

DAROFFDESIGN

Draft

August 1, 2014 Edit September 12, 2014

Recent Revisions to the State of the Art (& Science) of Testing for Slip Resistance of Interior Floor Tile Surfaces

By: James Rappoport, AIA - NCARB

Attorneys and their experts representing slip – trip – fall Plaintiffs, property owner Defendants and joined design professional should make themselves aware of recent changes in the art (& science) of testing for the slip resistance (* footnote # 1) of interior floor tile finishes.

Floor tile samples in many architects' and interior designers' resource libraries and literature provided to specifying design professionals as well as trade and over-the-counter customers at floor tile and home improvement centers, may still reference slip resistant testing methods and results based on tests that have recently been withdrawn by the Tile Council of North America (TCNA) (*footnote # 2) and ASTM (*footnote # 3). In my review the building code (* footnote # 4) and other literature describing the testing of floor tiles for slip resistance, I discovered confusion regarding a recent change in the art (& science) of testing floor tiles for slip resistance. This recent change in the art (& science) of testing for the slip resistance of interior floor tiles has/will likely alter the specifications for floor tiles and both Defendant and Plaintiff expert testing and legal presentations related to whether floor tile finishes as installed were/are compliant with Article 302 (slip resistance) and in Article 403 (floor or ground surfaces) in ADAAG 2010 (* footnote #5).

For ready reference I offer the following citations from ADAAG 2010:

302 Floor or Ground Surfaces

302.1 General. "Floor and ground surfaces shall be stable, firm, and slip resistant and shall comply with 302. "

Advisory 302.1 General. "A stable surface is one that remains unchanged by contaminants or applied force, so that when the contaminant or force is removed, the surface returns to its original condition. A firm surface resists deformation by either indentations or particles moving on its surface. A slip-resistant surface provides sufficient frictional counterforce to the forces exerted in walking to permit safe ambulation."

403 Walking Surfaces

403.2 Floor or Ground Surface. "Floor or ground surfaces shall comply with 302."

In my review of many floor tile samples and manufacturers' literature printed prior to 2012, I found reference to an ASTM testing method known as ASTM C 1028 (2007) and among both USA and EEC tile manufacturers the statement that some of their tiles are compliant with a test result of 0.6 for a level surface in a wet condition and a test result of 0.8 for a ramp in a wet condition. While these testing parameters seem to have been referenced by floor tile manufacturers prior to 2012, I could not find reference to slip resistance testing requirements in any of the more recent building codes and as noted above, ADAAG 2010 also does not specify testing means and methods for slip resistance or testing results.

In review of additional literature related to this subject of testing slip resistance of interior tile floor surfaces I confirmed the likely source for this 0.6 – 0.8 testing result in the following United States Access Board (* footnote # 6) article:

Chapter 4.5 Ground and Floor Surfaces

"Many variables affect the performance of a given walking surface, including slope and cross slope, its material,

jointing, texture, and finish, the presence of moisture or contaminants, the material that contacts it and the method of ambulation. Design guidelines cannot encompass all criteria contributing to the safety of a walking surface. ADAAG addresses surface material, texture, and finish and requires them to be "stable," "firm," and "slip resistant."

No standard or method of measurement exists for these characteristics except for slip resistance. A "stable" surface is one that is not permanently changed by ordinary contaminants or applied force so that when a contaminant or force is removed, the surface returns to its original condition under normal use. A "firm" surface is resistant to deformation by indentations or particles moving on or across it."

"Slip-resistance is based on the frictional force necessary to keep a shoe heel or crutch tip from slipping on a walking surface under conditions likely to be found on the surface. The static coefficient of friction provides a close approximation of a surface's slip resistance. ADAAG does not require compliance with a specified level of slip resistance since the static coefficient of friction, which can be measured in several ways, varies according to the measuring method used. (Recommended levels in the ADAAG appendix of 0.6 for level surfaces and 0.8 for ramps are advisory, not mandatory). Affected industries (floor finishes, ceramic tile, and plumbing fixtures) each employ a different testing method in designating the slip resistance of their products. In the absence of any specified means of measuring slip resistance, materials and products can be specified according to the values determined within the industry."

"ADAAG is not interpreted as prohibiting use of specific materials since texturing or other treatments may sufficiently enhance slip resistance, though some alternatives, such as applied surfaces, will require greater maintenance (reapplication) than others."

Access Board Recommendation:

"Slip resistance should be specified according to the conditions likely to be found on the surface. Exterior routes and spaces that are not protected, lobbies and entrances, bathing facilities and other areas where floor surfaces are often wet, should have a higher level of slip resistance."

In review of the tile industry literature I also confirmed that the source of the 0.6 – 0.8 testing guidelines came from the Tile Council of North America, who (prior to 2012) recommended the test method ASTM C 1028 and these 0.6 – 0.8 testing results.

Back in January of 1998 when the initial ADA accessibility guidelines were published (known as ANSI 117) (footnote # 7) there is a similar notice in the Appendix stating:

"The Occupational Safety and Health Administration recommends that walking surfaces have a static coefficient of friction of 0.5. A research project sponsored by the Architectural and Transportation Barriers Compliance Board (Access Board) conducted tests with persons with disabilities and concluded that a higher coefficient of friction was needed by such persons. A static coefficient of friction of 0.6 is recommended for accessible routes and 0.8 for ramps."

More recently I understand that the Tile Council of North America and ASTM withdrew this ASTM C 1028 testing method recommendation in favor of the ANSI A 137.1 (Section 6.2.2.1.10 "Dynamic Co-Efficient of Friction" (DCOF) (* footnote # 8) testing method. This new testing method apparently came from a consensus reached at the ANSI A 108 Standards Committee and I understand has been the guidelines set forth in EEC under certain DIN (German) standards. I further understand that the Tile Council of North America adopted this new ANSI A 137.1 standard in 2013 with the expectation that the industry as a whole would rely on their recommendations beginning in early 2014. I now understand that what was once a "recommendation" is **now a requirement**.

The testing method to achieve reliable results under ANSI A 137.1 is the use of a testing machine that is known as the BOT 3000 and while there is no actual parallel testing result when comparing the earlier ASTM C 1028 test result of 0.6 – 0.8 to testing results under ANSI A 137.1 with the BOT 3000 testing equipment, some knowledgeable experts have identified that a result of 0.6 tested with the ASTM C 1028 method is similar to a result of 0.38 tested with the ANSI A 137.1 test with the BOT 3000 testing equipment. I understand that design professionals could compare earlier tile tests under ASTM C 1028 testing at 0.60 with a test result of 0.42 with the BOT 3000 testing equipment for an interior tile floor finish that can become wet. However, given that the Tile Council of America has now deemed the ASTM C 1028 testing method to be unreliable, reference to this withdrawn testing method and/or comparison of results from this unreliable testing method to the ANSI A 137.1 testing method and results seems to be in and of itself unreliable.

I also note that the Tile Council of North America cautions as follows:

“Tiles with a DCOF of 0.42 or greater are not necessarily suitable for all projects. The specifier shall determine tiles appropriate for specific project conditions, considering by way of example, but not in limitation, type of use, traffic, expected contaminants, expected maintenance, expected wear, and manufacturers’ guidelines and recommendations.” “Tile installations exposed to elements which reduce traction can create slippery conditions where the risk of a slip cannot be completely eliminated.” Tiles with a DCOF of less than 0.42, shall only be installed when the surface will be kept dry when walked upon and proper safety procedures will be followed when cleaning the tiles.”

Meanwhile, I understand that UK and EEC tile manufacturers became frustrated with ASTM C 1028 because of various and unreliable results from the so called 50# Hand Pull Slip Static Coefficient of Friction (SCOF) testing device defined by ASTM C 1028 and this frustration seemed to result in reliance on the English XL Variable Incidence Tribometer (* footnote # 9) testing device engineered to test for ASTM F 1679-04 and ANSI 1264.2. I understand that neither of these testing methods have been adopted by the Tile Council of North America and that ASTM F 1679-04 was withdrawn by ASTM itself.

Also, meanwhile, the American Institute of Architects (AIA) MasterSpec at Sub Section 093013-2 states the following:

1.1 PRODUCTS, GENERAL

- A. ANSI Ceramic Tile Standard: Provide tile that complies with ANSI A137.1 for types, compositions, and other characteristics indicated.*

Therefore, while the ASTM C 1028 test and the rest results of 0.6 – 0.8 were a “recommendation”, now that MasterSpec has established this specification for the ANSI A 137.1 testing results and therefore what was once a recommendation is now a specification requirement.

With this as background, since the ASTM C 1028 testing method has been found to not be reliable and because the new test ANSI A 137.1 is said to be reliable and has become a specification requirement, and further because the Tile Council of North America has now recommended ANSI A 137.1 and further since ASTM C 1028 has been withdrawn and also since there does not seem to be a parallel testing result by and between ASTM C 1028, ASTM F 1679-04, ANSI 1264.2 and ANSI A 137.1, the results obtained from the English XL Variable Incidence Tribometer may be difficult to equate to the Tile Council of North America ANSI A 137.1 current requirements of Sub Section 093013-2 of MasterSpec.

Notwithstanding when the floor tile was selected, specified, manufactured and installed, Plaintiff and Defendant experts and attorneys are well advised to consider the testing method and results that can be supported by the Tile Council of North America, namely here in year 2014, ANSI A 137.1. Whether a “cross check” using the earlier ASTM C 1028 test is warranted or not seems to be problematic, since the Tile Council of North America and ASTM have withdrawn this test method as being unreliable.

Here below are photos of the three (3) testing machines noted above:



50 # Hand Pulled Slip Tribometer

ASTM C 1028 (2007)
Static Coefficient of Friction Testing
Previous Standard – **Now withdrawn**
Access Board Guidelines
0.6 Minimum Wet or Dry
& 0.8 for Ramps Wet or Dry



English XL Variable Incidence Tribometer

ASTM F 1679-04 (*)
ANSI 1264.2 (**)
(*) Withdrawn by ASTM
(**) Workplace testing
0.50 “threshold of safety”



BOT-3000 “AcuTest” Tribometer

ANSI A 137.1 (2012)
Dynamic Coefficient of Friction Testing
Current Standard - 2014
Tile Council of North America
0.42 or greater Wet

(*) Footnotes:

#1 “Slip Resistance”

Is a term defined in Article 302 of ADAAG 2010 as follows:

A slip-resistant surface provides sufficient frictional counterforce to the forces exerted in walking to permit safe ambulation.”

#2 Tile Council of North America (TCNA)

“Established in 1945 as the Tile Council of America (TCA), the Tile Council was created with the sole purpose of expanding the ceramic tile market in the United States. TCA’s research laboratory has developed and patented many innovative installation materials which have improved ceramic tile installation. Additionally, towards the goal of expanding the ceramic tile market in North America, TCNA regularly conducts independent research and product testing, works with regulatory and trade agencies, offers professional training, and publishes installation guidelines, tile standards, economic reports, and promotional literature. The Tile Council of North America, Inc. (TCNA) publishes industry-consensus guidelines for ceramic tile installation. “

#3 ASTM (International)

Is the acronym for the American Society for Testing and Materials (ASTM). It is an international [standards organization](#) that develops and publishes voluntary consensus technical [standards](#) for a wide range of materials, products, systems, and [services](#).

#4 Building Code

Many USA jurisdictions currently reference the model building codes known as the **International Building Code (IBC)**, published by the International Code Council, first published in 2000 and updated and promulgated every 3 years. Referencing IBC 2012: [Section](#) 1003.4 states: *“Walking surfaces of the means of egress shall have a slip-resistant surface and be securely attached”* and at [Section](#) 1009.9.1 *“Stairway treads and landings shall have a solid surface. Finish floor surfaces shall be securely attached.”* And also at [Section](#) 1010.8.1 *“The surface of ramps shall be of slip-resistant materials that are securely attached.”* (Noting that the term “slip-resistant” is not defined).

Excerpted, in part, from the 2012 International Building Code. Washington, D.C. International Code Council, 2011. Reproduced with permission. All rights reserved. www.iccsafe.org

#5 ADAAG

Is the acronym for the Americans with Disabilities Act Accessibility Guidelines — These regulations apply to new construction, as well as to any alterations of existing structures, and provide specific guidance in implementing

accessibility guidelines. The most recent ADAAG guidelines were published by the US Department of Justice in September of 2010 and went into practice in March of 2012. Many of these ADA guidelines are incorporated into Chapter 11 of the International Building Code.

#6 United States Access Board

The United States Access Board is a federal agency that promotes equality for people with disabilities through leadership in accessible design and the development of accessibility guidelines and standards for the built environment, transportation, communication, medical diagnostic equipment, and information technology.

#7 ANSI

Is the acronym of the American National Standards Institute. ANSI also publishes technical standards for a wide range of materials, products, systems and services. The Americans with Disabilities Act published by the Department of Justice in 1998 became known as ANSI 117.

#8 Co-Efficient of Friction (COF)

Is the measurement of how smooth or rough a floor surface is to provide a sufficient resistance to friction along a walking surface so as to prevent the testing surface from “slipping” across the floor finish surface?

ASTM C 1028 is a test for Static Co-Efficient of Friction (SCOF), which is a testing method to measure the force applied to start the testing surface to move over the floor finish surface being tested.

ANSI A 137.1 is a test for the Dynamic Co-Efficient of Friction (DCOF), which is a testing method to measure the force applied when the testing surface is moving over the floor finish surface being tested.

Co-Efficient of Friction as tested under ASTM C 1028 is known as a Static Co-Efficient of Friction (SCOF) measured by pulling a weight across various surfaces with a particular type of shoe leather (which is no longer used). “Slip resistance” is defined under ASTM C 1028 as being 0.6 (level) – 0.8 (ramp) with a wet testing surface. Test results varied widely.

Co-Efficient of Friction as tested under ANSI A 137.1 is known as a Dynamic Co-Efficient of Friction test, measured by the BOT 3000 testing device that is said to more accurately mimic how people actually walk on a floor and when they begin to slip. ANSI A 137.1 is now (year 2014) a requirement of ANSI with “slip resistance” defined as testing at .42 or better for a level interior floor finish expected to be walked upon when wet. This test is not recommended for outdoor areas or ramps. While ASTM C 1028 was (just) “recommended”, I understand that ANSI A 137.1 is now a requirement of ANSI with the goal of this new Dynamic Coefficient of Friction (DCOF) standard being to provide tile manufacturers and the industry with a standard method and equipment to benchmark a minimum testing result to determine if floor tiles are “slip resistant”. This testing method is now a requirement of MasterSpec.

I further note my understanding that floor finishes testing as “slip resistant” when installed should be maintained and cleaned periodically in order to maintain their intended slip resistance and moreover the Tile Council of North American recommends that installed tile floor finishes should be tested and checked periodically to verify slip resistance and that surfaces that have lost their slip resistance over time can be treated with a slip resistant treatment, however, it has been my experience that if this treatment (top coat) is itself not cleaned and replaced from time to time a buildup of the treatment (top coat) can result in an even less slip resistance.

#9 Tribometer

According to Webster, an instrument to ascertain the degree of friction in rubbing surfaces... with linguist roots in the Greek “Tribo”, pertaining to or resulting from friction and the French “Meter”, a measuring device.

Tribometry is the measurement of friction and Tribology is the science of friction.

I understand that ASTM F 2508-2011 is the standard practice for validation and calibration of walk way tribometers using reference surfaces and that this ASTM F 2508-2011 protocol was published by ASTM on March 15, 2011 (before ANSI A 137.1 was adopted).

James Rappoport, AIA – NCARB
2121 Market Street
Philadelphia, PA 19103
Tel 215 636 9900 x 325
Email Jamesr@daroffdesign.com
Web Jamesrappoport.com
Web www.daroffdesign.com

**James Rappoport, AIA – NCARB
Professional Expert Profile:**

James Rappoport is Principal – Architect of Record at Daroff Design Inc. + DDI Architects PC, a full service Planning, Architectural & Interior Design practice founded in 1973 and specializing in ground-up, renovation and historic adaptive reuse projects for office facilities, hotels, resorts, restaurants, conference facilities, aviation terminals and entertainment projects throughout the USA and Internationally.

Mr. Rappoport has successfully provided technical consultation, expert witness opinions, affidavits, certificates of merit, depositions, mediation presentations, testimony and trial support in more than 150 legal cases, engaged by both defendants' and plaintiffs' legal teams. Mr. Rappoport is the author of several professional text books and trade journal articles, has been awarded multiple copy rights and is an active member of the American Institute of Architects (AIA), the US Green Building Council (USGBC), the International Code Council (ICC), and the Construction Specifications Institute (CSI). He is certified by the National Council of Architectural Review Boards (NCARB).

Areas of Expertise

Architecture	Hotel & Resort Design & Planning
Architectural Codes / Design & Standards	Interior Design & Planning
Architectural Design	Office Building Design & Planning
Architectural Practice	Owner – Architect Agreements
ADA – Accessibility Compliance	Owner – Contractor Agreements
ADA – Accessibility Design	Professional Liability (Architecture & Design)
Building Codes & Ordinances	Project Planning
Construction & Architecture	Slip – Fall Accident (Causes)
Construction Claims	Site Assessment & Development
Construction Disputes	Site Planning & Design
Facility Programming	Standard of Care (Architecture & Design)
Furniture, Fixtures & Equipment Specifications	Urban Design
Furniture, Fixtures & Equipment Failures	Urban Development & Planning

Education:

Bachelor of Architecture, Cornell University, 1964
M. Sc. Architecture & Urban Design, Columbia University, 1966
Post Graduate Studies in Urban Economics, NYU, 1967-1969
First Licensed to Practice Architecture in New York State, 1969
American Institute of Architects – Continuing Education - Ongoing

Professional Licenses and Registrations: (NCARB Certified)

Arizona	Georgia	Louisiana	New Hampshire	Pennsylvania	US Virgin Islands
California	Hawaii	Maryland	New Jersey	South Carolina	West Virginia
Colorado	Illinois	Massachusetts	New York	Tennessee	Wisconsin
Connecticut	Indiana	Mississippi	North Carolina	Texas	
Delaware	Kansas	Missouri	North Dakota	Virginia	
Florida	Kentucky	Nevada	Ohio	Washington DC	