Fall Prevention and Control

The concepts and solutions in this article have application both for business operations and for workers' compensation.

Architectural and human factors play an important role when people fall. It is important to understand these factors in order to develop and implement an effective risk reduction program.

Problem Overview

Customers and employees alike fall down and sustain injuries. Some injuries are disabling and very costly in claims dollars, public relations, lost work or productivity, etc. As is the case with the majority of accidents, most slip, trip and fall accidents are **preventable**. Although it is obvious that accidents due to falls are a problem, few people recognize its magnitude.

Definitions

A ***"fall"*** is the interruption of the human locomotion process. A fall occurs when a person is unable to regain his or her balance and erect posture after slipping or tripping. The terms *"slip and fall"* and *"trip and fall" refer* to this process or occurrence. Generally, a *"slip and fall"* occurs when a person loses his or balance because there is insufficient friction between the forward moving heel and the surface on which the person is walking. A "trip and fall" occurs when a person loses his or her balance because the forward motion of the non-weight supporting foot hits an obstacle in the walkway. Usually, people slip and trip without falling. Only a small percentage of slips and/or trips result in falls.

There are three categories of falls:

- Falls on level areas.
- Falls on ramps and stairs.
- Falls from elevations.

This discussion only covers falls on level areas and falls on ramps and stairs that occur in buildings or on sidewalks.

Architectural Elements

Slippery walking surfaces (inadequate friction) and defects, such as raised edges, cracks, gaps and holes (surface continuity) are the two most common contributing factors in fall accidents.

When people walk, the friction between the shoes they wear and the walking surface allows for forward motion. The National Bureau of Standards refers to this as "anti-slip coefficient friction." The lower the "anti-slip coefficient friction" is, the more slippery the surface is. The accurate measurement of the coefficient friction is extremely difficult. Most testing authorities still do not agree on the best procedure or equipment to use for this task. In addition, the friction measurement is as dependent on the material of the heel and sole of the shoe as it is on the walking surface.

Research has shown some friction is necessary to prevent a shoe from slipping as it first strikes the walking surface and is rolled forward to transfer the body's weight and provide continuing forward thrust.

If the friction in the area between the shoe and walking surface is too low, a slip can occur. The slip may or may not result in a fall.

The occurrence of a fall is dependent upon the following factors: a person's age and physical condition and the level of the friction. For example, when people slip on ice, or other extremely slippery surfaces, they quickly scramble to regain their footing. However, they usually fall because the very low coefficient friction of the ice does not allow them to keep or regain their balance.

Walking Surface Construction

The makeup of a walking surface construction material is an important element that determines walking surface friction and its hazard level. The following is a summary of the hazard levels of common construction materials:

High Hazard Level

High hazard materials include floor materials, such as terrazzo, glazed ceramic tile, marble and granite. These have a have a very low anti-slip coefficient of friction. When wet, these surfaces become extremely slippery. Unfortunately, these are common materials in high traffic areas, such as entryways and stairs.

Medium Hazard Level

These include wet or weathered wood, unglazed ceramic tile and vinyl tile. These usually have an adequate anti-slip coefficient of friction. However, they require precautions during maintenance. An excessively buffed surface becomes a high hazard and is unsuitable for pedestrian traffic areas. Although smooth, finished concrete is adequate when dry, it becomes very slippery when wet and is, therefore, a high hazard.

Slight Hazard Level

Many materials provide an adequate level of surface friction, even when wet. Such materials include rough-finished concrete, carpet, and dry, well-maintained wood.

When evaluating surface friction conditions, it is important to consider potential environmental changes. Snow, ice and rain significantly reduce the "anti-slip coefficient of friction" of walking surfaces. Low areas subjected to "puddling" will freeze and result in ice patches. Down spouts that discharge water across areas meant for walking may also create reduced surface friction and may result in icy walks during winter months.

Newly installed surfaces may provide adequate levels of surface friction, but they can deteriorate over time, depending upon usage. This is common with stairways where many people use the path of travel closest to the handrail.

Surface Continuity

Uneven surface continuity is the second most common contributing factor to fall accidents. A person unconsciously adjusts his or her stride to the "anticipated walking surface continuity." This adjustment normally occurs during the first few steps. Even the slightest change in surface continuity increases the chance of a fall. Cracks, holes, raised edges, gaps, debris, spauling, scaling or pitted surfaces, exceeding one-half inch in height, depth or width, are conditions that contribute to a lack of surface continuity. Other conditions are torn carpeting, doormats, raised door thresholds, loose boards and nails

on boardwalks and docks, loose stair nosings, missing manhole covers, missing caps on utility valves, and other similar defects.

Other Architectural Elements

Illumination

Inadequate illumination can contribute significantly to slips, trips, and falls. Sufficient natural or artificial illumination can reduce or eliminate this problem. Illumination should be at a level that allows pedestrians to easily see the walkway and any changes in it. Changes include stairs, ramps, turns, or other conditions. The normal recommended minimum level of illumination is at least one foot-candle measured at the walking surface. One foot-candle is enough illumination for a person with normal vision to be able to discern the contours of the walkway.

Stairways

Improper Construction and Design: Stairways are also a common source of falls. Research has shown that the vast majority of accidents on stairways result from improper construction, poor design and hazardous conditions. The most common accident on stairways is a fall while descending. The usual cause is a slip or misstep due to a substandard design, or the existence of hazardous conditions on the stairway. The most common substandard design feature is a stairway with low risers and long tread surfaces, or high risers and short tread surfaces. Hazardous conditions include slippery conditions, foreign objects on walkways, loose carpeting, and worn or polished metal nosings. These conditions are responsible for a large percentage of the accidents on stairways.

Steep Stairways: The rise angle of the stairway is important. There is a significant correlation between stairways that rise at angles of 39° to 40° or greater and falls resulting in serious injuries. Accidents occur for several reasons. First, a person may be unable to properly evaluate the angle or height and may misjudge the step. This causes him or her to stumble and fall. In part, the misjudgment may occur because of a "learned pattern." The person has become accustomed to using properly designed stairs with a somewhat lower angle of rise.

Handrails: Another problem related to steep stairways is that the handrails are usually at the same slope as the stairs. The handrail, therefore, is not within the "lunge range" of a falling person. As the person falls, his or her outstretched hand is at a much higher plane than the handrails. Installing handrails that meet code requirements corrects this problem. Handrails can sometimes prevent stumbles, slips and trips from turning into falls and can reduce injury potential and severity by breaking some falls.

Riser Height: Probably the most important aspect of stair geometry is riser height (height of each step) and tread depth. If a riser is too high, the foot tends to land too far out on the tread of the next lower step. Consequently, the ball of the foot to has little or no support from the tread surface. If the riser is too low, the foot lands so far back on the next lower tread that the heel of the opposite foot catches as the person lowers it to the next step. Both of these conditions can cause missteps resulting in falls. Correcting riser heights can contribute to a reduction in slips, trips, and falls. In addition, risers should be uniform in height and depth within a given stairway.

Tread depth is the actual depth from each step or riser. Adequate depth is necessary to provide safe support for the feet when climbing and descending stairs. Inadequate depth causes the ball of the foot to land in an open space or slip on the edge of the step. A tread that is too deep causes the heel of the foot in motion to catch the edge of the step. Steps that are either too narrow or too deep can also lead to falls.

Generally, riser heights should be between 6-1/2 inches to 7-3/4 inches. Tread depths should be between 9-1/2 inches to 10-1/2 inches, exclusive of any nosing or overhang. Various building codes and the Life Safety Code mandate step dimensions within this approximate range, depending upon the building's occupancy. Stairways above and below these ranges pose a significant potential for a fall.

Human Factors

Walking is virtually an automatic series of body movements linking together a continuous series of steps. There is little, if any, conscious thought to the process. The brain processes information so quickly that most people can easily accommodate changes in surface continuity or obstacles in the way if they see or anticipate them. It is the unseen and the unanticipated change or obstacle that causes trips and/or loss of balance in falls. However, the type of surface a person is walking on as well as the individual's age and physical condition can determine his or her gait and the likelihood of an accident.

When a person begins walking, the brain adjusts the gait and stride to accommodate "anticipated walking surface conditions." Sensory feedback from the feet, eyes, and so on defines the anticipated conditions. During the first few steps, the brain, after processing the sensory feedback, measures the friction of the walking surface relative to the person's shoes and any anticipated obstacles. The brain then sets the stride and gait to accommodate the anticipated walking conditions. When anticipated conditions change significantly, the potential for a fall greatly increases.

When walking from an area of adequate surface friction to one having less surface friction, such as from a clear sidewalk to an icy one, the foot will loses traction and rapidly slips from its intended position. The result is normally a fall. This type of incident occurs because of an unanticipated encounter with a very low friction-walking surface. If an individual begins walking on a continuous icy surface, the brain modifies a person's gait and stride to accommodate this condition. The person gives much more conscious thought to walking in an attempt to deal with the unusual conditions. He or she takes deliberate, slower and shorter steps to reduce the necessary friction needed to walk forward.

The same situation occurs in a trip and fall incident. As a person begins to walk on a smooth surface, such as a public sidewalk, the brain sets his or her gait and stride for the surface conditions. If the person encounters an obstruction or changes in elevation in the walkway, an accident can occur. Changes as little as 1/4 inch in height on a walkway can cause a trip or stumble. This is important to remember when evaluating the condition of sidewalks or other walking surfaces.

People can easily accommodate changes and obstacles on walkways if they see or anticipate them. It is the unseen and unanticipated changes that cause trips and/or loss of balance resulting in falls.

The age and physical condition of individuals using walkways can also affect the probability of falls. Small children tend to shuffle their feet making them more apt to fall. However, the probability of a severe injury is small. Senior citizens, by contrast, tend to be more cautious when walking to compensate for the changes in the physical conditions that accompany aging. These changes include reduced eyesight, slower reflexes, a declining ability to regain balance, less muscle pliability, and more brittle bone. As a result, older adults are more likely to sustain severe injuries than children and young adults.