Prevention of Slips, Trips and Falls Through Facility Design

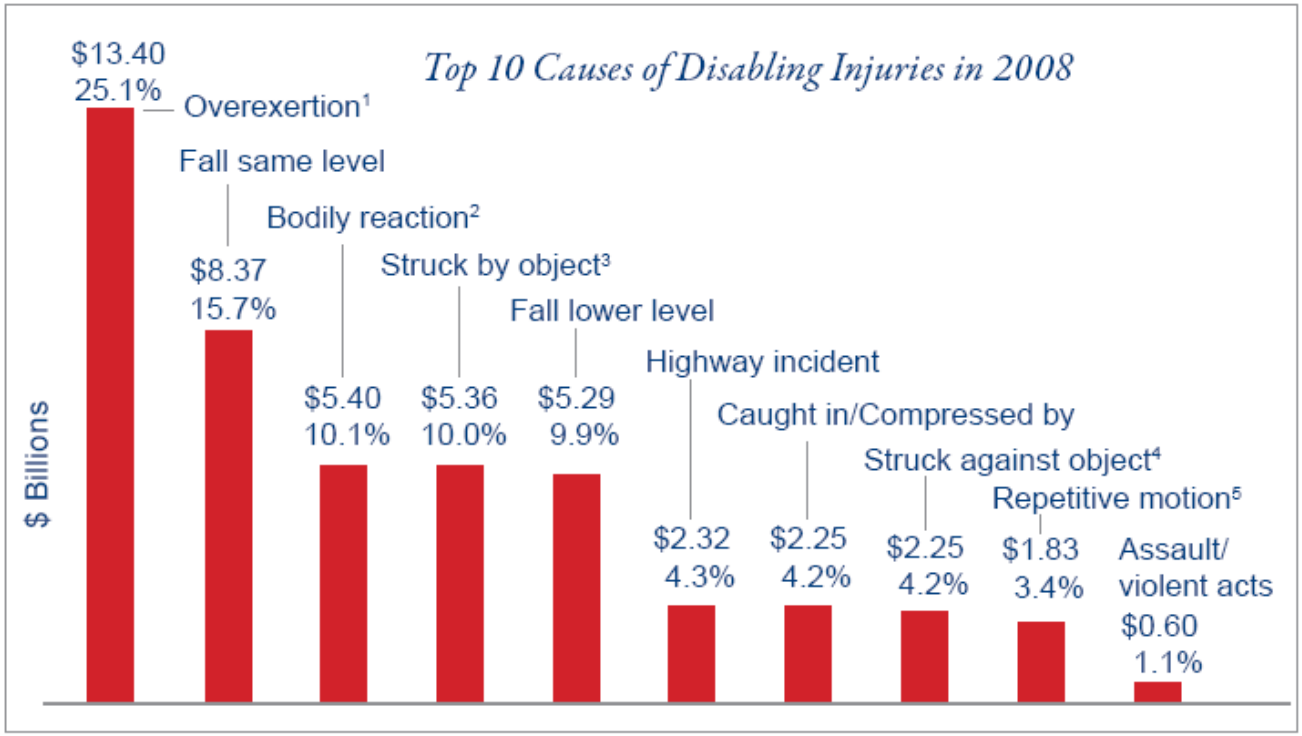
Wayne S. Maynard

Prevention through Design- A new way of doing business: Report on the National Initiative
Omni Shoreham Hotel-Washington DC, August 22, 2011

Agenda

- Overview of slip, trips and falls (STFs); the problem
- A systems approach to STF prevention
  - Stakeholder discussion; proactive versus reactive approaches
- Example of a PtD initiative for prevention of STF
- Facility design standards, references and guidelines on slip resistance, measurement of slipperiness, trip hazards and design solutions for walkways and stairways

2010 Liberty Mutual Workplace Safety Index



[1]Overexertion – Injuries from excessive lifting, pushing, pulling, holding, carrying, throwing
[2]Bodily reaction – Injuries from slipping or tripping without falling
[3]Struck by object – Such as a tool falling on a worker from above
[4]Struck against object – Such as a worker walking into a door
[5]Repetitive motion – Injuries due to repeated stress or strain

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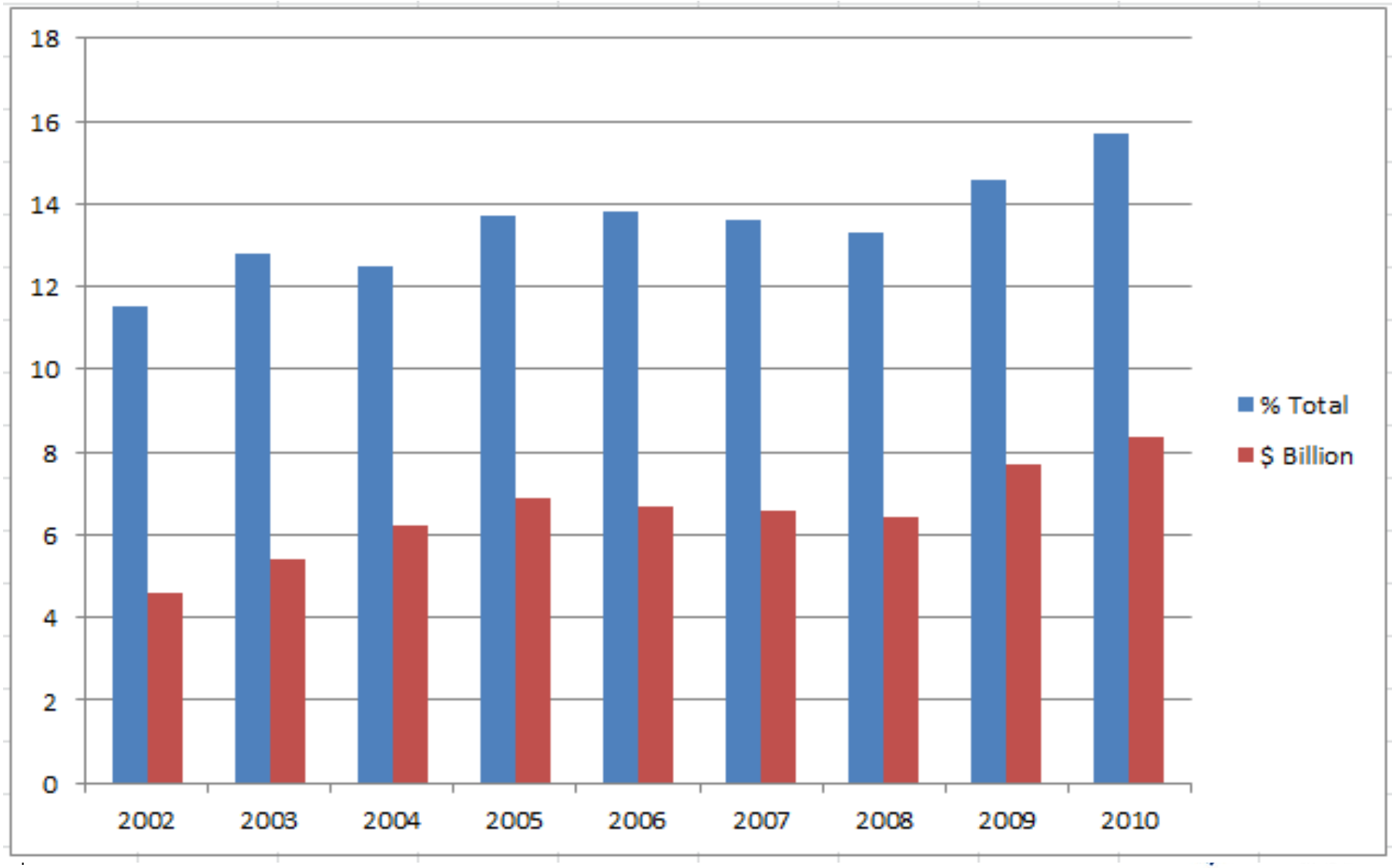
Falls - Same Level



Slip, Trip and Fall Prevention Continuum

Gielo-Perczak K, Maynard WS, DiDomenico A [2006], *Reviews of Human Factors and Ergonomics*, HFES. Vol. 2, Santa Monica, CA, pp. 165–194

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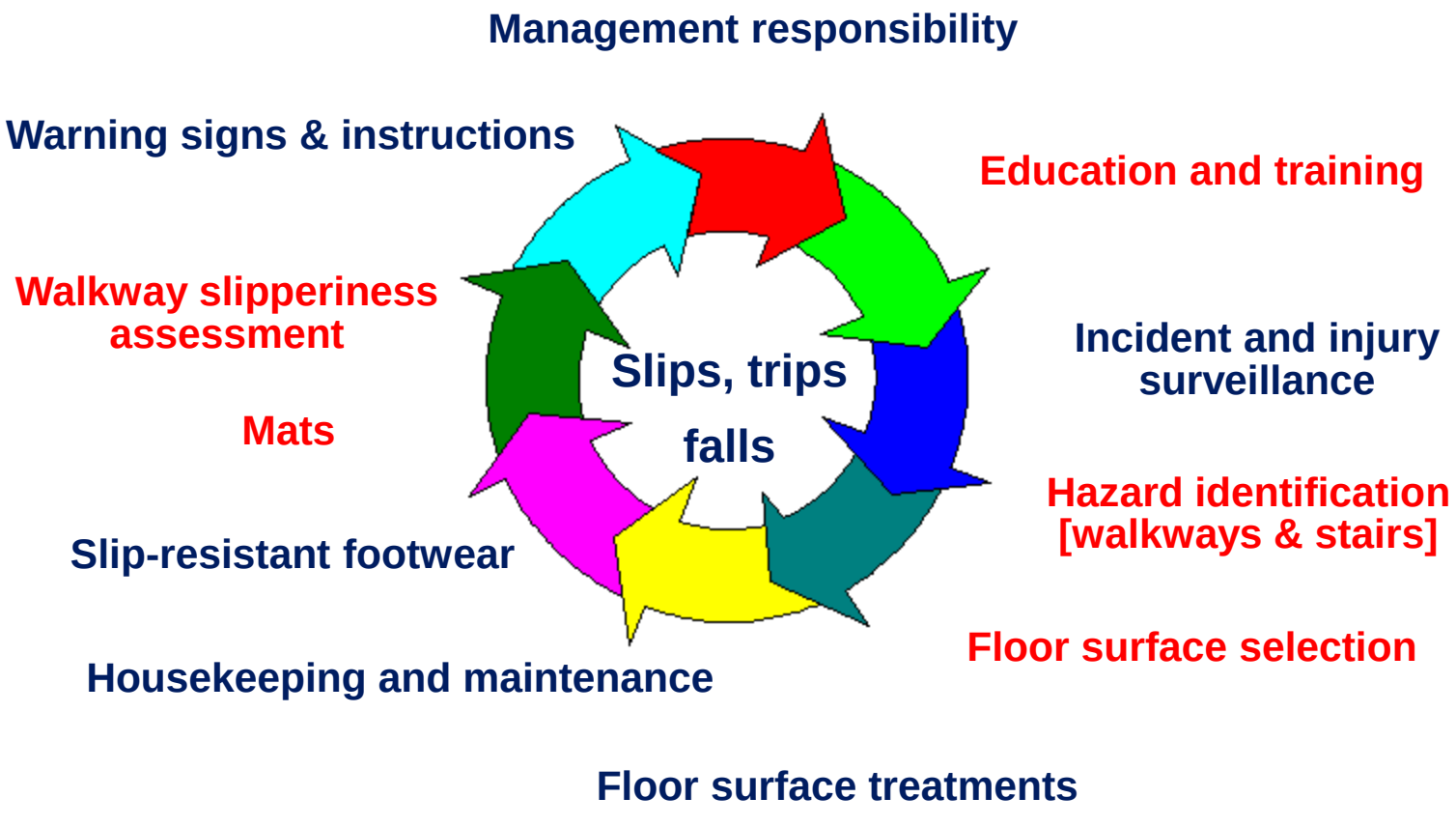
Slip, Trip and Fall Prevention Continuum



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Who Needs Training?

- Major Stakeholders in Slip, Trip and Fall Prevention
  - Architects
  - Design and Construction
  - Facility Managers
  - Property Management
  - Maintenance and Housekeeping
  - Human Resources
  - Risk Management & Safety
  - Operations

Hazard Identification

- Definitions:
  - "Slip resistant"
  - "Slip resistance"
  - "Slippery"
- Characteristics of a "slip resistant" walkway surface
- Elevations and trip hazards
- Proactive design of walkway surfaces, ramps and stairs for STF prevention

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Overview

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Best Practice

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sections on t
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- Limit
- Work
- Share

The Facilitati
information
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The worksho
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Corporate Re
Interior and Exterior Slip
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- Background
  - Causes of slips, trips and fa
    - Tribology: friction/t
      of water and contan
    - Designing for aging
- Codes, standards and guidelines or
  and slips, trips and falls
  - ADA-ABA (US Access Bo
    walkways and stairways. U
    and Floor Surfaces.
  - Building Code Commentar
  - ASTM, NFPA standards an
  - Lighting.
  - US Access Board Research
- Enhancing Interior Guidelines:
  - Flooring selection
    - Flooring types and
      advantages/disadva
    - Slip-resistance test
      ASTM D2047, UL
    - Slip-resistance testi
    - Types of slipmeters
      (PIAST) slipmeter.
    - Surface roughness,

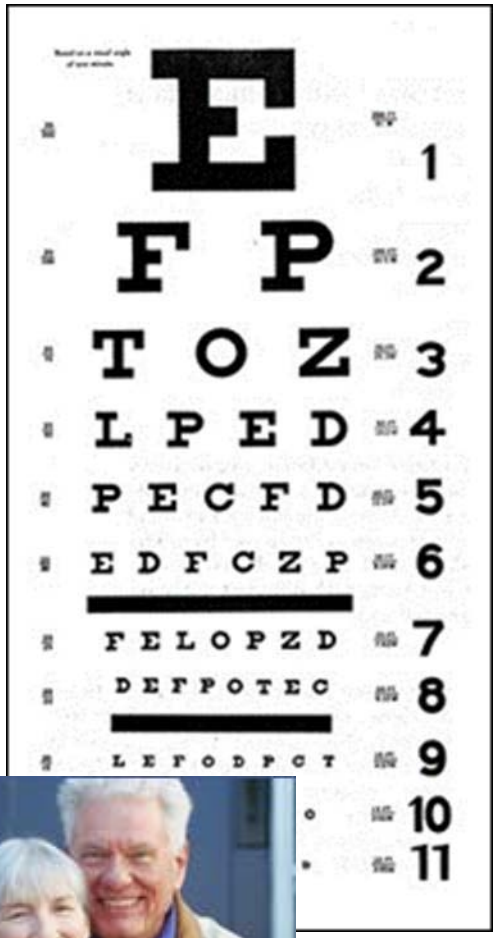
Corporate Real Estate Training
Interior and Exterior Slips, Trips and Falls
Agenda (cont)

    - Matting design at entrances and lobbies.
    - Trip hazards
  - Stairways
    - Missteps and air steps: design standards, handrails, stair rails, treads and slip-resistance.
    - Detectable warnings: color and contrast tread nosing and when needed.
    - One and two step stairways; problems and solutions
- Enhancing Exterior Guidelines
  - Hazards: Parking lots/garages, sidewalks, curbs, ramps and cut-throughs,
  - Snow and ice removal; deicing salts advantages/disadvantages
  - Drainage.
  - Detectable warnings; curbs, sidewalks and others.
  - Stairway issues.

*Each section will include a workshop on how to integrate lesson material into the Liberty Mutual Tenant Construction Guidelines and Corporate Real Estate Due Diligence Checklist.

Hazard Detection: Age and Vision

- Range of visual accommodation; visual detection of hazards
- Loss of contrast sensitivity (diabetes, other illnesses)
- Poor dark adaptation (slow/incomplete)
- Less color sensitivity
- Glare sensitivity (cataracts, reduced glare recovery >age 50)



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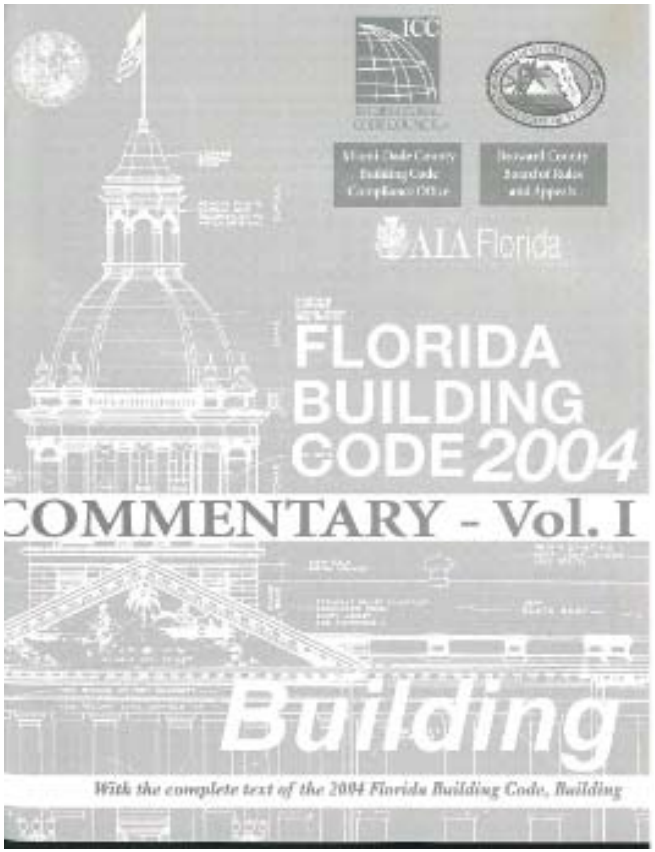
What Is Slip Resistant?

- **slip resistance**, *n*—the relative force that resists the tendency of the shoe or foot to slide along the walkway surface. Slip resistance is related to a combination of factors including the walkway surface, the footwear bottom, and the presence of foreign materials between them.
- **slip resistant**, *n*—the provision of adequate slip resistance to reduce the likelihood of slip for pedestrians using reasonable care on the walking surface under expected use conditions.

ASTM F1646-05e1, Standard Terminology Related to Safety and Traction of Footwear

Slip-Resistance Standards



To minimize the hazard of slipping on smooth or slick floor surfaces during normal or emergency use, all floor surfaces in the means of egress are required by the code to be uniformly slip resistant. The use of hard floor materials with highly polished, glazed, glossy or finely finished surfaces should be avoided. However, the code does not specify standards or particular performance levels for slip resistance.

One method available to establish slip resistance is measuring the static coefficient of friction is greater than 0.5 between the floor surface and leather [Type 1 (Vegetable Tanned) of Federal Specification KK-L-165C] Another method is laboratory testing in accordance with ASTM D 2047 to determine a static coefficient of resistance. Further information regarding slip resistance is available in Bulletin No. 4 entitled "Surfaces" issued by the U.S. Architectural and Transportation Barriers Compliance Board (ATBCB).

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Slip-Resistance Standards

The landmark Americans with Disabilities Act (ADA), enacted on July 26, 1990, provides comprehensive civil rights protections to individuals with disabilities in the areas of employment (title I), State and local government services (title II), public accommodations and commercial facilities (title III), and telecommunications (title IV). Both the Department of Justice and the Department of Transportation, in adopting standards for new construction and alterations of places of public accommodation and commercial facilities covered by title III and public transportation facilities covered by title II of the ADA, have issued implementing rules that incorporate the Americans with Disabilities Act Accessibility Guidelines (ADAAG), developed by the Access Board.

3.5 Definitions.
Accessible Route.
A continuous unobstructed path connecting all accessible elements and spaces of a building or facility. Interior accessible routes may include corridors, floors, ramps, elevators, lifts, and clear floor space at fixtures. Exterior accessible routes may include parking access aisles, curb ramps, crosswalks at vehicular ways, walks, ramps, and lifts.

4.1 Minimum

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A FEDERAL AGENCY

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Why are surface cha
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persons with mobility imp
level and ramped surfaces both indoors and out. Findings from this limited human-subject testing confirmed that individuals who have gait and mobility disabilities make greater demands on the walking surfaces of floors, ramps, and walkways. The information in this Bulletin was derived from this and other research in order to provide designers with an understanding of the variables that affect the measurement and performance of materials specified for use on walking surfaces.

What surface characteristics are required of an accessible route?

What values are recommended for ground and floor surfaces along an accessible route?
The surfaces of the accessible route on a site or within a building or facility must be designed to provide slip-resistant locomotion for both level and inclined travel by persons with disabilities. Research findings suggest that such surfaces should have a slip resistance somewhat higher than might be provided for individuals without disabilities.

Researchers' recommendations for a static coefficient of friction for surfaces along an accessible route, when measured by the NBS-Brungraber machine using a silastic sensor shoe, were approximately 0.6 for a level surface and 0.8 for ramps. These values are included in the advisory material in the Appendix to ADAAG, but are not in any way mandatory.

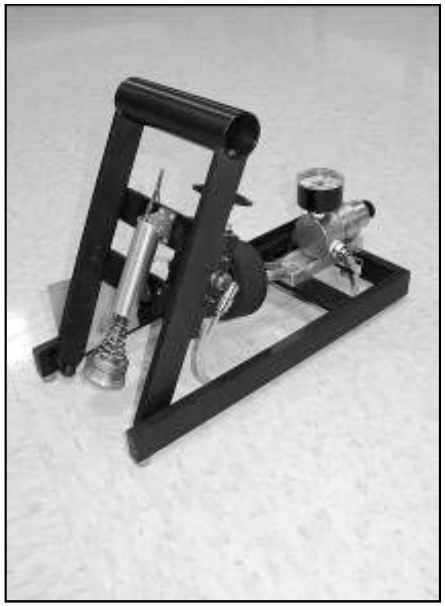
What Is "Slippery"?

- Measured using a tribometer or slipmeter
  - <0.5 (relatively slippery), 0.5 - 0.6 (generally acceptable), >0.6 (relatively not slippery)
- Most studies show that people can walk comfortably and safely on surfaces with a coefficient of friction greater than 0.4, but 0.5 offers an additional safety factor*
  - This is called a Slip-Resistant surface
- Wet or dry
- No mandated COF values. Recommended guidelines: ANSI, ASTM, US Access Board, OSHA*

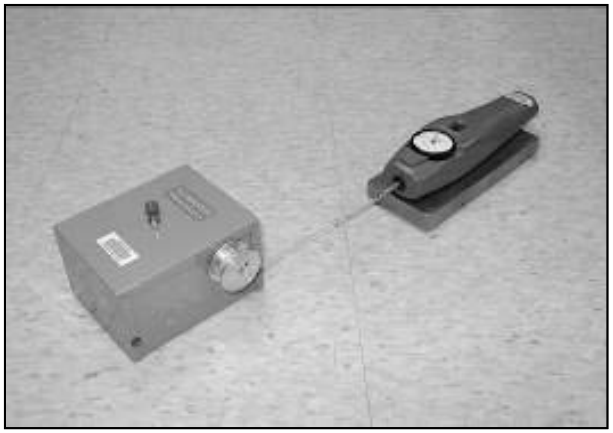
* Miller, J. M. (1983). Slippery work surfaces: Towards a performance definition and quantitative coefficient of friction criteria. *Journal of Safety Research*, 14, 145–158

Measuring Slipperiness: Tribometers

Brungraber Mark II
(PIAST)
Output =
“slip resistance value”



English XL (VIT)
Output = “slip index”



Horizontal Pull
Slipmeter (HPS)
ASTM F609
Output = “slip index”

Other Tribometers

James Machine
ASTM D2047
and UL 410

British Pendulum Tester
TRRL Tester (BPST)

American Slip Meter

BOT 3000
Universal Walkway Tester

Brungraber Mark III

ASTM C1028
Horizontal Pull
Dynamometer

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Slip Resistance Standards

- ANSI/ASSE A1264.2-2006, Standard for the Provision of Slip Resistance on Walking-Working Surfaces
  - 0.5 dry only “slip resistance guideline”
  - Specifies HPS, Brungraber Mark II, Mark III and English XL
- ANSI/NFSI B101.1-2009 Test Method for Measuring Wet SCOF of Common Hard-Surface Floor Materials
  - Includes wet SCOF values for High, Moderate and Low Traction
  - “Approved” and “Recognized” tribometers
- ASTM F2508-11, Standard Practice for Validation and Calibration of Walkway Tribometers Using Reference Surfaces
-

Flooring Selection

- Lobbies
- Restrooms
- Kitchens
- Cafeteria
- Stairs/steps
- General office
- Manufacturing

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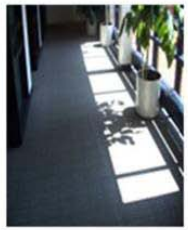
Flooring

Unsealed Brushed Concrete

Quarry Tile with Embedded Grit

Textured Glazed Ceramic Tile with Raised Points



Carpeting

Textured Porcelain Pavers

Quarry Tile withOUT Embedded Grit

Textured Rubber Tiles or Sheets

Terrazzo

Diamond Plate

Hardwood Floors

Vinyl Composition Tile (also Glazed ceramic or porcelain)

Performance

- Excellent to Good slip-resistance, BOTH wet and dry.
- Good slip resistance dry, Fair wet.
- Good to Fair slip resistance dry, Poor wet.

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Entrance Design and Mats

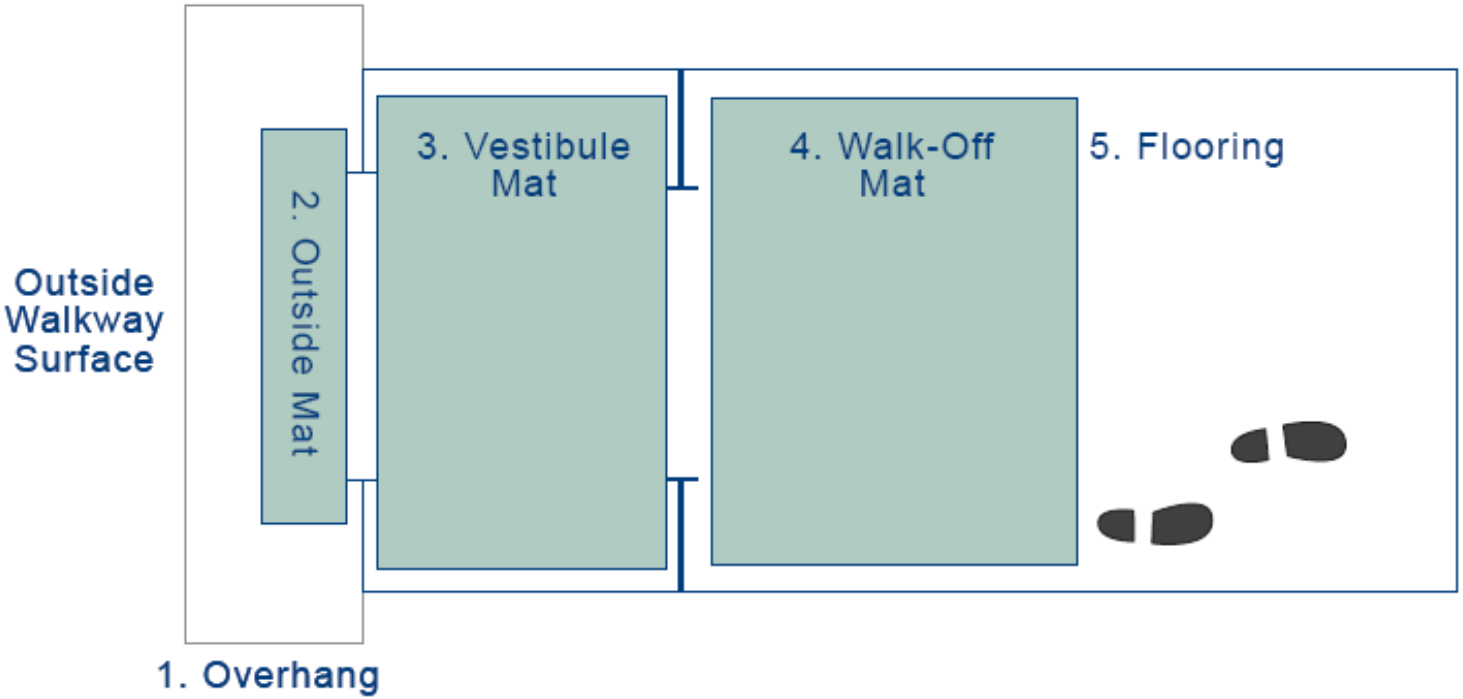

Figure 3. Entrance mat depth guideline

LC 5408 R1

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Entrance Design and Mats

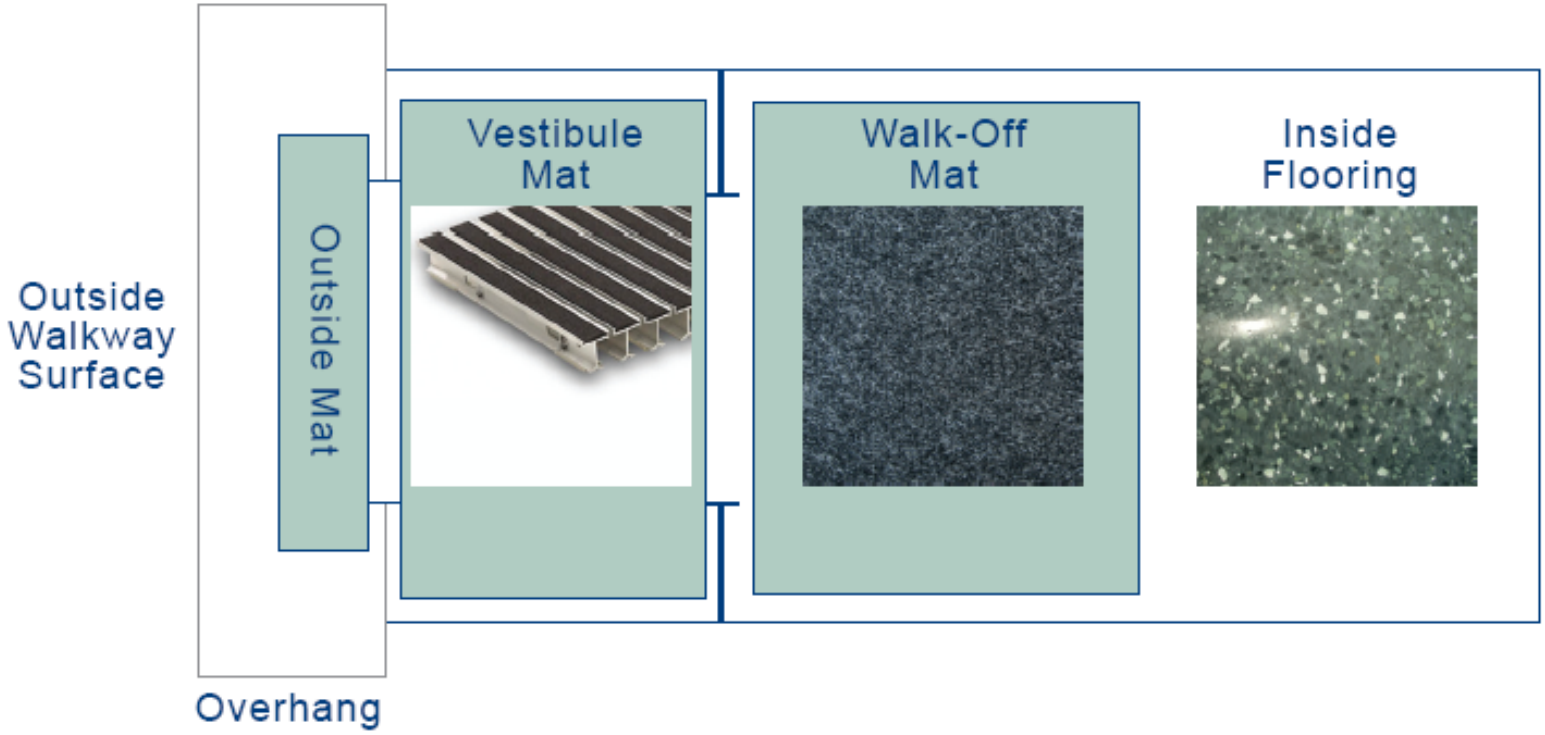

Figure 4. Entrance mat selection strategy

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Tripping Hazards

- Changes less than ¼ inch (6mm) in height may be without edge treatment
- Changes ¼ inch to ½ inch (6mm-12mm) beveled with slop no greater than 1:2 (rise:run)
- Greater than ½ inch (6mm) ramp or stairway
- *However, no raised areas should be permitted in main course of pedestrian travel (Maynard)*

ASTM 1637, Standard Practice for Safe Walking Surfaces

2010 ADA Standards for Accessible Design, Chapter 3, section 303, Changes in Level

NFPA 101, Chapter 7, Changes in Elevation

Parking Lots, Sidewalks, Curbs

Florida Building Code Commentary

Figure 1003.3.2
FREE-STANDING OBJECT

To minimize the hazard of slipping on smooth or slick floor surfaces during normal or emergency use, all floor surfaces in the means of egress are required by the code to be uniformly slip resistant. The use of hard floor materials with highly polished, glazed, glossy or finely finished surfaces should be avoided. However, the code does not specify standards or particular performance levels for slip resistance.

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1003.5 Elevation change. Change in level in the means of egress shall be either by a ramp or a stair. The presence and location of ramped walkways shall be readily apparent.

1003.5.1 Where a change in level means of egress not exceeding 21 inches (533 mm) is achieved by a stair, the minimum tread depth of such stair shall be 13 inches (330 mm) and the presence and location of each step shall be readily apparent.

Exception: Within dwelling level.

Minor changes in elevation located in any portion of the means of egress (i.e., exit access, exit or exit discharge) may not be readily apparent during normal use or emergency egress and are considered to present a potential tripping hazard. The section addresses the trip hazard for changes by stairs between 12 and of 21 inches by requiring a larger minimum tread depth effectively limiting the height of risers (See Section 1008.1.4).

1003.5.2 Where change in elevation of 12 inches (305 mm) or less occurs in exit access corridors, exits and exit discharge, ramps complying with Section 1010 shall be provided.

Exception: Within dwelling level.

Where the elevation change is less than 12 inches (305 mm), a ramp is specified to make the transition from higher to lower levels. The ramp is intended to reduce accidental falls associated with tripping hazards and must be constructed in accordance with Section 1010.1. The presence of the ramp must be readily apparent from the directions from which it is approached. Handrails are one method of identifying the change in elevation. In lieu of handrails, the surface of the ramp may be finished with materials that contrast with the surrounding floor surfaces. The walking surface of the ramp should contrast both visually and physically (See Section 1008.1.4).

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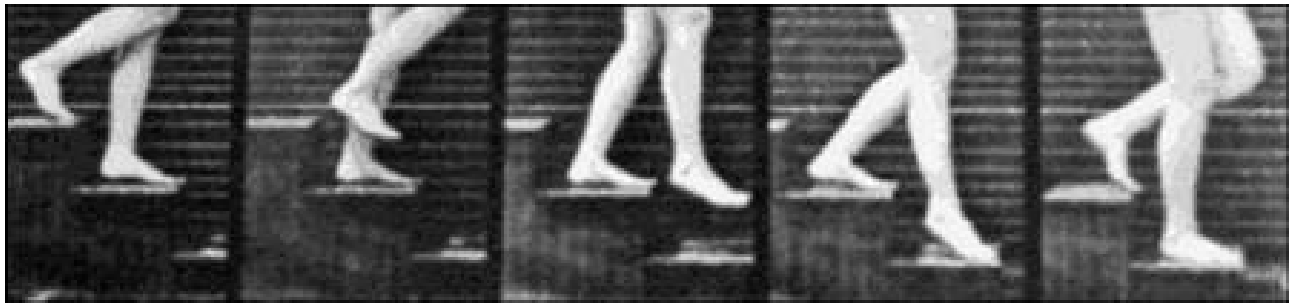
Color and Visual Contrast

- ADA specifies that detectable warnings "shall contrast visually with adjoining surfaces, either light-on-dark, or dark-on-light.” (70% contrast in light reflectance value LRV)
- Safety Yellow (ISO 3864, ANSI Z535.1) "most visually detectable“ (US Access Board Research)

Safety Yellow

Stairs/Steps

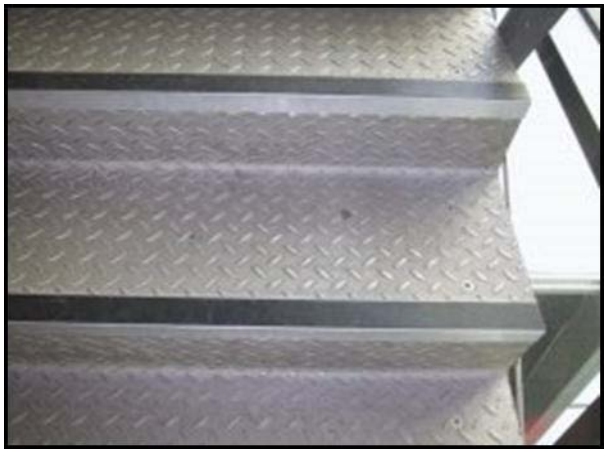
- Missteps/loss of balance
  - Over step, under step, air step
  - Tread depth and ball of foot to land
  - Average length of 95th percentile male foot is 8.25 inches + 1 inch for shoes



Muybridge, 1955

Treads

- “Steps and treads shall be of slip-resistant material” (NFPA 101)
  - Extend whole tread
  - Nosing strips okay
- Nosings shall extend not more than 1.5” (ADA-ABA)
- Stairway tread marking-strip width 1-2”



Design: Handrails

- When do you need?
  - 1 or more risers except residential (check local and state codes)
  - Tread width <44 inches one handrail on right side descending. Also, stair rail on open side but not both
  - ≥44” handrails both sides and stair rail with hand rail on open side

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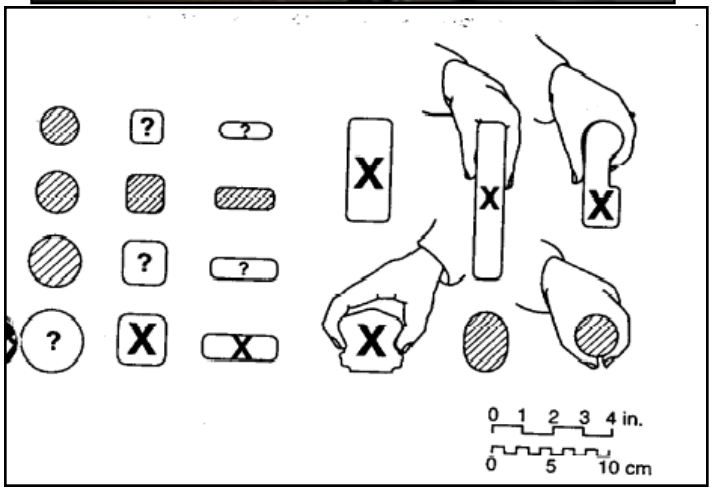
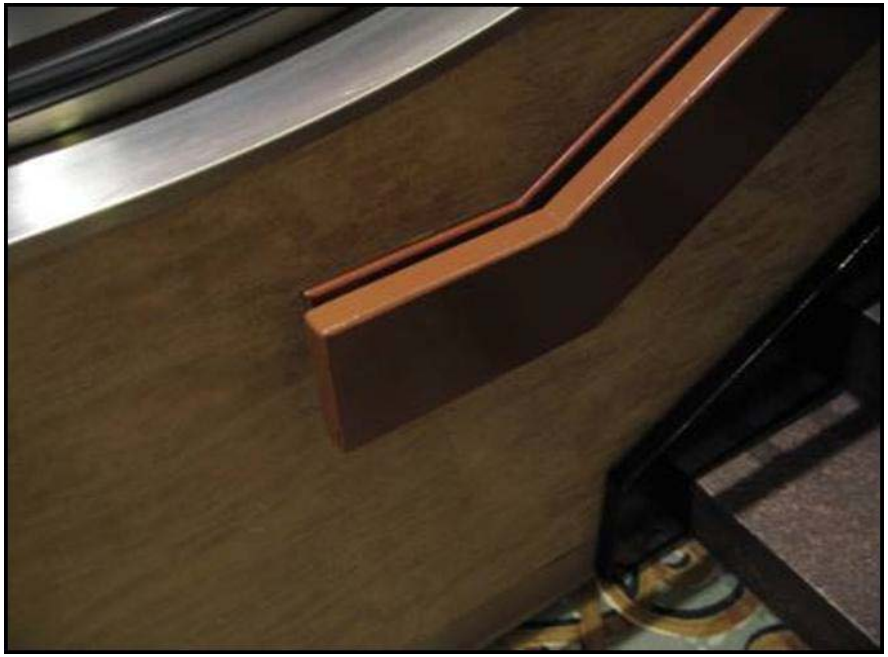
Design: Handrails

- Both sides of stairs, full length of stair
- 60” wide; intermediate rail
- 34” high min. and 38” high max
- Extend 12” at top of stair, one tread depth from bottom step at bottom
- Hand rail 2 1/4” diameter
- Clearance 1 1/2 “ away from wall



Design: Handrails



"Shape that is other than circular with a perimeter dimension of not less than 4 in. (100 mm), but not more than 6 1/4 in. (160 mm), and with the largest cross-sectional dimension not more than 2 1/4 in. (57 mm), provided that graspable edges are rounded so as to provide a radius of not less than 1/8 in. (3.2 mm)"

Source: NFPA 101 Chapter 7 Means of Egress, Stairs

Stair Rails: Open Stairways

- Install a two-rail system; a top rail at 42 inches and a second handrail at 34 inches minimum and 38 inches maximum vertically above stair nosings
- Protect the open area under the top rail to the stairway steps by installing a fixed barrier
  - Fixed barriers preferred to balustrades
- Handrails both sides preferable; required right side only descending; stair widths <44 inches

One and Two Step Entrances

- Avoid if possible (air steps common)
- Risers follow guidelines for stairs
- Possibly install hand rail
- Not ADA compliant-might need ramp
- Use safety yellow on step edges


LMRIS before


LMRIS after

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Summary

- Same level falls remains a huge issue and prevention starts with design; public places and workplaces
- Prevention through Design is an important proactive approach to STF prevention
- Key stakeholders include Architects, Design and Construction and Facilities Managers all working together
- Building codes are vague on slip and trip design prevention and leave decisions to business owners
- Handrails; different guidelines on when, how many and design. Take most safe approach
- Safety professionals play an important role; educating key stakeholders and facilitating design improvements