Identification of Flooring Having Sustainable Wet Slip Resistance

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The widely-accepted principle of safety by design, as well as U.S. laws and building codes, require that flooring be slip-resistant over its life cycle — not just at the time of installation. Safety criteria based solely on static coefficient of friction, often used in the U.S. for assessing safety, are too often misleading where flooring gets wet or otherwise lubricated in use. Over 150 safety criteria have been adopted in Germany and Australia for specific situations — swimming pool decks, commercial kitchens, restrooms, etc. These are based on a laboratory test device, the variable-angle ramp, that is not readily portable. The pendulum tester is a portable ASTM method, has been used successfully since at least 1971 for assessing pedestrian traction potential, and is a national standard for pedestrian traction in 44 nations on four continents. Abrasion of a flooring sample, tested with the pendulum before and after, is being used to assess "Sustainable Slip Resistance." Some architects and property owners are now combining this pendulum-based test with situation-specific safety criteria to specify and verify safe flooring.

Introduction

The purpose of this paper is to provide an overview of a particular testing method and selection criteria for use in choosing and sourcing slip-resistant flooring that maintains good tribological characteristics over its life cycle. The test method is known as Sustainable Slip Resistance (SSR), and together with situation-specific safety criteria is becoming an established methodology in certain international venues.

In safety engineering it is widely accepted that "safety by design" is the most reliable method of preventing accidents; people should not be expected reliably to use safety equipment (e.g. slip-resistant footwear) or exercise special caution ("Slippery [or wet] floor" warnings). If flooring is in an area where it can get wet or otherwise lubricated (airborne deep-fryer fat, automobile grease, etc.), it needs to be slip-resistant under such conditions.

Although it is sometimes assumed that flooring slip resistance never changes with time, experience of building and cruise ship owners shows that this is not true. Wear from shoes plus abrasive soil on a busy floor, or certain inappropriate maintenance practices, can in some cases reduce the wet slip resistance in a matter of weeks — or even an hour.

Post-construction cleanup using an abrasive pad has in a number of instances destroyed the slip resistance before the building or outdoor swimming pool has even opened. One well-publicized example was at the Watershed Centre in Kilkenny near Waterford, Ireland. The tile installed had good barefoot slip resistance, but this was destroyed by post-construction cleanup with an abrasive pad before the pool opened. In the four months after the new pool opened in December 2008, there were 28 reported slips and falls while various remediation methods were tried. The pool subsequently was closed until April 27, 2009 (Kilkenny Alive, 2009) after being remediated successfully by chemical treatment. Numerous lawsuits are in progress.

The Americans with Disabilities Act (ADA) requires that flooring accessible to disabled persons be slip-resistant — not just when the building is constructed, but throughout its lifetime. Typical building codes in the USA require that "Every existing building, structure, premises or portion thereof shall be maintained in conformity with the code regulations and Department approvals in effect at the time of such construction and occupancy ... Every existing building, structure, or portion thereof shall be maintained in a safe condition and good repair … all physical elements of every existing building, structure or portion thereof shall be maintained … by restorative means, in a condition as close as reasonably feasible to their originally required and approved state." (City of Los Angeles, 2008)

If a building owner can be confident that his or her new flooring will sustain its slip resistance for a period of years this can protect a considerable investment in the flooring and prevent business interruptions as well as protect the safety of the pedestrian. The stakes are even higher for hotels and cruise ships, which are occupied virtually nonstop with guests who will not tolerate the noise involved in changing out hard flooring.

Sustainable Slip Resistance (SSR) testing was developed by Strautins (2007, 2008) in Australia for McDonald's Restaurants to identify flooring that is not highly susceptible to loss of its slip resistance from wear or some types of inappropriate maintenance. This test and appropriate selection criteria can help avoid investment in inappropriate flooring as well as prevent costly, life-altering accidents and increased healthcare costs. This paper explains the method and how it can be used to improve flooring safety in the USA.

Test Methods and Safety Criteria

Germany and Australia have for over 10 years had detailed flooring slip resistance standards based on some 150 specific situations — e.g. external walkways, swimming pool decks, swimming pool stairs, commercial kitchens, hospital operating rooms, etc. (Sotter, 2000; CTIOA 2001a) Many architects elsewhere in Europe have informally adopted them. The slip

resistance ratings are based on humans walking an oily or wet flooring sample in standard footwear and/or bare feet on a laboratory variable-angle ramp the repeatability of which was extensively documented (Jung and Schenk, 1988). However, the test results apply only to flooring before it is installed. In some cases initially good wet slip resistance is gone after the building has been open for only a few weeks. The ramp test can't be used to assess safety of the flooring on site under the ambient conditions.

The United Kingdom has since 1971 had well-established slip resistance standards based on a portable test method, the pendulum. This test was developed for pedestrian traction by the U.S. National Bureau of Standards in the 1940s and further refined in the UK (Giles *et al.*, 1964). It was validated for pedestrian traction in 1971, together with its safety standards, in the UK over a period of 25 years by 3500 real-world public walking area tests and site accident records (Greater London Council, 1971, 1985). The test is an ASTM standard (E 303), slightly modified for pedestrian traction.

In the USA, architects and designers generally look for a wet static coefficient of friction of 0.60 or higher by ASTM method C 1028 to assess potential safety for wet areas of level floors. This can give deceptive results, applying "safe" ratings to some flooring samples that are in fact very slippery when wet (Powers et al., 2007). The method is now acknowledged by ASTM (2005), Ceramic Tile Institute of America (2001b), and Tile Council of North America (Astrachan, 2007) to be inadequate for assessing safety.

The ASTM C 1028 method does not represent the most current state of knowledge about testing methods, but this is not widely known by American architects and property owners. An objective in this section is to correct this situation and suggest a more useful test and safety standards (safety assessment) for due diligence based on the pendulum. The pendulum is now a standard test method for pedestrian slip resistance in 44 nations (European Committee for Standardization EN 13036-4, 2003 names many of them) on four continents and has been endorsed by Ceramic Tile Institute of America since 2001 (CTIOA, 2001b).

The SSR test procedure consists of an initial wet pendulum test; abrasion, wet, for up to several thousand cycles with a standard (100x100 mm 3M green Scotchbrite) abrasive pad under a standard load of 1 kg at 50 cycles/min; and another wet pendulum test after abrasion. Both hard and soft rubber pendulum sliders (or "test feet") might be used if the area is walked on in both hard-bottom footwear and bare feet or soft-soled footwear. The abrasion is conducted either manually, or mechanically using a Gardco 12VFI linear washability and wear tester.

Typically, about 85 percent of the loss in slip resistance after 5000 cycles has already occurred after 500 cycles (Strautins, 2008). Depending on the flooring buyer's situation, the flooring might be considered to have Sustainable Slip Resistance for a level floor if (for example) the wet Pendulum Test Value (PTV) is 35 or higher after abrasion for 500 cycles. The 500-cycle result in the laboratory has been found by in situ pendulum tests to be roughly equivalent to 6-12 months of wear in customer areas at a busy McDonald's Restaurant. The 500-cycle specification was adopted by McDonald's in Australia in October 2006. Other

major property owners such as Aldi, Toyota, Westfield and a major cruise ship company have adopted similar specifications.

In the USA, flooring with SSR is available in ceramic tile, natural stone, and resilient products. Abrasive-containing coatings, some transparent, are also available that have SSR.

In some cases, analogous to the variable-angle ramp test-related standards mentioned above, the SSR safety standards are situation-specific (Natspec, 2009; Bowman, 2010) rather than "one size fits all." Thus a minimum pre-abrasion wet PTV of 35 might be required for hotel or hospital bathroom floors; a minimum of 45 (hard rubber slider) for stair nosings that get wet in use; and 54 (hard slider) for commercial kitchens and steep outdoor ramps. If the flooring is to be sealed after installation, the laboratory tests should be conducted with the correct sealer applied. Cleanability tests with expected contaminants (local mud, coffee, red wine, ketchup, etc.) by owners and/or other duty holders are also advisable before final selection of flooring. The methods of cleaning (Tari, Brassington *et al.*, 2009) should be planned. (A dirty mop with dirty water might not be adequate for non-slip flooring, but abrasive pads can destroy wet slip resistance quickly.)

Experience has shown that what is specified and ordered is not always what is delivered, and it is prudent for property owners to verify that flooring meets their slip resistance specification both before installation and at turnover of the property for occupancy. Monitoring of slip resistance every 3–12 months after that can further protect pedestrian, owner, and other duty holders.

Conclusions

Sustainable Slip Resistance as a test method and formal or informal standard provides advantages over formalized and standardized test methods currently in place, in that it addresses a most important component of product utility: the ability of the test method to assess potential product wet slip resistance over its life cycle. The ability of the surface to maintain its slip resistance over time and with wear is a significant aspect of product use, and the informal adoption of this standard as part of due diligence potentially establishes conformance with the state of the art in surface slip resistance determination.

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