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Standard Practice for Selection of Walkway Surfaces When Considering Pedestrian Safety[1]

This standard is issued under the fixed designation F3132; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice outlines key elements for selecting new or planned walkway surfaces for reduced risk of slips and falls. It is intended for use by those involved in decisions regarding selection of interior and exterior slip resistant walkway surfaces under expected use conditions. Elevation and obstacle risk, trips and falls are excluded from this standard.

1.2 Conformance with this standard practice will assist in the reduction of slip and fall risk on walkway surfaces.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use. Where more stringent standards exist, those standards should be followed.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

F1646 Terminology Relating to Walkway Safety and Footwear

F1694 Guide for Composing Walkway Surface Investigation, Evaluation and Incident Report Forms for Slips, Stumbles, Trips, and Falls

F2508 Practice for Validation, Calibration, and Certification of Walkway Tribometers Using Reference Surfaces

F2965 Guide for Selection of Walkway Surfaces and Treatments When Considering Aggressive Contaminant Conditions in Commercial and Industrial (Not Including Construction) Environments

2.2 *Other Documents:*

ANSI/TCNA A137.1 American National Standard Specification for Ceramic Tile

3. Terminology

3.1 See Terminology F1646 for the following terms: *contaminant*, *fall*, *pedestrian*, *ramp*, *slip*, *slip resistant*, *slip resistance*, and *walkway*.

3.2 *Definitions:*

3.2.1 *aggressive contaminants, n*—See Guide F2965.

3.2.2 *available friction, n*—an inherent characteristic of a walkway surface that would result in measurable friction upon the attempted or actual sliding of another object across that surface; can only be measured using a method, apparatus and contaminant (if any) that have their own inherent influences on the measurement value itself.

3.2.3 *friction, n*—the resistance to the sliding of one surface across another surface; may be evaluated through different methodologies and described using different terms.

4. Significance and Use

4.1 Use of this standard practice will enable architects, design and construction engineers, facility managers, property managers and safety professionals to be more proactive in reducing the risk of slips and falls through selection of walkway surfaces and materials. This standard practice will help with decisions regarding selection of slip resistant walkway safety solutions at the design phase of new construction and renovation as well as maintenance during occupancy phases. This standard practice should reduce the need to treat or replace slippery walkway surfaces post installation.

4.2 The information in this standard may be superseded by federal and jurisdictional regulations and laws.

5. Selection of Walkway Surfaces

5.1 *General:*

[1] This practice is under the jurisdiction of ASTM Committee F13 on Pedestrian/Walkway Safety and Footwear and is the direct responsibility of Subcommittee F13.50 on Walkway Surfaces.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

5.1.1 Walkway surface materials addressed in this standard are described in Guide F1694, subsection 6.3.2.2, Walkway Construction Materials.

5.1.2 Selecting walkway surface materials for specific applications and locations shall be in conformance with the manufacturer's recommendations.

5.2 *Conditions of Use:*

5.2.1 Conditions of use that determine the need for walkway surfaces with higher available friction include, but are not limited to:

5.2.1.1 Areas expected to be normally wet with water.

5.2.1.2 Areas where aggressive or persistent contaminants such as grease, oil, soils, or deicing materials are commonly found.

5.2.1.3 Typically-uncontaminated walkways that may become hazardously contaminated due to reasonably foreseeable misuse (for example, use of a walkway surface in a manner not intended by the specifier, manufacturer, or property holder but which may result from readily predictable human behavior).

5.2.2 Specify walkway areas where higher available friction may be required, for example restrooms, entrances, lobby areas, cafeterias or areas where water and contaminants are foreseeable in normal usage and through maintenance practices. See Section 6.

5.2.3 Conditions that shall be considered in the selection of walkway surfaces:

5.2.3.1 Whether the walkway is part of a code-mandated means of egress,

5.2.3.2 Durability of materials including applied finishes and coatings,

5.2.3.3 User characteristics such as age and physical disabilities/limitations,

5.2.3.4 Likely distractions and expected user degree of awareness of surroundings and conditions,

5.2.3.5 Slopes, ramps, or stair treads,

5.2.3.6 Low illumination levels below 0.2 ft.-candle (2.2 lux),

5.2.3.7 Facility owner/manager/employer control of expected footwear,

5.2.3.8 Existence of other warnings and informational devices,

5.2.3.9 Visual adaptation transitions (for example, from high illumination levels to low illumination levels),

5.2.3.10 Foreseeability and conspicuity of conditions,

5.2.3.11 Intended use and location,

5.2.3.12 Primary and transient contaminating processes,

5.2.3.13 Exposure to weather,

5.2.3.14 Anticipated maintenance (see 6.3.4 Janitorial Practices in Guide F1694),

5.2.3.15 Levels of usage such as expected pedestrian traffic, and

5.2.3.16 Facility commonly used by the elderly.

5.3 *Walkway Surface Manufacturer Laboratory Friction Data:*

5.3.1 Obtain and evaluate manufacturer friction test results for walkway surface products for when the walkway is dry. If walkway surface is recommended for use in wet areas, obtain and evaluate test results when walkway surface is wet.

5.3.2 Determine the appropriateness of testing (for example, wet testing for a wet environment). If the test method was "modified" (often indicated as "mod"), the modification should be documented particularly when selecting products for higher available friction or for other specific applications. Assess whether the testing procedure was clearly defined with details regarding modifications made to the test method.

5.3.3 Review the credentials of the testing organization, if available, and whether friction test readings (including outliers) are provided or just averages.

5.3.4 Recognize the limitations of the manufacturer's friction test data. Manufacturer's published results are for new products only. Available friction could change over time due to wear and floor maintenance.

5.4 *Evaluation of Friction Test Results of Flooring Materials:*

5.4.1 When walkway tribometer measurements are taken as part of the selection process, only walkway tribometers that meet the requirements of Practice F2508 shall be used.

5.4.2 If friction testing is conducted, perform the testing in accordance with the tribometer manufacturer's operational instructions or per a published standard test method. Friction test results from different tribometer models are not comparable.

5.5 *Surface Roughness:*

5.5.1 Surface roughness can affect available friction particularly when the walkway is wet or when grease, oil, or other friction-reducing contaminants are present.

5.5.2 *Surface Microroughness*—Typically measured with a stylus-type profilometer. While research on surface roughness measurement and slip risk is limited, some studies in the UK have produced guidelines on Rz roughness and slip probability. See Appendix X1, Surface Roughness Guidelines, Microroughness – Measurement and Slip Risk Research.

5.5.3 *Surface Macroroughness*—Certain walkway materials (for example, broom-finished concrete) have a high degree of inherent macroroughness. It is of note that walkways with high macroroughness can be more difficult to clean. Grit can be applied to walkway surface materials in coatings using broadcast or blended methods during construction/installation to improve available friction. Blended grits are generally more durable than broadcast methods. Types of grits in order of most to least durable include silicon carbide (Mohs hardness 9.5), aluminum oxide (Mohs 9.0), and silica or sand (Mohs 7.0). The uniformity of available friction on gritcoated walkway surfaces will depend upon the uniformity of the grit distribution. Grits and coatings manufactured for this type of application should be utilized in accordance with manufacturer instructions. See Appendix X1, Surface Roughness Guidelines, Macroroughness – Coatings and Surface Texture.

5.6 *Examples of Walkway Surface Materials:*

5.6.1 There are many flooring materials available. The following are material descriptions with comments on general frictional characteristics. Consult manufacturer specifications and recommendations for guidance on specific products but note that such information may be incomplete or obsolete if obtained from retailers or distributors.

5.6.1.1 *Quarry Tiles*—Quarry tiles are manufactured with unglazed or glazed surfaces, and some have structured/raised patterns or abrasive media to increase surface roughness and the available friction of the surface.

5.6.1.2 *Ceramic and Porcelain Tiles*—Ceramic and porcelain tiles are manufactured in many sizes and finishes. Some are intended for use only in dry areas and some are specifically engineered to have higher available friction in wet areas. Ceramic/porcelain tiles used in interior applications expected to be wet shall conform with the 2012 (or later) revision of ANSI/TCNA A137.1. Note there are some tiles with raised patterns or textures which may increase available friction or may be purely for aesthetic purposes. Gaps between mosaic tiles may increase available friction by increasing the "sharp" edges that may contact footwear; this effect may be reduced if the mosaic tile edges are rounded.

5.6.1.3 *Resilient Floor Coverings*—This includes vinyl tile and sheet vinyl, vinyl composition tile, "linoleum", rubber, cork and thermoplastic flooring. Check with manufacturers as many resilient floor coverings are not recommended for use in wet applications. Check with manufacturers regarding the use of polishes and coatings which may affect available friction.

5.6.1.4 *Dimension Stone (natural stone such as granite, marble, limestone, slates, quartz) and Engineered Stone*—Dimension stone flooring is typically made in a wide range of finishes, for example polished, honed/matte, flamed, bush hammered, etc. Available friction is affected by the stone finish and may differ depending on the type of stone. Smooth, polished dimension stone and engineered stone products should be avoided at entrances in wet and humid climates and around areas expected to be wet.

5.6.1.5 *Terrazzo*—This has similar surface characteristics to polished dimension stone and can be slippery when wet. Smooth, polished terrazzo should be avoided at entrances in wet and humid climates and around areas expected to be wet.

5.6.1.6 *Wood Floors*—Bare wood floors have varying grain characteristics that may affect the available friction of the surface. The effect of paints and other finishes on the available friction of wood flooring will depend upon the initial substrate roughness and the thickness of finish coatings. Wood finishes, any recommended additives, and maintenance products shall be used in accordance with manufacturers' instructions.

5.6.1.7 *Concrete*—Unsealed concrete may offer adequate available friction wet or dry, depending upon the method of finishing (for example, coarse broom finish versus smoothly polished). The effect of sealants or finishes on concrete slipperiness will depend upon the initial substrate roughness and the thickness of sealant/finish coatings. Manufacturer instructions shall be followed for sealers, finish coatings, and maintenance products.

5.6.1.8 *Laser Fused or Flame Sprayed Systems*—These systems utilize various, sometimes proprietary, methods to permanently fuse or bond complementary materials to a base substrate (typically metallic) to increase available friction. While the long-term durability of available friction varies with the type of system selected, these methods can be utilized on a variety of materials and shapes, such as flat plates, formed metals, ladder rungs, and grates.

5.6.1.9 *Resinous Floors*—Examples include epoxy, urethane, and acrylic/methlymethacrylate (MMA), polyurethanes and polyaspartics. Check with manufacturer and installer about methods to improve available friction where desired.

5.6.1.10 *Clay Brick Pavers*—Clay brick pavers are manufactured in many different sizes, but usually come in two basic textures, smooth and wirecut (rough). Wirecut textures provide higher available friction. Waxes and polishes that are often applied to brick pavers will affect available friction so information on their performance and proper usage shall be obtained.

5.6.1.11 *Unit Concrete Pavers and Slabs*—Precast concrete pavers and slabs may offer adequate available friction wet or dry and are manufactured in many different sizes, textures and finishes. Chamfers and certain textures enhance available friction. Joints between units also enhance available friction. Certain glazed, ground, or polished surfaces on these products may result in less available friction. Some sealants applied to concrete pavers and slabs will affect available friction. Manufacturer instructions shall be followed for sealers, finish coatings, and maintenance products.

5.6.1.12 *Painted Walkway Surfaces*—Certain painted walkway surfaces may be more slippery than unpainted surfaces; when deemed hazardously slippery, an additive may be required to increase available friction. Paints and any recommended additives shall be used in accordance with manufacturers' usage guidelines.

5.6.2 *Effects of walkway surface topography on tribometry*—Typical tribometer designs operate with more statistical reliability on planar walkway surfaces. Precision and bias statements in tribometer test methods are usually obtained from testing planar walkway surfaces. Specifiers should note that walkway surfaces with certain sculpted contours, patterned texturing, high particulate asperities, uneven low/high spots, or "terracing" (as on some slate flooring) may not be reliably testable using typical tribometers. This is due to the measurement sensitivity of typical tribometers to the position and direction of testing on such materials. As such, other methods may be necessary to characterize the available friction of such a surface and to verify its continued performance over time.

6. Planning

6.1 Proactive prevention of interior and exterior slips and falls requires preplanning by stakeholders including architects, design and construction engineers, facility managers, property managers, safety practitioners and others.

6.2 Walkway surface materials with higher available friction should be considered for areas with increased traction demand such as ramps and inclined surfaces, at entrances, and areas expected to be wet or soiled. Increasingly-steep ramps and slopes require comparably increased levels of available friction – for example, the available friction that is adequate for a 1:20 ramp may be inadequate for a 1:10 ramp.

6.3 *Building Entrances:*

6.3.1 Perform a risk assessment to determine likelihood of soils, water and contaminants being tracked into the building and contributing to slips and falls during inclement weather

conditions. Entrance design risk assessment for slips and falls includes the combination of whether an overhang is present, the available friction of exterior walkway surfaces including sidewalks and curbs, vestibule mat type/condition and lobby area walkway surface, mat type, and mat condition. Mats should only be relied upon to mitigate slippery conditions when management can reliably maintain mats in place whenever needed.

6.3.2 Select entrance mats appropriately made for removing water and soil from footwear, especially during inclement weather. Mats should have a slip resistant backing (as represented by the manufacturer) and not create a trip hazard (for example, through the use of beveled edges or thicker anti-curl backings). Mat options/alternatives include, among others, recessed grilles, recessed carpet tiles, or recessed mats with water absorbent surfaces that aid in soil removal from footwear. Mats are a maintenance item requiring management oversight to insure they remain properly positioned, free of wrinkles, adequately clean, and in serviceable condition.

6.4 *Restrooms and Food Service Areas*—Restrooms and food service area walking surfaces (where food or drink, or both, are served, carried or consumed) shall be slip resistant. Walkway surfaces which are slip resistant when wet or contaminated should be considered for restroom areas, around water fountains, and for other areas where walkway surfaces are susceptible to wet or contaminated conditions.

6.5 *Other Considerations:*

6.5.1 Transitions from a surface with higher available friction to one of lower available friction (including when there is an undetected water spill or debris on the walkway) are associated with an increased risk of slip incidents. Consider the use of surfaces having more uniform available friction, and consider mats, warnings or other effective controls to reduce the probability of slips at such transitions.

6.5.2 Research maintenance and cleaning protocols for slip resistant walkway surfaces or discuss with the manufacturer, or both, before disqualifying those slip resistant walkway surfaces that appear difficult to clean.

6.5.3 Heavily walked-on flooring is subject to wear which may reduce available friction. The level of available friction should be considered a maintenance topic requiring periodic inspection. The renewal of available friction may be necessary when wear has reduced surface texture.

7. Keywords

7.1 available friction; pedestrian safety; slip resistance; slip resistant; walkway surfaces

APPENDIX

(Nonmandatory Information)

X1. SURFACE ROUGHNESS GUIDELINES

INTRODUCTION

Surface roughness has been shown to have substantial effects on the friction between shoe heels and floor surfaces under various types of walking environments (**1**).[3] Surface roughness characteristics of flooring can reduce likelihood of a slip caused by hydroplaning effect, which may occur with water films or puddles of water. The guidance below explains surface roughness in two forms; topical microroughness and macroroughness associated with finish textures, coatings and aggregates.

[3] The boldface numbers in parentheses refer to a list of references at the end of this standard.

X1.1 Microroughness – Measurement and Slip Risk Research

X1.1.1 Microroughness measurements using a stylus-type profilometer can provide a relative set of numbers that measure how rough one topical surface is when compared to another. Microroughness measurements can estimate the relative slip risk of the floor's surface, measured in micrometers (μm). *Rpm* roughness represents the allowable volume of contaminant before the surface is fully covered. A surface with a larger *Rpm* value (Fig. X1.1.) or void volume can contribute to higher available friction and better slip resistance by allowing direct contact between the shoe and liquid-contaminated floor surfaces, by establishing direct solid-to-solid contact (**2**). A surface with a higher *Rpm* value is preferred (Fig. X1.1.) compared to a surface which has a lower *Rpm* value (Fig. X1.2.)

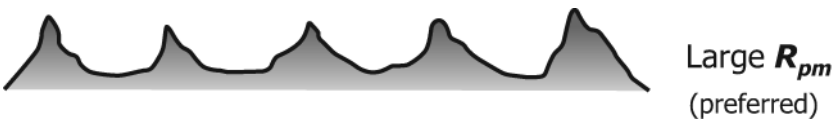

FIG. X1.1 Surface Roughness: Better Slip Resistance