedestrian areas, remembering that some people have impaired vision.

If your property includes outdoor walkways or courtyards, check them too. Watch out for smooth surfaces. Even if they're a relatively small part of the area and are included for decorative effect, smooth walking surfaces can be treacherous when there's rain, dew or snow. Pedestrians who are walking on rough surfaces such as broom-finished concrete may take long strides that cause them to slip when they step on a surface that has unexpectedly lower traction.

Then have in-house personnel or outside specialists test flooring and walkways for slip resistance as appropriate. See Chapters 5 for a description of tests for static coefficient of friction and surface roughness to assess slip resistance of flooring. Chapter 11 tells you how to prioritize flooring risks using those test data. Chapter 10 describes periodic Tortus testing for areas where you need to monitor floor maintenance to maintain optimum slip resistance of the flooring.

Hazard Prevention/Minimization

Try to assure that walking surfaces that may become wet or otherwise lubricated are appropriate slip-resistant materials — as described, in Chapter 5, by Table 5-1 and the corresponding information for barefoot areas. Establish procedures for specifying new floors so that new construction or renovation of existing properties won't result in purchase of new problem flooring. For work areas where spillage is inevitable, consider whether flooring should have spillage displacement volume (see Chapter 5.)

Look at areas where people enter from outdoors. Make sure that slip resistance will be adequate for whatever weather is likely to occur. Remember that a short length of absorptive floor mat isn't necessarily enough to keep the floor beyond it dry. Consider arranging for special precautions during periods of rain or snow.

It's obvious that floors must be kept clean and orderly, and that spills on floors that are slippery when wet or otherwise lubricated must be cleaned up as soon as possible. See Chapter 12 for other risk reduction techniques. Farther on in the present chapter, we'll summarize some of the most cost-effective methods of reducing risk.

Chapter 10 discusses floor maintenance. Award floor-care contracts based on safety, not just on cost and cosmetics. Establish and control the frequency of cleaning, buffing/scrubbing and restoration of floor finishes based on safety with due consideration of the manufacturers' recommendations. At drugstores, supermarkets, perfume counters, and other places where customers inevitably test spray products, give special consideration to maintenance and make sure that the flooring is appropriate for this situation.

When your program starts to show results, ask your insurance carriers whether they'll discount your premiums based on your reduced risks.

Training for Employees, Supervisors and Managers

Consider giving employees information on how the design and condition of their solings affect slip resistance. This can help them be safe not only at work, but also off the job. For jobs in which slipping is a high risk, consider a partial subsidy for slip-resistant footwear. You may want to allow shoe vendors to visit the work site periodically to make it more convenient for employees to buy slip-resistant footwear during their lunchtime or other breaks.

Have responsible employees set up procedures for periodic inspections of areas that are likely to have spills. Make sure employees know that the first priority when a spill occurs is to warn people not to walk through it.

Give supervisors and managers information on how they can reduce risks cost-effectively in their areas. Make it clear that well-chosen investments in risk reduction are a valuable part of their service to your organization.

Training is not just a one-time thing, but must include periodic refreshers. These can be in the form of posters, seminars, memos, verbal reminders, or any method that helps employees realize that even though risks may have decreased, the appropriate actions remain the same.

New Technology Solves an Ancient Problem

For thousands of years, people have appreciated the beauty of smooth, glossy floors. Unfortunately, usually such floors when wet are slippery.

Slip-resistance requirements imposed by the insurance industry in Germany have resulted in an innovative process (see Figure 15-1) that improves stone or porcelain tile slip resistance, to footwear or bare feet, with little impact on gloss. A regional processing center applies the process to ceramic tile or stone before the flooring is installed. At the processing center, a laser burns "divots" in the surface that are about one-thousandth of an inch deep, eight thousandths wide and spaced some

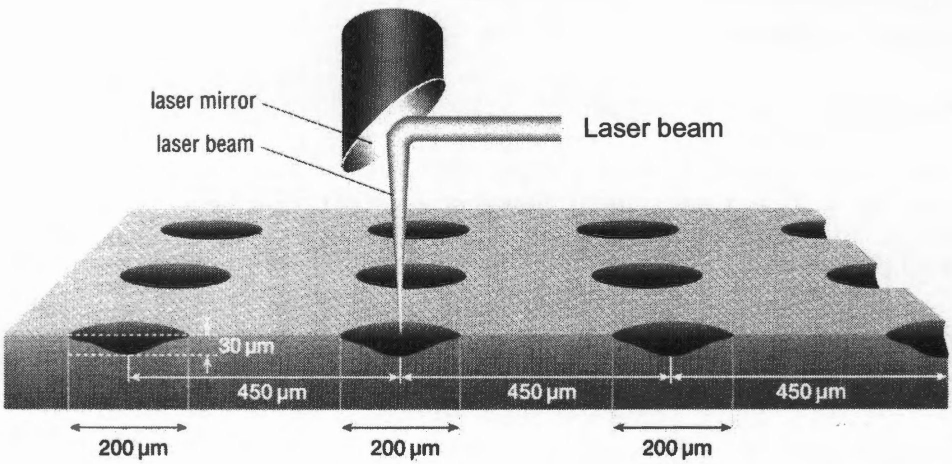


Figure 15-1.
Schematic of the SafeStep process for treating tile and stone. Dimensions are in micro-meters (µm); 25.4 micro-meters = 0.001 inch

20 thousandths of an inch apart, with closer spacing when higher slip resistance is required. A surface that before treatment is very slippery when wet can be raised to R9 or R10 shod slip resistance, or to A, B, or C barefoot slip resistance. The increased traction comes mainly from suction force. Because the divots have gentle contours, the flooring reportedly is easily cleanable.

Surface roughness is increased, from what might be as low as two to four microns, to 11 microns or more. The appearance of the flooring changes very little, and a glossy look can be maintained despite the increased wet slip resistance.

Treated products are available in the United States through distributors of many European-manufactured tiles. Although the process isn't presently applied on tile and stone produced in the United States, it can be applied by Italian, Spanish, and German producers before the flooring is shipped to their United States distributors. Already applied in six countries (including the major ceramic-tile-producing countries), the process is expected to be established in the United States in the year 2000. The vendor is SafeStep, located in Walls, Mississippi (Telephone: 901-484-0301. Web site: www.safestep.de). The process is also offered, under the name ViboGuard, by Villeroy & Boch (Telephone: 714-774-2454). If you're planning new construction or renovation and you want a glossy tile or stone floor, look into this option.

Top Ten Ways of Stopping Accidents

Here's a countdown of some of the most simple and cost-effective ways of stopping slip and fall accidents.

10. **Post warnings when and where appropriate.** This is the least satisfactory way of handling a problem, and you should use it preferably as a temporary solution while planning to implement a permanent one. Warnings must be conspicuous and, to the extent possible, use pictographs to be understandable to people who aren't literate. The preferred background color is Safety Yellow. Even the best warning signs might go unnoticed, though. Due to distractions or heavy foot traffic people might not see the warning. If they need to go through the area, they might slip despite their best efforts. For an area that pedestrians can avoid, consider cordoning off the area. Signs plus safety tape or safety yellow chains can do the job.

Many hardware stores sell warning signs. You can also obtain signs and warning tapes from Emed Co. (1-800-422-3633; web site www.emedco.com) or Grainger Industrial Supply (outlets throughout North America; web site www.grainger.com).

9. **Use solings appropriate to the situation.** With some solings, it's difficult to avoid slipping on a wet floor even if the floor is "slip-resistant." Use the principles in Chapter 6 when you select footwear.

8. **Chemically etch or grind concrete if it's too smooth.** Smooth concrete can be very slippery when it's wet. Contractors normally roughen a concrete walking surface after it's poured, but sometimes this important step is omitted.

7. **Make sure stairs comply with your local building code, and that nosings are easy to see (even for a visually impaired person).** Stairs need to have uniform rise and run, and handrails that are firmly mounted and easy to grip. Avoid having confusing carpet patterns on stairs, or steps so uniform in appearance that it's hard to tell where each step's nose is. On hard surfaces, abrasive tapes can help.

6. **Specify appropriate slip resistance for new flooring.** Use the information in Chapter 5 to select the correct minimum slip resistance for the situation. Don't buy problems.

Ceramic tile is very much an international business, and most tile sold in the United States is made overseas, with Italy and Spain being the biggest suppliers. Many overseas manufacturers can supply their U.S. distributors with variable-angle ramp test categories (also known as German standard DIN 51130 test data) for their products. Here are a few examples:

U.S. Distributor	Telephone
Agrob Buchtal	770-442-5500
Azuvi, Inc.	714-632-9390
General Ceramic Tiles	305-591-8140
Villeroy & Boch	714-774-2454

Domestic tile manufacturers can also obtain ramp test data for their products.

Slip-resistant vinyl-based resilient flooring is available in rolls from Altro Floors (1-800-565-4658; web site www.altrofloors.com). In addition to flooring for areas where shoes are worn, Altro supplies special dimpled flooring for bare feet in wet areas.

For many types of flooring and other architectural products, some of which are advertised as slip-resistant, see Sweet's Homebuilding & Remodeling Catalog File (1-800-892-1165; web site www.sweets.com).

5. **Use mats and rugs in sensitive areas.** Where spills of water or other liquids from drinking fountains or from ice or beverage vending machines are likely, absorbent mats or area rugs (with slip-resistant backing) can help to confine spills and prevent slips. Make sure the mats have beveled edges and are not tripping hazards. At entrances where there's flooring that's slippery when wet, provide enough length of matting to dry solings while the wearers are walking. A length of five yards or so may be needed. If you don't supply entry mats and there's an accident, you may be in a very weak position.

4. **Apply abrasive tapes or abrasive coatings.** Abrasive tape can improve the situation on stairs, but replace the tape if it becomes loose, worn or torn. For abrasive coating of floors that can't be chemically etched, epoxy with alumina (aluminum oxide) particles is often a good choice. Make sure the grit size is appropriate for the situation, and that the effectiveness of the abrasive is not masked by too thick a coating on top of it.

3. **Maintain surveillance of potentially slippery areas, and clean up spills before anyone falls.** Glossy vinyl flooring without exposed abrasive content is very likely to be slippery when wet. Constant or frequent surveillance is required, especially in places such as a supermarket, where spills could occur at any time. When a spill occurs, act immediately to make sure no one steps in it. Then clean it up and make sure no one steps on the floor until it's dry.

2. **Trap rain, mud, and snow at the entrance.** In warm weather, place an abrasive mat outside and an absorptive mat inside. In cold weather, put an absorptive mat just inside the door, followed by an abrasive mat. When mats get dirty or saturated, they must be exchanged for clean ones. Consider

offering plastic bags at the entrance for umbrella storage so people don't shake out water from their umbrellas far into the building.

1. **Chemically etch ceramic tile and stone that is slippery wet.** Select your contractor carefully, because inept etching can permanently damage the flooring. Cost of etching large areas is typically $1–$2 per square foot. Make sure that on level floors, the static coefficient of friction, wet, measured by the ASTM C 1028-96 test method after etching exceeds 0.60. Wet slip resistance can be improved significantly without necessarily affecting peak-to-valley surface roughness much.

   In some cases it's feasible for in-house personnel to perform microscopic surface texturing at much lower cost than contractor acid etching; see "Chemical Etching of Tile and Stone" in Chapter 12.

Falls caused by slips, trips and missteps are the largest cause of injuries to the public. Using the principles in this book, we can eliminate the conditions that cause most falls. Then we can all get on with the business of living without the pain and suffering, disabilities, premature deaths, and heavy financial losses that accompany these accidents.

Part IV:
Legitimate Lawsuits and Fraud

What's in this part —

Personal injuries with more than trivial damages are often settled with the aid of attorneys. The first chapter in this part discusses some things that you should do immediately following an accident, when lawyers might not yet be involved.

Following that, Chapter 15 discusses slip-and-fall fraud and gives some hints that might help you assess whether a claim of an accident that happened on your premises is part of a scheme to collect damages through fraud.

CHAPTER

14

Too Late! The Lawsuit

If you're reading this book because an accident has already injured you or someone on your property, you may need advice from a Personal Injury Attorney (if you're the injured party, a potential Plaintiff) or a Defense Attorney (if you're a potential Defendant). It isn't the purpose of this book to tell you how to win a lawsuit — there are several books on that subject. This chapter contains information that will help you to avoid making mistakes before you've contacted an attorney. The discussion below is a general one, and specifics may vary from one legal jurisdiction to another.

Chapter 4 discussed some cases studies of slips, trips and missteps in which the damages were large. High-dollar cases often involve serious spine or head injuries. Consequences can be severe and may last a lifetime. As one slip-and-fall victim, a young pregnant woman, said, "my life changed in an instant."

If You're the Victim

If you have a slip-and-fall accident, you can't always be sure at first how serious your injuries are or what your total losses will be in terms of pain and suffering and lost income. You should do some things immediately.

1. **Report the accident.** You or a friend or relative should make sure the owner or proprietor of the property knows immediately that the accident occurred on that property. At many business properties, the Security Department will take care of this. Before leaving the premises you, or your friend or relative, should politely ask to take away a copy of the written accident report. If asking doesn't work, insist. This may be the only chance your attorney has of getting a copy of this report.

2. **Don't assume that what you tell doctors about the cause of the accident is confidential.** Notes taken in the emergency room or other medical facilities may show up later during litigation.

3. **Preserve your footwear and affected clothing for later examination.** Store the footwear you were wearing in a non-biodegradable plastic bag; don't use the footwear again until your claim is settled. Don't wash clothing that shows grease, bloodstains, etc. relevant to the accident.

4. **Ask someone to make photographs of the accident scene and surroundings.** A friend or relative can do the job; snapshots are better than no photographs at all. The idea is to record the scene before significant things are changed. A $10 disposable camera with flash is okay if a personal camera isn't available. If a video camera is available, that can also be satisfactory, particularly if lots of camera angles are needed or motion (like showing someone jiggling a loose handrail, for instance) is important.

   The area surrounding the accident scene might be important because of tracked-in grease from a nearby parking area, for instance. How many pictures are needed? As many as necessary to show the situation. It's hard to give a number, but don't hesitate to shoot a full roll of 24 exposures from different heights and angles. Indoors, use a fast film such as 400 or even 800 speed; the flash might not penetrate very far.

5. **Make photographs of your injuries and subsequent condition as you recover.** When insurance adjusters or jurors need to know about your injuries, a picture can be worth a thousand words.

6. **Decide quickly whether you need to get an attorney involved.** If you do need an attorney, his or her investigation should preferably start before any of the evidence is gone and witnesses become impossible to trace.

   Most slip-and-fall claims are for less than $10,000. If your costs seem certain to be only medical expenses of a few hundred dollars, with no lost income or other damages, you might not need an attorney. Make sure that you have the time and patience to do what's required to get fair compensation.

If you think you might need an attorney, you must choose one very carefully. It's very important that your attorney has the knowledge, financial resources, and specific experience needed and is willing and able to put in the time and hard work do a good job for you. We'll discuss this subject further in the pages that follow.

Document the Accident and Your Condition

While the facts are fresh in your mind, fill out the five-page questionnaire at the end of this chapter. If you engage an attorney, give him or her the questionnaire. Don't show it to other people, or it will no longer be an attorney-client privileged communication.

Buy a bound diary and record, in ink, how you feel (pain and suffering because of the accident) daily or at least weekly. Keep records of your medical visits and expenses and any other losses (such as lost earnings) resulting from your injuries.

If you want some heavy reading to do while you're recuperating, you might want to try, *How Insurance Companies Settle Cases,* (James Publishing, Costa Mesa, California) by Clinton Miller, who is an insurance litigation consultant and expert witness. Although it aims primarily at attorneys representing plaintiffs in automobile accidents, the book gives some interesting insight into how insurance companies go about handling accident claims in general. It includes, among other things, discussion of some techniques not written in insurance-company claims manuals, such as lowballing, unreasonable delays, and intimidation.

Engaging an Attorney

Unless you already know and trust an attorney who has been very successful in obtaining slip-and-fall settlements, you should probably have no-charge conferences with at least three personal injury attorneys before engaging one. These conferences will be educational for you and are vital for evaluating the attorney and your case.

Find out the attorneys' track records in this type of case. Ask if they are familiar with the latest edition of attorney and forensic expert Charles Turnbow's book, *Slip and Fall Practice* (James Publishing). It may be available in a local or county public law library, if not on your attorney's bookshelf.

You may want your attorney to work on a contingency basis, meaning that the law firm is paid only out of the award you receive, if any. This means that the attorney's pay could be zero. Since the risk can be high, you can understand why the attorney may want what seems to you like a large share of the proceeds (like one-third or more) for fees and expenses.

The high risk also explains why you might need to pay, as they occur, various out-of-pocket expenses incurred in preparing your case. This arrangement is more likely when the case is a small one. If the potential damages are large, the law firm might bankroll your legal expenses.

While you're weighing up your prospective attorney, he or she will be weighing the potential hourly income to the firm from taking your case. If the damages are relatively small and/or liability appears difficult to prove, the attorney might decline to handle your case. Important factors to the law firm also include the likelihood of getting paid for their efforts, what hourly compensation they're accustomed to, how heavy their case load is, what period of time is likely to pass before the case is settled, and how a jury is likely to react to you as a witness. For a law firm that has high overhead, spending large amounts of attorneys' time for net proceeds to their firm of $20 per hour, or maybe nothing at all, is not an economic proposition.

The attorney you select might elect to decline your case later, after finding out more about it. Subjects of interest to the attorney (and to you) include who the responsible parties are, and whether the responsible parties have sufficient insurance or assets. Also crucial is the issue of *notice.* Did the potential defendants know, or ought to have known, that there was a hazard? Your attorney will need a good strategy for making this point.

Salesmanship and negotiating skills are important in your attorney. The attorney must "sell" your case to the claims adjuster or to the other side's attorney. Most cases of this type settle out of court, and it's best if your attorney doesn't aggravate the other side to the point where they don't want to concede anything.

Forensic Experts

It may be necessary to have a slip-and-fall forensic consultant investigate your case, particularly if the defense has a similar expert who apparently disagrees about the technical causes of your accident. Your attorney would engage your side's consultant, so that the initial findings would be privileged information. However, since the consultant may have an important role in your case — and because you might need to pay his or her fee — you will want to be comfortable with the qualifications and credibility of the person chosen.

In addition to a slip-and-fall consultant, sometimes a *human factors* consultant is needed. This specialty involves evaluating how people respond to stimuli such as the things they see and hear, and how they physically accomplish certain tasks. Human factors involve the psychology as well as the biology of the person as they relate to the cause of the accident.

In contrast to other witnesses, a forensic consultant testifying in litigation is permitted to express an *opinion*, based not only on the facts of the case but on his or her background and experience in the field. Your consultant should base his or her opinion primarily on facts and will not necessarily be favorable to your case.

If the consultant performs the investigation early enough in the proceedings, and the opinion is unfavorable but seems incorrect to you, it's preferable from your standpoint that the consultant is not called on — by either side — to testify. This is why the consultant should be engaged early in the case. If you're fairly sure that the consultant is wrong, another consultant can be engaged before *expert witnesses* are designated for courtroom testimony. When a consultant is *designated* as an expert witness by your attorney before you know the consultant's opinion, if his opinion is unfavorable to you it may be too late to prevent him from being called to testify.

Depending on the circumstances of the accident and the damages, other expert witnesses in a slip and fall court case might include one or more biomechanics experts, engineers and construction experts, orthopedic surgeons, neuropsychologists, psychiatrists, chiropractors, vocational rehabilitation experts, economists, certified public accountant ... well, you get the idea.

Unlike your lawyer, expert witnesses can't take a case on a contingency basis — that arrangement might tend to bias their testimony, or at least raise suspicion of bias. This means that expert witnesses have to be paid, even if you lose your case and receive no award at all.

Many experts require payment in advance for any work they do on a case. An arrangement to pay your expert after the fact might raise questions in a jury's mind as to whether the expert won't get paid unless his or her testimony is favorable to your case.

If You're Potentially a Defendant

There could be many defendants in a slip-and-fall case, for instance the property owner, the architect or designer, the general contractor, the flooring vendor, the flooring installer, the floor polish vendor, the tenant company on the premises, the floor maintenance company, and for good measure those perpetual defendants the Doe family, often listed simply as "Does 1 through 50." If the attorneys identify other potentially responsible parties eventually, those names will replace some of the Does. Most often, though, there are only one or two actual defendants.

If you're at the scene and are a potential defendant, immediately after taking care of the emergency aspects of the accident you should document what happened. Refer to the questionnaire that starts on the next page for some of the relevant facts that should to be documented if you have the information. Observations of the victim's footwear could be important — its color, style, soling type, and condition. Make photographs of the scene. Preserve as possible evidence recordings from video monitors in the area. They may be your best defense against fraud (see the next chapter).

If a potentially hazardous condition (such as a slippery floor) did exist, you're not necessarily required to preserve the hazard until a claim settles — that could cause more accidents. Check with your insurance company or your attorney if you think you should change an existing condition promptly.

SLIP/TRIP AND FALL ACCIDENT DESCRIPTION

CONFIDENTIAL: Attorney-Client Privileged Communication

Victim's name:

PLEASE ANSWER THESE QUESTIONS TO THE BEST OF YOUR KNOWLEDGE BUT IF YOU HAVE NO IDEA OF THE CORRECT ANSWER, DON'T GUESS.

Concerning the scene of your accident

At what type of place and what address did the accident occur?

Where at that address? (In lobby of office building, front entrance of store, etc.)

When? (Date and time of day)

What type of walkway? (Stairway, ramp, level floor, parking lot, etc.)

What type of walkway surface? (Ceramic tile, marble, wood, etc)

Was there a transition in walkway surface? (Carpet to tile, wood to marble, etc.)

If slope or stairs, were you ascending or descending?

Was the surface in good physical condition? (Even, unbroken, etc.)

Was it contaminated? (Wet, oily, dirty, littered, etc.)

Do you think that the floor was slippery? If so, do you think this contributed to the accident?

Were there any other dangerous conditions? (Broken railing or step, uneven floor, etc.)

Were there any signs posted warning of dangerous conditions or urging caution?

Was weather a factor in the accident? If so, describe how:

Was lighting a contributor to your accident? If so, please describe the lighting (artificial or natural, glare from floor, lighting too dim, etc.):

Your footwear

What type of footwear were you wearing? (Athletic shoes, sandals, high heels, etc.)

Was it in good condition before the fall?

How about after the fall? (Broken strap, broken heel, etc.)

What was the heel material? (Rubber, leather, etc.)

What was the sole material?

Do you think your footwear may have contributed to your fall?

Have you worn it since the accident?

NOTE: *Stop wearing this footwear and preserve it as is for expert examination later. Also preserve, without cleaning or repair, any clothing or other items that were stained or damaged in the accident.*

Your condition at the time of the accident

Height:

Weight:

Age:

Do you require corrective glasses or contact lenses?

Were you wearing them at the time of the accident?

Were you under the influence of prescription or non-prescription drugs or medications?

Had you consumed alcohol?

Did you have any disabilities or were you more than two months pregnant?

Was your attention distracted? If so, by what?

Your activity

What were you doing when the accident occurred?

Were you hurrying?

Were you changing direction or turning a corner?

Were you carrying or pushing anything heavy or that blocked your view?

Did you have small children with you?

Were you talking with someone?

Were you a customer of the place where the accident occurred? If so, do you have receipts, credit card vouchers or other proof of the date and why you were there?

The accident

How did the accident happen?

Did you fall forward or backward? Onto your left or right knee, buttock, hip, etc.?

Were there witnesses?

Please list witnesses:

Name (if you know it)	Male/ female	Companion, another customer, employee, etc.	Approximate age

Were any of the witnesses in uniform?

Immediately after the accident

Did any witnesses speak to you?

What did they say?

Did building, company or store personnel (other than witnesses) speak to you about the accident?

Did you have assistance from building, company or store personnel?

If so, from whom? (Describe persons if you don't know their names)

Were other (non-medical) personnel called to the scene?

Was any cleanup of the site (spills, dirt, etc.) done? If so, please describe:

Your personal background

Have you ever claimed more than $1000 in medical expenses and other damages from a previous slip-and-fall or trip-and-fall accident?

Your social security number:

Do you hold a driver's license in the State in which you reside? If so, year obtained:

Additional non-medical information

Please supply any other information that you feel is relevant to events leading up to, and immediately following, your accident.

The Sting: Slip-and-Fall Fraud

CHAPTER 15

Among insurance fraud practitioners, slip-and-fall claims have historically been one of the most popular scams. One reason for this is that there are many floor surfaces that really are slippery when wet or otherwise lubricated, so that property owners and their flooring vendors often find themselves in a weak legal position. Another reason is that in legitimate slip-and-fall accidents, the victim is often the only witness, and a jury can't always expect bulletproof corroborating testimony.

Let's look at some of the characteristics of a typical slip-and-fall scam, and how honest folks — whether property owners, flooring vendors, or just ordinary insurance-premium-paying citizens — can avoid becoming victims of this type of fraud. First, we'll consider why an insurance company might settle a potentially bogus claim without contesting it in court.

How to Lose a Lawsuit

Insurance companies settle out of court (and eventually raise their policyholder's premiums accordingly) when they can see a good chance that they'll lose big time if they go to trial. When an apparently genuine personal injury has occurred with alleged premises liability, ingredients necessary for the injured person to win an award are (1) presence of a *hazard* such as a slippery floor, (2) *notice,* meaning that the defendant knew, or should reasonably have known, that the hazard existed; (3) *causation* of the injury as a result of the hazard, and (4) *duty* of the defendant to have eliminated the hazard under standards of ordinary or reasonable care. Did you notice that most of these items deal with the *defendant's* actions before the accident, rather than anything the alleged *victim* did or didn't do?

Before we start bashing the victim, let's remember for a moment that the (innocent) victim might someday be you. If you hate physical activity and like the idea of being on disability for the rest of your life, a real slip-and-fall accident could be a godsend for you. However, if you enjoy your work or sports, are an expectant mother, or perhaps a successful businessperson, a slip-and-fall can be a tragedy that changes your life forever — and for the worse. Consider whether your career, hobbies, or love life might deteriorate even because of injuries that are hard to prove, such as constant headaches or back pain.

The people most at risk of serious injury in slip-and-fall accidents are women over age 50. Their bones may have been significantly weakened by osteoporosis — which means that when they fall, the injuries are likely to be bone-shattering and lead to complications from surgery.

The Hazard

Now let's return to the *hazard.* Consider a floor that's in a building lobby or a fast-food restaurant where it could easily get wet or greasy. Wet, because people in lobbies often shake out their umbrellas after they've walked over those long, clean absorbent mats placed inside the door. Greasy, because in a restaurant grease occurs not only in spills but as settling particles suspended in the air itself. Such floors need to have not only high static coefficients of friction, dry and wet, but also adequate peak-to-valley surface micro-roughness to prevent hydroplaning, which can momentarily make traction nonexistent.

In an industrial or commercial environment where oily or greasy substances are present, greater surface roughness is necessary than where water is the only contaminant. The important thing is to make sure that the flooring selected is suitable for its use (as described in Chapter 5) and then to maintain it properly.

Notice

An uninjured person who gripes about your "slippery floor" might seem like a pest. But that complainer can be either your best friend or your worst enemy, depending on how you react. If the floor really is slippery, take appropriate action promptly to correct the situation. Make sure the floor is cleaned appropriately — don't just use a damp mop that spreads grease around. If the floor is tile or stone, appropriate treatment (such as chemical etching) by a competent, experienced contractor might make a big improvement. For wood, concrete, or resilient flooring, other types of remedies are available. If you should choose to try to save a few bucks by ignoring the hazard, remember — you are under notice!

"Actual" notice from a third party isn't essential to prove negligence. If you *should have* discovered the hazard by using ordinary care, that's "constructive" notice. A manufacturer of ceramic tiles or an architectural firm should know the slip resistance of flooring before it's installed. An aerospace company or fast-food chain that has full-time safety professionals is certainly in a position to have the coefficients of friction and surface roughnesses of existing flooring tested and compared with suitable criteria to establish suitability of use. Often others whose expertise is not nearly so clearly defined as this also find they are considered to have been under constructive notice.

Failure to inspect regularly is often a costly issue for owners or occupiers of commercial properties. In some supermarket cases, the jury has decided that inspections every 12 minutes are necessary.

Causation

There must be a link between the hazard and the alleged injury. However, any competent con artist should be able to set up that match by giving sufficient thought to the staging of the accident.

Duty

If the known hazard could have been prevented or eliminated at reasonable cost, one or more of the defendants probably had a duty to do that. Slip-and-fall damages sometimes far exceed a million dollars for a single accident — imagine the damage to your own life and income if you were unable to do your work, drive, shop at the supermarket, dance, or play a sport ever again. So you make the call: what's a reasonable prevention cost? Just complying with the local building code is seldom adequate — most codes are vague when it comes to slip resistance of flooring. Jurors may be unsympathetic to a property owner or occupier who could have solved a known problem at trivial cost but was too stingy or lazy to do it.

The Sting

Now let's look at some of the possible ingredients of a successful slip-and-fall sting. These items are not evidence or even indicators, but might be helpful clues. Remember that you may someday be the innocent slip-and-fall victim who gets further hurt by unfounded suspicion.

Let's consider some questions insurance investigators or attorneys might ask about the location, the "victim" (claimant), the witnesses, the injuries and other damages, the offer to settle out of court, and the victim's doctor and lawyer, if any are involved in the case. Since we hate to be fooled and generally want to trust people, let's hope that any suspicions we might have are unfounded.

The Location

A building that's open to and used by the general public is a good site for a slip-and-fall scam because the owner is likely to have "deep pockets" to pay the claim. Busy times for the building or business staff when there are few other witnesses (like just before Friday dinnertime in a restaurant) make it more likely that the staff will have been distracted by their other duties and not able to provide damaging testimony against the scammer.

Private workplaces and homes are not immune from personal injury fraud. Workers' compensation is a source for funds that ultimately come from the employer. People about to be laid off or evicted might become claimants. Visitors to a private home may claim injury, and the homeowner or tenant could even be an accomplice planning to share in the insurance payoff.

The Victim

Is the victim a "real" person who answers the telephone, has a street address (not just a post office box), can be interviewed at home by the insurance investigator (before the case is in litigation), and has a legitimate social security number and a driver's license that he or she got more than two weeks ago? Does he remember his doctor's and lawyer's names without looking them up? Are other family members on workers' compensation benefits? Fraudulent claims might be submitted either repeatedly by a group of seasoned professional con artists or on a one-time basis by an opportunistic amateur or beginner con.

The Accident

Let's say the victim slipped on a patch of liquid on the floor, and sustained a very bloody nose along with skinned knuckles and other claimed injuries. Could the victim or an accomplice have brought along the lubricating liquid, or picked it up on-site (for instance, if the site is a supermarket) and have planted it on the floor moments before? Could the victim have brought along a syringe of blood to squirt up his nose? Could the victim have been willing to skin his own knuckles to make the show more convincing?

If the accident happened at work, was it an unexpected circumstance? For instance, was the employee doing physical labor during his lunch hour, or out of his normal work area?

The Witnesses

Good — there are impartial witnesses, one a businessman visiting town from Cleveland, another a lady tourist from Houston. The insurance investigator might contact them later at home by telephone to confirm some details. But don't forget, today it's simple and inexpensive to establish a voice mail number in a distant area code, or to have your calls automatically transferred from an out-of-town number to your present location. A cellular telephone with an out-of-town area code might be "in town" full time. The "victim" in last week's accident might become a witness to this week's accident, which injures one of last week's "witnesses," at another location.

The Damages

Well, the injuries are definitely confirmed — they show up on X-rays. But did they occur in the claimed incident or years before in a high-school football game? Or last Saturday night when the claimant accidentally ran his car into a tree? Sometimes detailed questioning of the victim's physician is in order.

Maybe the victim also had other damages. Her designer eyeglasses were smashed. Not only was her vacation ruined, but also the expensive camera she was carrying was destroyed. Could the broken items have been props that were already broken and worthless when the claimant brought them onto the premises?

If the claimant suffers lost earnings, are her corroborating documents typed on blank paper rather than business letterhead? Is her employer a real firm? Is she a long-term or a new employee? Is the length of her absence from work consistent with the extent of injury?

The Offer to Settle

It's good that the facts of an accident are established as soon as possible. However, a claimant who's too anxious to settle for a reasonable amount to "get this over with" and continue on his interrupted vacation is worth a further look. The after-effects, medical costs, and lost wages of a real slip-and-fall accident sometimes go on for years.

The Victim's Doctor and Lawyer

Medical and legal professionals may be either willing or unwitting accomplices. An accurate medical report can be "doctored" by a scam artist and reproduced at a neighborhood copy shop for submission so that the changes are hard to detect. Is the medical report written wholly or partly in layman's terms? And don't forget that a doctor too can be conned — how much would you respect your doctor if she didn't believe you when you told her you were in pain?

Not all physicians and chiropractors are immune to the pleasures of unearned income. Do records show that treatments were often carried out on Sundays or holidays? Is the treatment inconsistent with the diagnosis? Does a minor injury stubbornly refuse to respond to expensive treatment?

Personal injury attorneys often work for a percentage of the hoped-for award rather than being paid by the client on an hourly basis. This system involves risk for the attorney, but helps make sure that even the poor have a chance against large insurance companies.

A legitimate attorney hates to spend hundreds of his labor hours, and perhaps considerable out-of-pocket expenses, only to find out at trial that he has been working for a scammer. Unscrupulous attorneys might be part of a slip-and-fall mill. But let's not get into the lawyer jokes just now. Willing participation by doctors and lawyers is more common in the higher-stakes auto-accident fraud game than in slip-and-fall.

Bye Bye Belli

Famous attorney Melvin Belli once was in court pressing a $3,000,000 slip-and-fall lawsuit against Kentucky Fried Chicken for a middle-aged schoolteacher. An incriminating surveillance tape suddenly surfaced from a previous claim the woman had filed (through a different attorney) against Disney World. During a short recess, without a word Belli's client got into a car and disappeared, leaving the surprised and embarrassed Belli in the courtroom! She has since served time for fraud in both cases.

Business Conditions for Scammers

Like any legitimate or illegitimate business, slip-and-fall scams are affected by the climate of the times. Juries in the United States today tend to be more conservative than in some times past, being more reluctant to hand out huge sums based on dubious evidence. Insurance companies are aware of this and many don't settle as easily as before, preferring to spend more money on legal proceedings and less on quickly settling small "nuisance" claims.

The trend toward insurance deregulation and mergers means a scramble for cost cutting so that underwriters can offer low premiums to beat the competition and get money in the door. Some of the risk-reduction services insurance companies performed that once were considered good business have been subject to cost cutting or elimination.

Don't Take the Fall

Insurance fraud hurts all honest folks by raising insurance premiums and, indirectly, consumer prices. Anyone whose responsibility includes flooring or premises liability might feel the pain from slip-and-fall fraud even more intensely. How do you defend against these scams?

Don't Be Negligent!

Negligence in safety matters could be defined as, "failure to act reasonably under the circumstances." When you know that there's a hazard, take action to eliminate it. If you don't know but "ought to know," make sure you act to find out what the hazards are before an alleged accident occurs.

To a scam artist, property negligence is a beautiful sight to behold. You too should be looking for hazardous situations on your property that may caused by unsuitable flooring, lubricants, or inappropriate maintenance practices. Act to solve the problems before someone gets hurt.

Don't think you're in the clear because your business property is used only by paid workers, with customers and members of the general public not invited in. Scams can occur under workers' compensation, and there's also the possibility of lawsuits against you from subcontractor personnel and outside sales representatives who visit.

When building or remodeling, choose flooring carefully with the floor's use in mind — see Chapter 5. Remember that maintaining an appropriately high static coefficient of friction is necessary, but may not be sufficient, for good traction. Static tests don't specifically evaluate hydroplaning potential, which exists when liquids are present and is greater for viscous liquids (like motor oil or hamburger fat) than it is for water. Peak-to-valley surface micro-roughness of the flooring is measured in the laboratory at little added cost ($50 or less) and is a criterion for evaluating hydroplaning potential. Where wetness or other contamination is inevitable, a relief surface may be appropriate in addition to sufficient micro-roughness.

Consider testing existing floors in place to see if the materials and maintenance practices are appropriate for the use of the floor. A small change in maintenance practices, perhaps intended to reduce cost, may turn out to be expensive. The combination of static coefficient of friction and surface roughness assesses suitability of existing flooring (see Chapter 5). Where maintenance is an issue due potential causes such as to changes in maintenance contractor or employee performance, changes in the maintenance products used, or tracking of oil and grease in from outside, use a contractor skilled in use of the Tortus instrument (Chapter 10).

Employees should be alert for slipping or tripping hazards that unavoidably occur from time to time. In some locations, like a little-used supermarket restroom, it may be understandable that no one sees or reports the problem for an hour. In other locations, like around the grape display or within a few feet of a manned checkout stand, there might be little excuse for not clearing up the problem within a few minutes of its occurrence.

Take Notice

Don't ignore complaints of slippery floors. Not only are they legal notice (see "Notice" earlier in this chapter), but they can be a helpful tip-off that there's a problem.

Blow the Whistle

Honest witnesses can help by being willing to report details and to testify if necessary. The best witness sometimes is your company's video surveillance system, which can provide "Film at 11" about what scammers did to set up their accident. Finally, take advantage of the national organization that tracks patterns and perpetrators of insurance fraud: in the United States, if you know of a confirmed insurance scam, report it to the National Insurance Crime Bureau at 1-800-TEL-NICB.

Appendix:
A Few Key References

Bowman, R., various publications listed on web site www.dbce.csiro.au/pubs/slip/, CSIRO, Australia. *Research and efforts to achieve consensus on a practical national slip resistance standard in Australia.*

Coté, R., *Life Safety Code Handbook,* National Fire Protection Association, Quincy, MA (telephone: 1-800-344-3555), revised periodically. *A U.S. national reference for providing safe egress from buildings and other structures.*

German Institute for Standardization (DIN), Methods DIN 51130, DIN 51097, and DIN 4843. *Variable-angle ramp slip resistance test methods for flooring where shoes are worn; flooring for barefoot areas; and footwear.*

German National Accident Insurance Board, Accident Prevention and Industrial Medicine Department, Munich, Code of Practice GUV 26.17, "Code of Practice for Floor coverings in Wet Barefoot Areas," April 1986. *Guidelines for traction in barefoot areas.*

Grönqvist, R.,"A Dynamic Method for Assessing Pedestrian Slip Resistance," People and Work Research Reports 2, Finnish Institute of Occupational Health, Topeliuksenkatu 41 a A, FIN-00250, Helsinki, Finland, 1995. *A survey of, and important contribution to, pedestrian slip resistance knowledge.*

Head Office for Accident Prevention and Industrial Medicine, "Guidelines for Floors in Work Rooms and Work Areas with Increased Slipping Hazard," ZH 1/571, Sankt Augustin, Germany, October 1993. *Slip resistance guidelines for areas where pedestrians wear shoes.*

Hughes, C., "Evaluation of Ergodyne," RAPRA Technologies, Shawbury, Shrewsbury, Shropshire, United Kingdom, February 2, 1993. *Tests of the instrument later known as the English XL.*

Hughes, C., "Evaluation of the Ergodyne," ibid., August 9, 1993. *Further tests of English's device.*

Hughes, C., Report No. 3, "Further Ergodyne Tests," ibid., April 8, 1993. *A third series of tests of English's device.*

Hughes, R.C., and James, D.I., "Slipping Determinations — Magic and Myth," undated paper, RAPRA Technologies, Shawbury, Shrewsbury, Shropshire, United Kingdom. *The first report on the relationship between wet slip resistance and peak-to-valley total mean roughness of the surface.*

James, D.I., "The Theory behind the DIN Ramp Tests," *Polymer Testing* 18 (1999) 3–10. *Comments on the variable-angle ramp test.*

Jung, K., and Schenk, H., "Objectification and Accuracy of the Walking Method for Determining the Anti-Slip Properties of Floor Surfaces," Zentralblatt for Industrial Medicine, Accident Prevention and Ergonomics, Vol. 39 (1988), No. 8, pp 221-228. *Precision study of the variable-angle ramp method, using 98 human subjects.*

Kyed, P.J., "Human Traction versus ASTM F 1679-96 Measurements: A Comparison of Ice and Wet ACRYZINC™ Sheet," Bethlehem Steel Homer Research Laboratories, Bethlehem, PA, March 10, 1999. *Assessment of the English XL portable instrument as a potential indicator of human traction.*

Manning, D.P., Jones, C., Rowland, F.J., and Roff, M., "The Surface Roughness of a Rubber Soling Material, Determines the Coefficient of Friction on Water Lubricated Surfaces," Health and Safety Laboratory, Broad Lane, Sheffield, United Kingdom, 1997. *How peak-to-valley total mean roughness of solings affects slip resistance on wet walking surfaces.*

Manning, D.P., Jones, C., Rowland, F.J., and Roff, M., "The Surface Roughness of Footwear Soling Materials; Relevance to Slip Resistance," J. Testing and Evaluation, November 1996, pp. 368-376. *Further information on roughness of solings and wet slip resistance.*

Sotter, J.G., "Phase I Final Report: Research toward the Rapid Minimization of Slipping Incidents on Construction-Site Steel Products," report to AISI OSHA/ SENRAC Steel Coalition, submitted to U.S. Occupational Health and Safety Administration, June 1998. *Exploratory study of slip-and-fall issues in steel erection.*

Standards Australia / Standards New Zealand, "Australian / New Zealand Standard: Slip Resistance Classification of New Pedestrian Surface Materials," AS / NZS 4586:1999, www. standards. com.au or www. standards.co.nz. *Following Germany's lead after extensive research of their own, Australia and New Zealand adopt the variable-angle ramp method as a standard for testing new flooring for areas where footwear is used, and for barefoot areas.*

Standards Australia / Standards New Zealand, "An Introductory Guide to the Slip Resistance of Pedestrian Surface Materials," HB 197:1999, www. standards. com.au or www. standards.co.nz. *Expanded version of Germany's guidelines for slip resistance and spillage volume displacement in areas where footwear is used, and for barefoot areas.*

Templar, J., *The Staircase,* (two volumes) Massachusetts Institute of Technology, Cambridge, MA, 1994. ISBN 0-262-20082-1. *The history, art, and science of stairs, beautifully illustrated.*

United Kingdom Slip Resistance Group, "The Measurement of Floor Slip Resistance: Guidelines Recommended by the UK Slip Resistance Group," Issue 2, circulated by RAPRA Technology Limited, Shawbury, Shrewsbury, Shropshire, United Kingdom, May 2000. *Description of test methods using the Surtronic 10 and the British Pendulum.*

Wilson, M., and Russell, R., "Slip Resistance Assessment and Accident Prevention," SATRA Bulletin, July / August 1997, pp. 130-135. *Features of good tread design for footwear used on wet surfaces.*

Wilson, M., "Slip Resistance Characteristics of Footwear Solings Assessed Using the SATRA Friction Tester," Journal of Testing and Evaluation, Vol. 24, No. 6, Nov. 1996, Kettering, United Kingdom, pp. 377-385. *The effect tread, or lack of tread, of solings has on wet slip resistance for materials of a range of hardnesses.*

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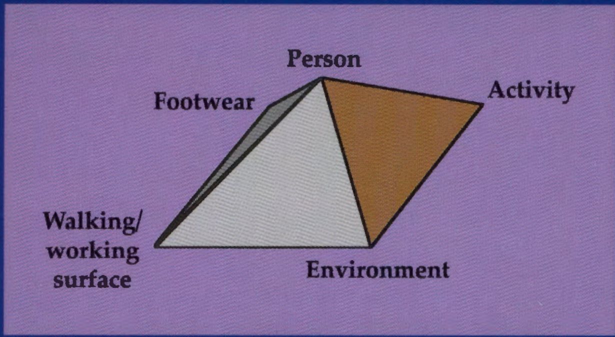

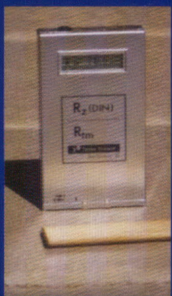

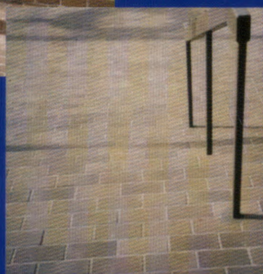

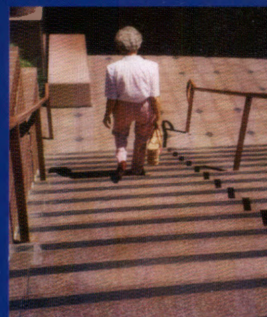

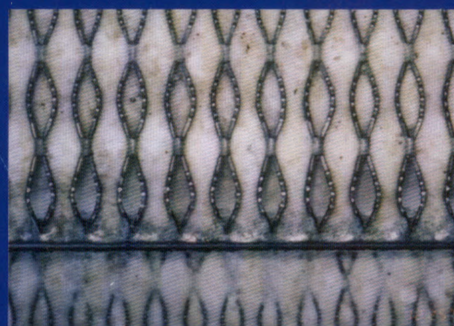

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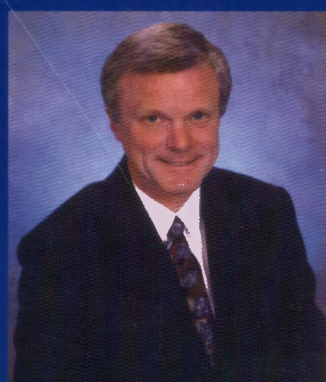
George Sotter, Ph.D. is a registered Professional Engineer who specializes in preventing and investigating accidents caused by slips, trips and missteps. His clients include attorneys, builders, floor treatment or maintenance companies, flooring manufacturers, insurance companies, property owners and managers, and restaurant chains.



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