SLIP AND FALL ACCIDENT INVESTIGATIONS - AN ENGINEERING PERSPECTIVE

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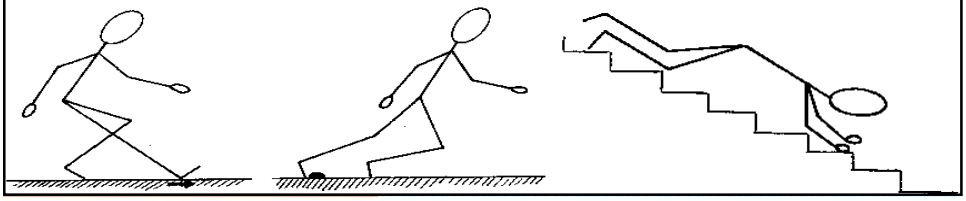
DEFINITIONS
Slip, Trip, Imbalance and Fall

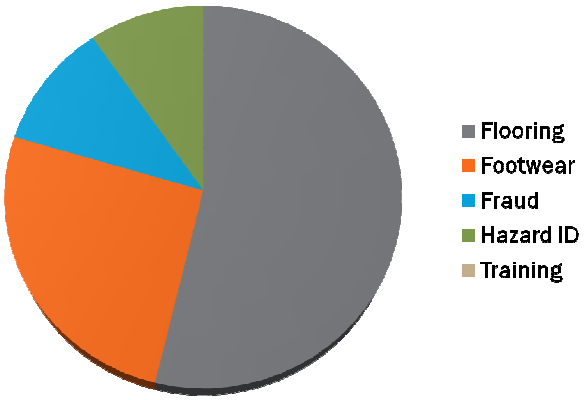
- ✓ Slip – Interaction between footwear and the walking surface
- ✓ Trip – Engagement with an object or irregular change in height along walking trajectory
- ✓ Imbalance – Stepping on unstable surface, like a lose tile, that cause instability
- ✓ Fall – An event that causes an individual to end up on the floor (ground)

STATISTICS

- Tens of thousands of pedestrians suffers slips, trips and imbalances each year and thousands occur each day.
- Cost of these injuries is in the billions of dollars per year.

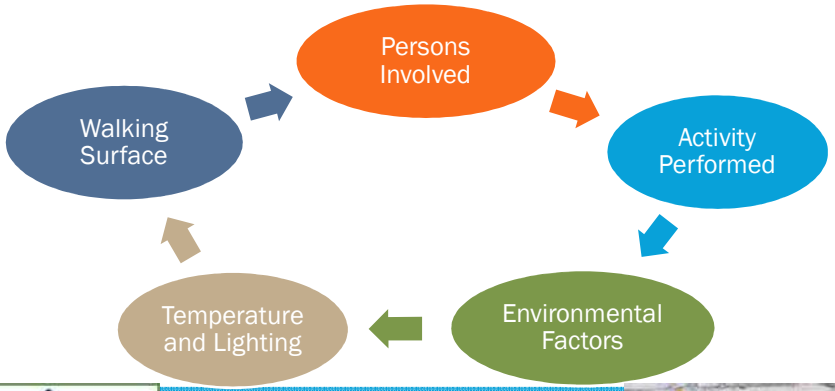


CAUSES OF SLIPS AND FALLS



Source: National Flooring Safety Institute

ACCIDENT FACTORS



FALLS

- ✓ Are commonplace affecting individuals from infant to old age
- ✓ Generally the outcome is no more serious than an embarrassment
- ✓ When injuries occur they can be debilitating and far-reaching

FALL PROBLEM

- Falls can occur on a level surface, on slopes, on steps, on stairs and from heights with different causes and results
- Falls involves a loss of balance due to some reason, which results in the person falling to the ground or another level

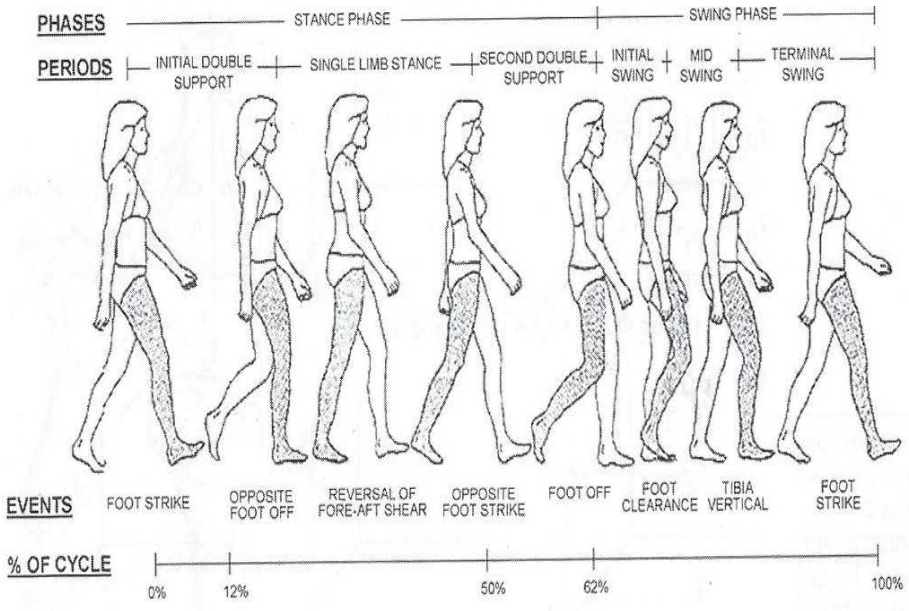
FALLS CATEGORIZED

- Circumstances (on the level, on a slope, on steps/stairs, from height)
- Age of the person (healthy adults, children, older persons)
- Place (hotel, terminal, parking area)

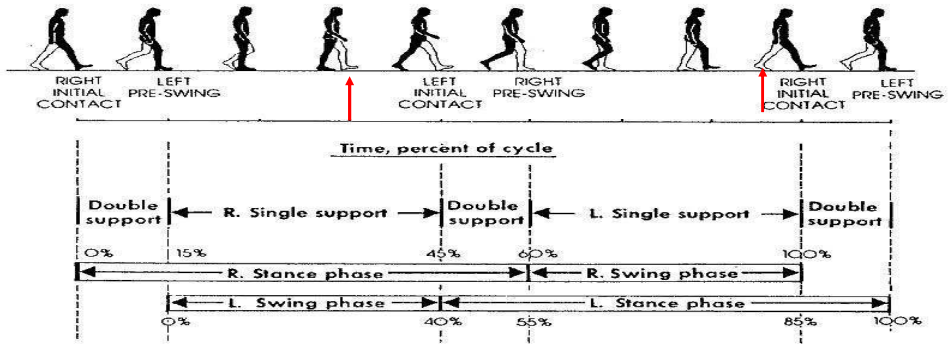
FALL FACTORS

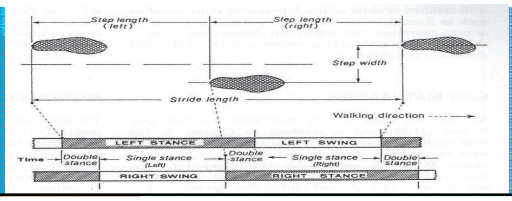
Gait	Balance	Stature
Strength	Vision	Behavior

NORMAL WALKING

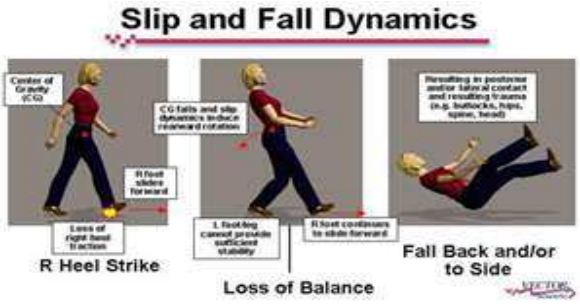


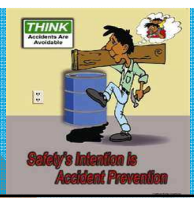
GAIT CYCLE





SLIP AND FALL DYNAMICS





FALLS INFLUENCED BY

Health	Fatigue	Medication
Alcohol	Environment	Activity

FALL OUTCOMES

- Fall on the level – lower or upper limb fractures, sprains, back or head injuries.
- Falls from height – often serious, forces generated and severity depends on the distance of the fall and the contact surface.

SLIP AND FRICTION

SLIP FACTORS

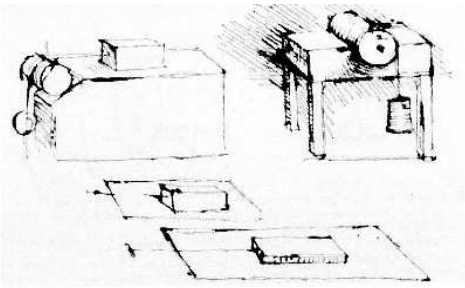
- The most dominant factor effecting slip is the coefficient of friction between the footwear and the flooring material
- Walkway geometry
- Environmental conditions

FRICTION - DEFINITION

The interaction between two surfaces in contact while moving one relative to the other while maintaining contact.

HISTORICAL PERSPECTIVE

In 1495 Leonardo Da Vinci was the first to deduce the basic laws of friction and the causes of slips, trips and falls.

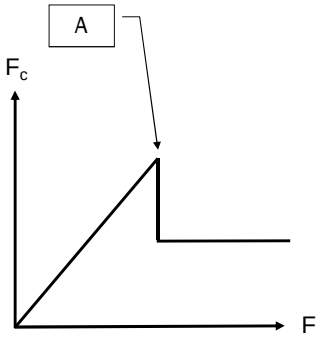


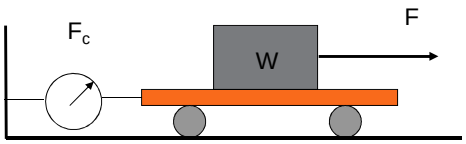
Da Vinci Friction Machine

HISTORICAL PERSPECTIVE

In 1781 Charles – Augustin de Coulomb studied "Dry Friction"
- The interaction between two contacting surfaces in the absence of lubricating fluid.

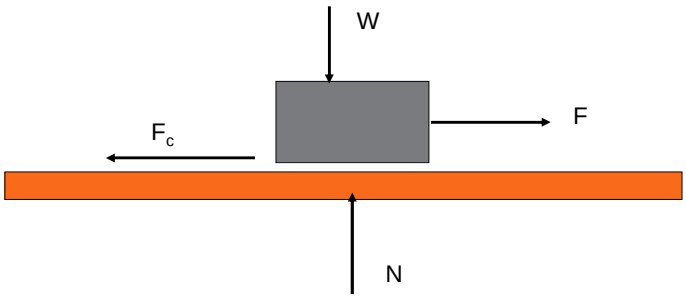
FRICTION - DEFINITION





At point A the block starts sliding on the surface

FRICTION - DEFINITION



FRICTION - DEFINITION

Only at point A the following relationship holds:

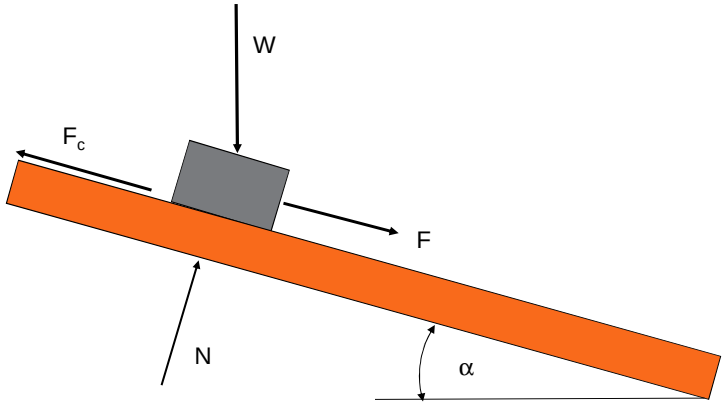
$$F_c = \mu_s W$$

where: F_c – Friction force
μ_s – Static Coefficient of friction
N – Normal force

The coefficient of friction is given by

$$\frac{F_c}{N} = \mu_s$$

FRICTION - EFFECT OF SLOPE



Equation still holds: $F_c = \mu_s N$

Where: F_c – Friction force

μ_s – Static Coefficient of friction

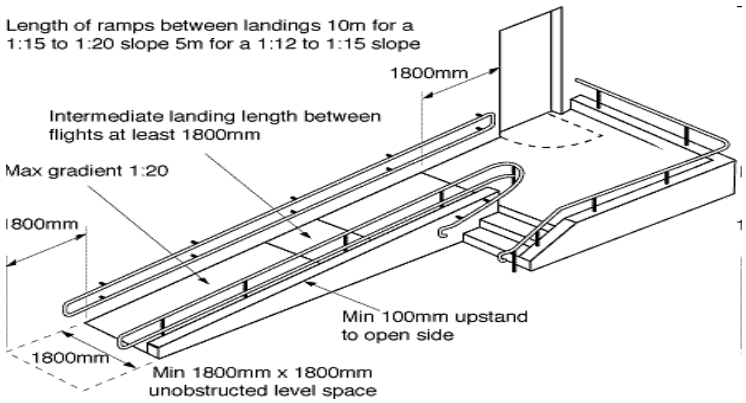
N – Normal force

Coefficient of friction is given by:

$$\frac{F_c}{N} = \mu_s - \tan\alpha$$

Apparent coefficient of friction is reduced

FRICTION - RAMP

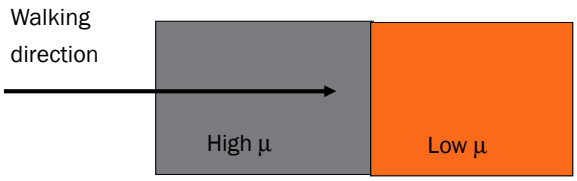


For a standard ramp of 1:20 the apparent coefficient

$$\frac{F_c}{N} = \mu_s - 0.05$$

This difference might change the conditions from safe to unsafe

FRICTION -EFFECT OF CHANGE IN COF



The transient from high to low coefficient of friction night cause slippage since human needs to take few steps to adjust their gate to the conditions.

FRICTION - EFFECT OF CHANGE IN COF

FRICTION - EFFECT OF CONTAMINATE

The presence of contaminates, such soil, reduces the value of the coefficient of friction since the particles change the mechanism from sliding to, at least, partial rolling.

FRICTION - EFFECT OF LOADS

The mean and standard deviation of dynamic friction of neolite

Glycerol	Test	Process 1		Process 2		Process 3		Process 4		Process 5		Process 6		Process 7	
ratio	condition	Mean	STD	Mean	STD	Mean	STD	Mean	STD	Mean	STD	Mean	STD	Mean	STD
0.99	1	0.342	0.114	0.271	0.033	0.213	0.047	0.262	0.060	0.156	0.050	0.127	0.027	0.161	0.045
	2	0.378	0.060	0.282	0.025	0.205	0.043	0.274	0.053	0.143	0.053	0.102	0.023	0.147	0.060
	3	0.322	0.063	0.205	0.034	0.163	0.037	0.199	0.055	0.123	0.038	0.104	0.011	0.122	0.036
	4	0.343	0.045	0.243	0.029	0.166	0.044	0.222	0.056	0.112	0.051	0.079	0.021	0.113	0.048
	5	0.301	0.058	0.195	0.031	0.154	0.032	0.198	0.042	0.113	0.029	0.100	0.015	0.119	0.027
	6	0.342	0.041	0.241	0.029	0.156	0.044	0.219	0.049	0.105	0.043	0.080	0.021	0.110	0.038
0.85	1	0.456	0.025	0.342	0.037	0.291	0.075	0.373	0.042	0.229	0.031	0.201	0.031	0.226	0.038
	2	0.466	0.018	0.344	0.035	0.275	0.059	0.371	0.046	0.212	0.035	0.181	0.031	0.211	0.033
	3	0.398	0.027	0.263	0.045	0.201	0.072	0.299	0.057	0.122	0.036	0.103	0.023	0.122	0.046
	4	0.418	0.023	0.296	0.038	0.210	0.064	0.317	0.054	0.148	0.037	0.116	0.028	0.138	0.039
	5	0.368	0.033	0.231	0.046	0.163	0.067	0.248	0.059	0.098	0.032	0.078	0.017	0.098	0.033
	6	0.390	0.026	0.268	0.037	0.174	0.064	0.279	0.056	0.113	0.037	0.087	0.027	0.108	0.036
0.7	1	0.570	0.080	0.486	0.032	0.443	0.050	0.541	0.041	0.360	0.051	0.428	0.036	0.402	0.031
	2	0.591	0.023	0.476	0.043	0.423	0.044	0.514	0.055	0.322	0.040	0.355	0.027	0.361	0.027
	3	0.422	0.084	0.335	0.036	0.313	0.021	0.386	0.046	0.183	0.026	0.270	0.033	0.232	0.024
	4	0.480	0.018	0.374	0.038	0.321	0.032	0.395	0.041	0.202	0.030	0.253	0.033	0.241	0.022
	5	0.403	0.020	0.286	0.036	0.256	0.015	0.324	0.037	0.125	0.024	0.203	0.022	0.169	0.023
	6	0.435	0.021	0.319	0.037	0.254	0.029	0.345	0.043	0.132	0.028	0.178	0.033	0.172	0.026
0.3	1	0.812	0.012	0.720	0.030	0.787	0.026	0.736	0.022	0.670	0.048	0.758	0.020	0.722	0.012
	2	0.800	0.010	0.718	0.031	0.740	0.020	0.729	0.025	0.615	0.040	0.701	0.030	0.677	0.021
	3	0.686	0.047	0.567	0.033	0.633	0.040	0.577	0.030	0.434	0.081	0.583	0.056	0.541	0.051
	4	0.681	0.024	0.587	0.035	0.583	0.032	0.613	0.032	0.448	0.035	0.525	0.055	0.529	0.046
	5	0.549	0.037	0.445	0.028	0.474	0.083	0.437	0.039	0.300	0.055	0.388	0.077	0.393	0.047
	6	0.531	0.050	0.462	0.032	0.443	0.062	0.472	0.046	0.264	0.066	0.321	0.126	0.348	0.032

Process number	Sand particles	Inlet pressure ($\times 10^5$ Pa)	Distance form nozzle (cm)
1	00	2.76	5.1
2	1	2.76	5.1
3	BB	2.76	5.1
4	00	2.07	5.1
5	1	2.07	5.1
6	BB	2.07	6.4
7	BB	2.07	10.2

Test condition	Load (g)	Speed (cm/s)
1	100	10
2	250	10
3	100	20
4	250	20
5	100	30
6	250	30

FRICTION

Effect of lubricant	The presence of lubricant, simple water, reduces the value of the coefficient of friction and therefore increases the chance for slippage.

Floor	DCOF
Dry ceramic	0·57
Dry steel	0·27
Oily plywood	0·43
Oily vinyl	0·11

FRICTION – CHEMICAL INTERACTION

Some surfaces are treated to be sticky. In this case the definition of coefficient of friction does not hold. Different methods have to be used to evaluate the slipping characteristic of the surface.

FRICTION - MINIMUM REQUIREMENTS

The consensus is that coefficient of friction in excess of 0.5 is safe and represent slip-resistant surface.

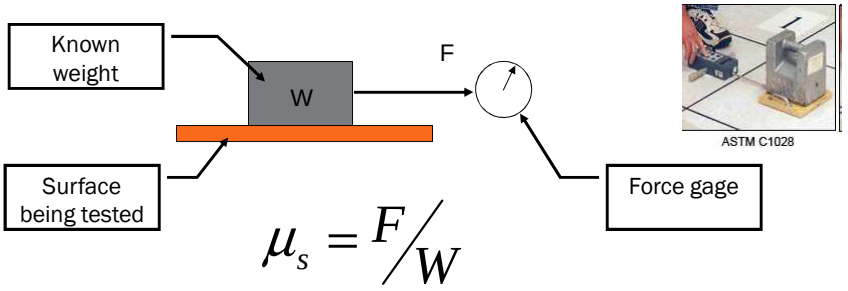
ADA specifies minimum value of 0.6 on Surfaces accessible by handicap)

FRICTION - STANDARDS

- Occupational Safety & Health Administration (OSHA) 1918
- Occupational Safety & Health Administration (OSHA) 1915
- American with Disabilities Accessibility Guidelines (ADAAG) 15.2
- ASTM
- National Fire Protection Association (NFPA) 415/417
- State and Local Building Codes

FRICTION - MEASUREMENTS

- ASTM C-1028 – Pull test



$$\mu_s = F/W$$

System has to be calibrated using a STANDARD tile

FRICTION - MEASUREMENTS

- ASTM C-1028 – Calibration

FRICTION - MEASUREMENTS

ASTM has many standards related to friction measurements for variety of cases

B-460
B-461
B-526
C-808

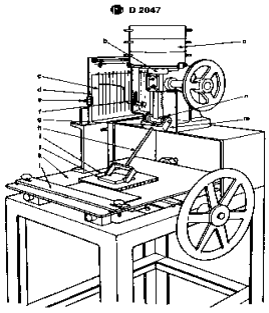
D-1894
D-2047
D-2394
D-2714
many more

The expert has to pick up the relevant standard for the particular case.

FRICTION - MEASUREMENTS

ASTM E 303 – British pendulum tester

ASTM F 489 – James Machine



ASTM F 1677 – Brungraber Mark II

Good for lab environment

FRICTION - MEASUREMENTS

ASTM F 1679 – English XL Standard was dismissed due to poor repeatability

FRICTION - MEASUREMENTS

FRICTION - MEASUREMENTS

Difficulties

- ✓ Sticktion in wet condition
- ✓ Local factors affect the measurement
- ✓ Surface was treated after the event
- ✓ No standard for statistical analysis

TRIP

TRIP FACTORS

- Height of the obstacle which interfere with the swing
- Visibility
- Color of the obstacle

TRIP MECHANISM

- At the impact instant the body has linear momentum that is being interrupted by the impact.
- Body is supported by one foot and it is easy to lose balance
- The center of gravity of the body is ahead of the tripped leg and there is a moment that causes the fall.

TRIP LOCATIONS

Thermal Expansion Joints (Walkways)

Cracks or Wide Unfilled Joints

TRIP LOCATIONS

Sidewalk Breakage

Sidewalk Irregularity

TRIP LOCATIONS

Transition between two different surfaces

TRIP LOCATIONS

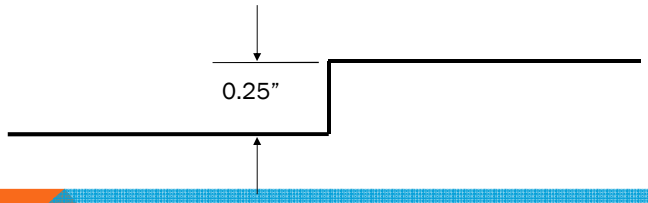
Roots penetrate the surface of the pavement





TRIP - MINIMUM REQUIREMENTS

The requirement is the height difference between two adjacent along the walk way will not exceed 0.25”.



TRIP - STANDARDS

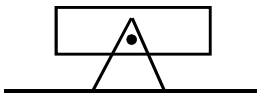
Occupational Safety & Health Administration (OSHA) 1918	Occupational Safety & Health Administration (OSHA) 1915	American with Disabilities Accessibility Guidelines (ADAAG) 15.2
ASTM	National Fire Protection Association (NFPA) 415/417	State and Local Building Codes

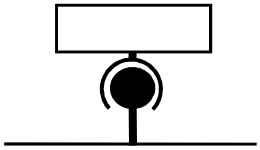
IMBALANCE

IMBALANCE - DEFINITION

Stepping on unstable surface along a walking path e.g. a loose tile

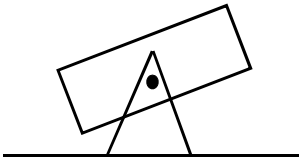
IMBALANCE - MODELING





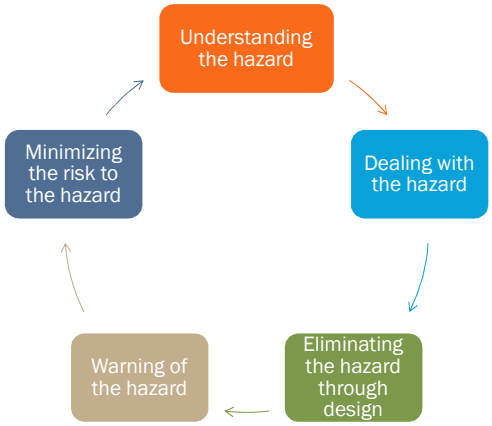
Loose tile can be modeled as a tile attached to ground by a pivot or a ball joint depends on its motion

IMBALANCE - MODELING



As the tile tilts, the magnitude of the supporting friction force is reduced just the same as in a ramp. In this case the apparent COF changes with the tile's angle. Also, the demand on the ankle might exceeds its capabilities.

ENGINEERING PRINCIPLES



Reduction of Injuries and a Proactive Approach

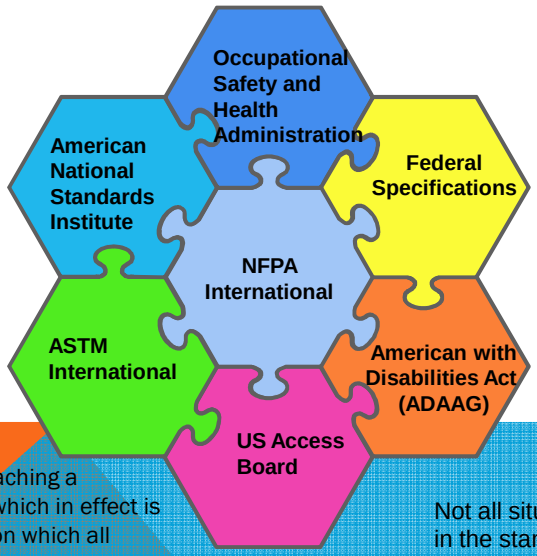
BEST PRACTICE

- ✓ Comply with accessibility standards in the American Disabilities Act (ADA) of 1990.
- ✓ US Access Board has standards which act as guidance for pedestrian facilities.

BEST PRACTICES

- The most important (fundamental) level of preventing an accident is removing any hazard.
- Most accident could have been easily preventable had management understood the dangers, identified the problem areas and quickly eliminated the hazard.

STANDARDS AND CODES



Other

- *Professional Societies*
- *International Code Council*
- *Underwriters Laboratories*
- *Industry Associations*

Based on reaching a consensus, which in effect is a minimum on which all participants can agree.

Not all situations are covered in the standard and code.

FALLING IN DIFFERENT ENVIRONMENTS

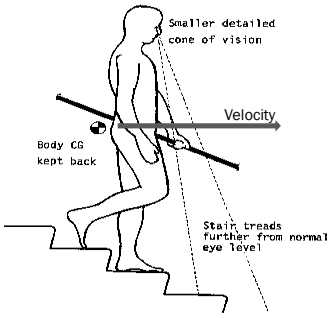
- Level walking surfaces
- Water, ice and snow
- Parking area
- Changes in level
- Entrances and exits
- Elevators and escalator
- Elevated surfaces
- Workplace falls
- Falls on public property
- Falls in residences
- Construction site
- Recreation and playground facilities
- Elderly and disabled

PATHWAYS

- Should have specified flooring materials
- Selected floor treatments
- Specific floor cleaning equipment and schedule
- Regular maintenance schedule
- Free of obstructions
- Non sudden change of grade greater than ¼ inch
- Static coefficient of friction equal or greater than 0.5

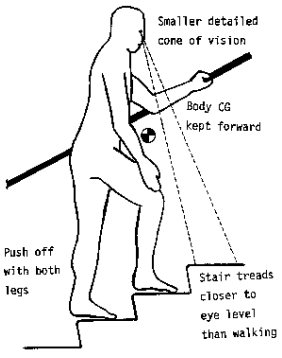
SLIP & TRIP ON STAIRS

Slip usually occurs during stepping down the stars since the leading foot requires small horizontal support force



SLIP & TRIP ON STAIRS

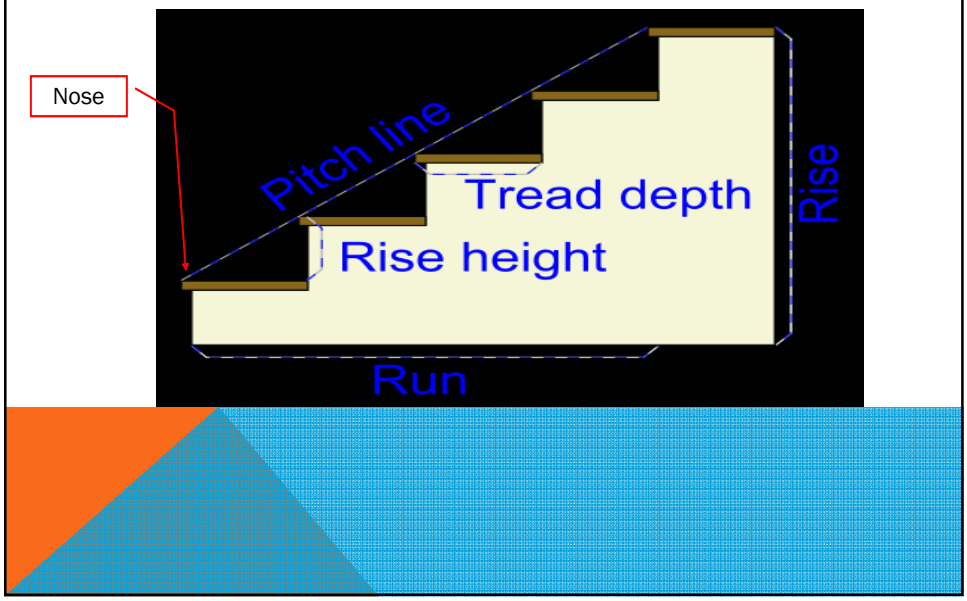
Trip usually occurs where the stair riser is not uniform and the leading foot hitting the stair too low



FALL ON STAIRS

- ✓ Poor illumination make it difficult to detect the stair's nose
- ✓ Rich pattern on carpeted stairs make it difficult to see the edge of the stair (same with wood)

STAIRS - DEFINITION



STAIRS - REQUIREMENTS

Riser	7” max.4” min.
Tread	11” min.
Width	20” min.
Head room	80” min.
Riser deviation	0.375” max.
Tread deviation	0.375” max.
Leading edge	max. radius of 0.5”
Nose projection	1.25” max.
Tread slope	0.25” max.

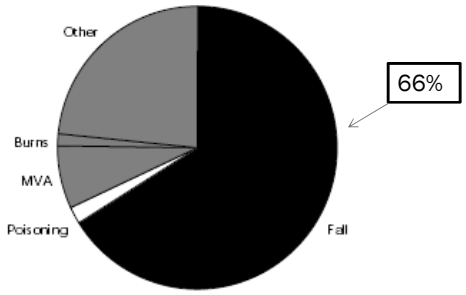
Dimensions can vary and depend on use

AGING AND FALLING

- Susceptibility to falling increases considerably with age
- One in three seniors will fall one or more times each year
- Injury is a potentially serious outcome of falling in older people
- Approximately half the falls occur within the persons home
- Impaired vision and hearing, peripheral sensation, muscle strength and reaction time all contribute to poor balance and falling

AGING AND FALLING

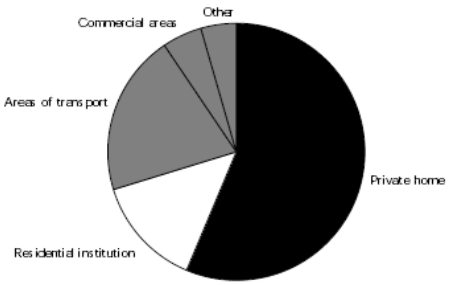
Type of injury, injuries among older people



(≥65 yrs), VISS: WH, LRH, RMH 2 yrs each, PANCH 1yr *N = 5101*

AGING AND FALLING

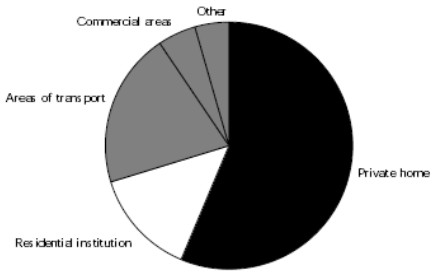
Location of injury, injuries among older people **2**



(≥65 yrs), VISS: WH, LRH, RMH 2 yrs each, PANCH 1yr *N = 4132, where location recorded*

AGING AND FALLING

Location of injury, injuries among older people

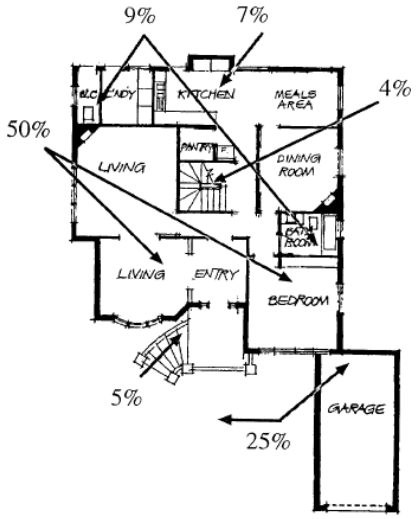


(≥65 yrs), VISS: WH, LRH, RMH 2 yrs each, PANCH 1yr

N = 4132, where location recorded

AGING AND FALLING

Location of falls in private homes, injuries among older people

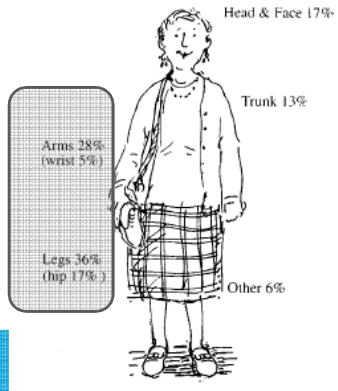


(≥65 yrs), VISS: WH, LRH, RMH 2 yrs each, PANCH 1yr

N=1618

AGING AND FALLING

Body parts injured, injuries among older people



(≥65 yrs),VISS: WH, LRH, RMH 2 yrs each, PANCH 1yr. Up to 3 injuries may be recorded per case. N of injuries=6298

AGING AND FALLING

Factors associated with falls in private home injuries among older people **Table 1**

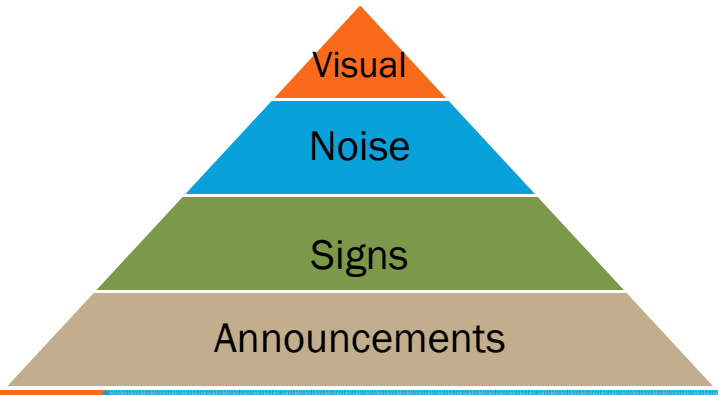
Factor	Cases N=1618*
stairs or steps	143
chairs	92
floors or flooring materials	85
beds	72
ladders	64
concrete and other man-made outdoor surfaces	43
ground and other natural surfaces	42
water	36
baths or showers	34
crutches, canes or walkers	29
runners, throw-rugs, door-mats	24
rugs or carpets	21

(≥65 yrs), VISS: WH, LRH, RMH 2 yrs each, PANCH 1yr
** Up to 4 factors may be recorded per case*

ILLUMINATION AND FALLING

- Lighting can disguise a defect or hazardous condition
- A change in the normal walking environment must be visible to the pedestrian and stand out from background stimuli
- Glare and too much or too little contrast in the walking environment can reduce the efficiency of the eye
- Walking surface should be evenly illuminated and should have a brightness level of at least 20 foot candles
- Contrast (ratio of dark to light) should be no less than 3-1 and no more than 20-1
- Measurement of luminosity and contrast requires a simple photographic light meter calibrated to read in foot candles

DISTRACTION AND WARNING



FLOOR CONSIDERATIONS

- Slipperiness of the floor material
- Circumstances used
- Full range of contaminates that might be experienced
- Clean and maintenance protocols
- Slip resistance of installed floor might be different from factory product
- Effects of time on floor surface
- Finish and Treatments properties
- Impact of wear

WORKPLACE FALLS

- Weather conditions
- Walking surface
- Foot floor interface
- Footwear and equipment
- Working practices
- Job training
- Management & organization factors

PARKING LOTS

- Typical illumination problem is that lights are obstructed by overgrown trees
- Stop blocks are not painted and cannot be detected because of poor lighting
- Rain and water on the surface cause glare
- Even shallow water hide potholes and other defects in the pavement

TERMINAL FACILITIES

- Passenger Flow
- Walking Surface
- Parking & External Areas
- Changes in Level
- Stairways
- Handrails
- Ramps
- Entrances and Exits
- Floor Coverings
- Escalators
- Elevators
- Moving Walkways

TRUCK LOADING DOCK

- Dock levelers or plates
- Maintenance and cleaning
- Enclosed bays
- Wheel chocks

BATHROOMS

- USUALLY SLIPPARY CONDITIONS DUE TO WET FLOOR
- COMING OUT OF A BATH TUB REQUIRES SOME BALANCING ACT WHICH DEMANDS HIGH COEFFICIENT OF FRICTION
- OLDER PEOPLE HAVE DIFFICULTY TO GET OUT OF A BATH TUB
- MATS, WHICH ARE SUPPOSE TO PROVIDE HIGH FRICTION, MIGHT MAKE THE SITUATION EVEN WORSE

ICE AND SNOW

VERY LOW COEFFICIENT OF FRICTION

SNOW MIGHT COVER OBSTACLES

DRASTIC CHANGE IN COEFFICIENT OF FRICTION FOR THE FIRST STEP OUT THE OF COVERED AREA

ELEVATORS, ESCALATORS, MOVING WALKWAYS

CAR AND FLOOR LEVELS SHOULD BE WITHIN 0.25 INCH

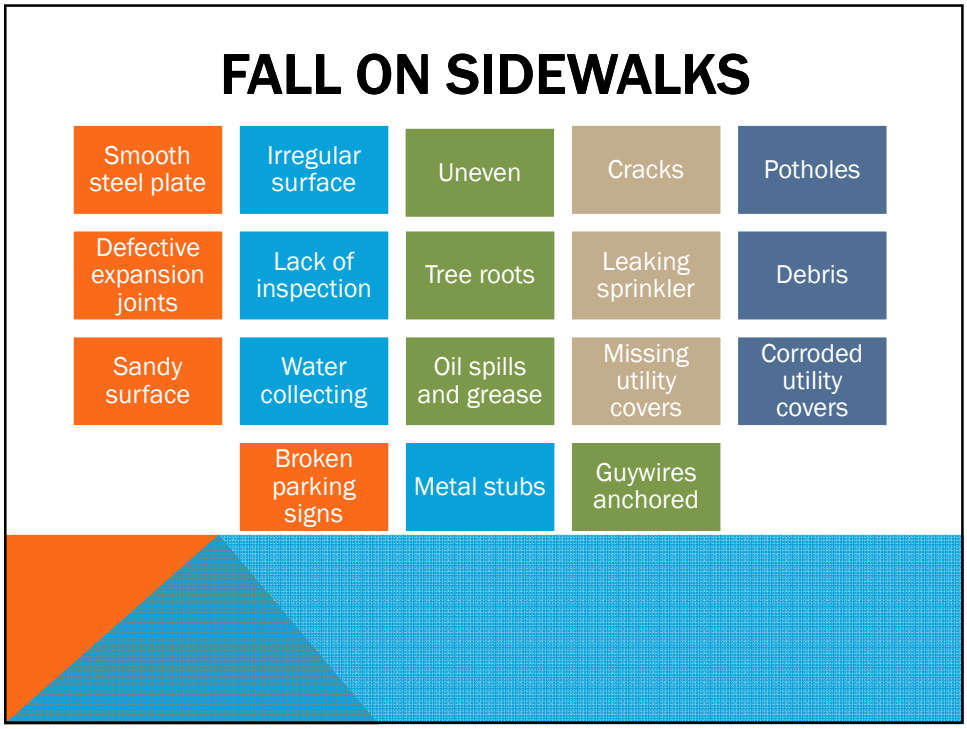
LARGE GAP BETWEEN THE CAR AND THE FLOOR CAN CATCH HIGH HEEL SHOE AND CAUSE A FALL. SAME FOR ESCALATOR

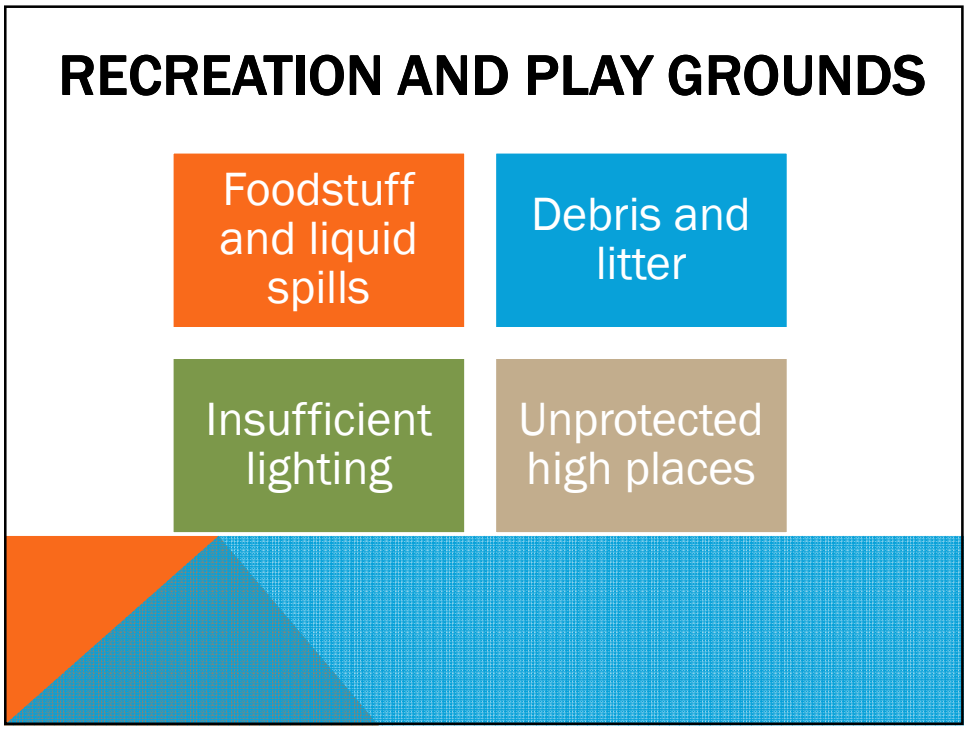
AVOID CHANGE IN FLOOR SURFACE FROM ONE FLOOR TO ANOTHER

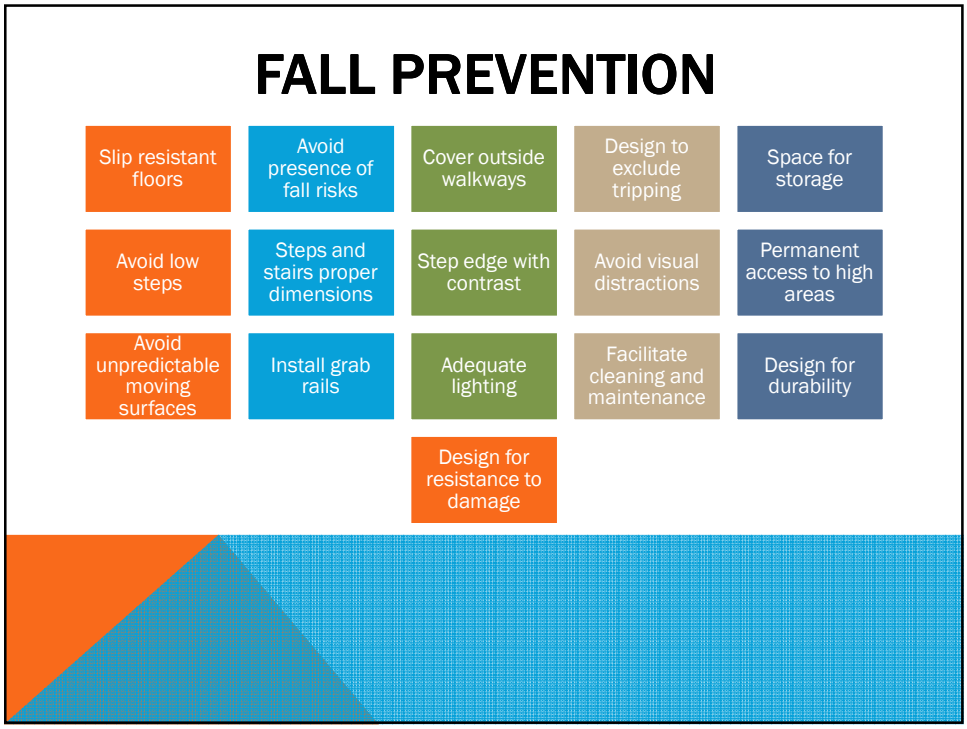
SUITCASES AND BAGS ON MOVING WALKWAYS CAUSE TRIP

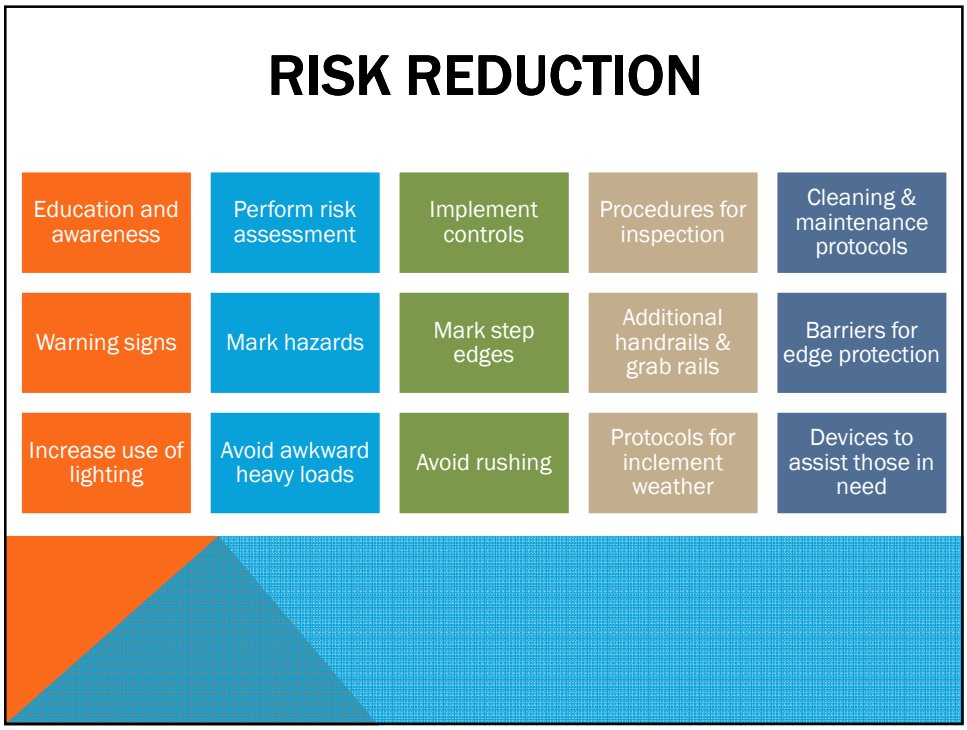
HIGH ACCELERATION OR DECELARATION DURING STEP ON/OFF FROM MOVING WALKWAYS CAN CAUSE A FALL

EMERGENCY STOP OF ALL THESE DEVICES CAN CAUSE A FALL


FALL ON SIDEWALKS
Smooth steel plate
Irregular surface
Uneven
Cracks
Potholes
Defective expansion joints
Lack of inspection
Tree roots
Leaking sprinkler
Debris
Sandy surface
Water collecting
Oil spills and grease
Missing utility covers
Corroded utility covers
Broken parking signs
Metal stubs
Guywires anchored


RECREATION AND PLAY GROUNDS
Foodstuff and liquid spills
Debris and litter
Insufficient lighting
Unprotected high places


FALL PREVENTION
Slip resistant floors
Avoid presence of fall risks
Cover outside walkways
Design to exclude tripping
Space for storage
Avoid low steps
Steps and stairs proper dimensions
Step edge with contrast
Avoid visual distractions
Permanent access to high areas
Avoid unpredictable moving surfaces
Install grab rails
Adequate lighting
Facilitate cleaning and maintenance
Design for durability
Design for resistance to damage


RISK REDUCTION
Education and awareness
Perform risk assessment
Implement controls
Procedures for inspection
Cleaning & maintenance protocols
Warning signs
Mark hazards
Mark step edges
Additional handrails & grab rails
Barriers for edge protection
Increase use of lighting
Avoid awkward heavy loads
Avoid rushing
Protocols for inclement weather
Devices to assist those in need

RISK REDUCTION

- Promote and monitor health
- Encourage exercise
- Promote good diet
- Adopt drug protocols
- Promote sleep management
- Discourage use of alcohol
- Encourage use of footwear
- Encourage use of proper clothing
- Promote eye exam and glasses

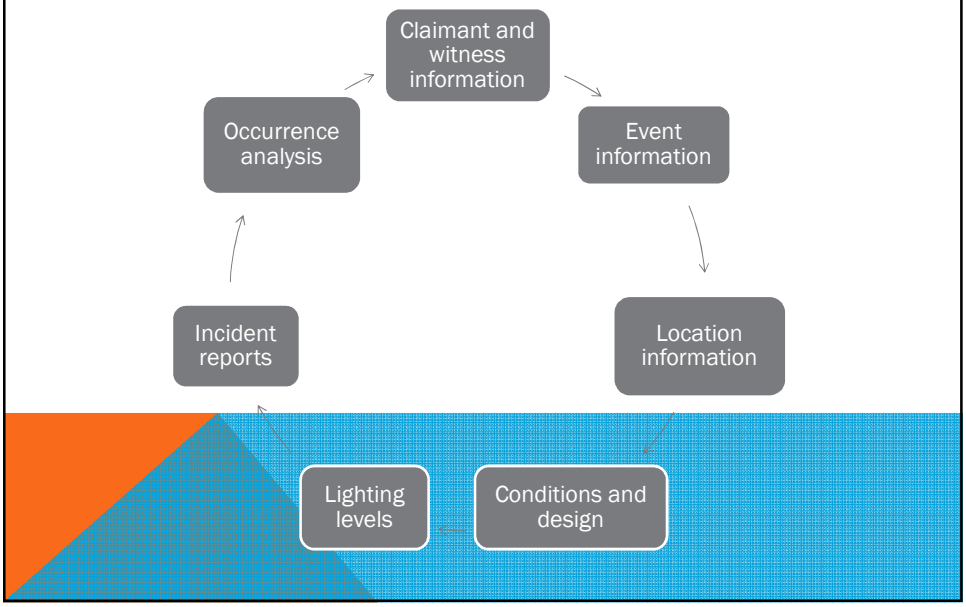
PREMISE LIABILITY

- Duty owed
- Trespasser
- Statues
- Notice
- Proximate cause
- Damages

INFORMATION NEEDS FOR SAFETY

- Provide information that can be rapidly assimilated using more than one sense.
- Provide detectable warnings
- Provide warning of any potential dangers.
- Information from the environment to travel along pathways safely and efficiently.
- Obtained visually by observing cues at critical junctures as entrances and exits.
- Visually impaired depend on cues to estimate distances and directions to determine location.
- Information needs to be redundant and in the multiple format.
- Manual of Uniform Traffic Control Devices.

ACCIDENT INVESTIGATION



CONDUCTING AN INVESTIGATION

Floor	• friction, roughness, maintenance, cleanliness, stability, contamination, condition, repair
Footwear	• type, sole, heel, wear, employer control, suitability
Personal	• sex, age, weight, eyesight, drugs, health condition, individual anthropometrics, level of concentration
Work System	• housekeeping, contamination, work arrangements, shift, time pressure, cleaning regime, handling of loads walkways, safety culture, management
Environ	• day of week, month, lighting, temperature, humidity, ventilation, vibration, housekeeping, ice, snow, leaves

CONDUCTING AN INVESTIGATION

TESTING and EXPERIMENTS

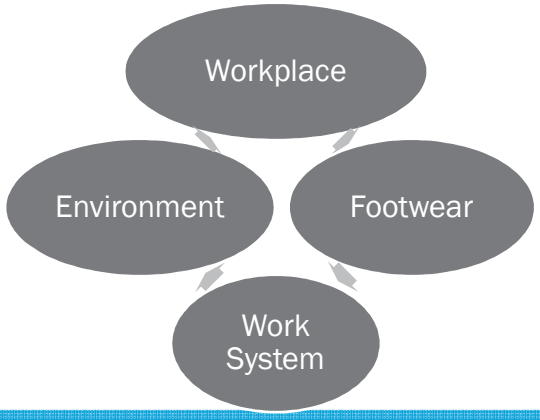
Performed ASAP in order to preserve the surface condition as it was at the time of the accident

GMC v. Carl PORRITT

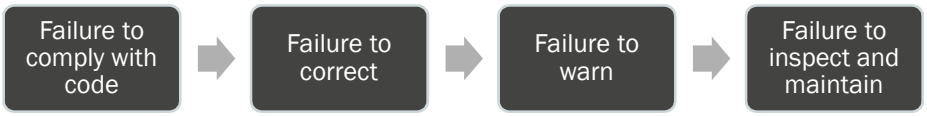
"Where testing is offered as evidence, the conditions in an experiment must be substantially similar to those at the time of the occurrence for evidence of the experiment to be admitted"

"For purpose of determining admissibility of scientific testing, determination of the similarity of the circumstances & conditions of a scientific test to those existing at the time of the occurrence is left to the discretion of the trial court."

STATUTORY CONTROLS



THEORY OF LIABILITY



DEFENDING

- Determine facts
- Analyze plaintiff information
- Evaluate prior accidents
- Review maintenance and inspection procedures
- Assemble facts
- Evaluate physical evidence
- Select expert
- Motion for summary judgment
- Limited immunity

VISION AND FALLING

- Vision and conspicuity
- Visual ability

WALKING AREA MAINTENANCE

- Floor cleaning
- Carpet and floor maintenance
- Floor Treatments
- Pavement maintenance

USEFUL EVIDENCE TO BUILD OR DEFEND CASE

- ✓ Review Accident Facts
- ✓ Evaluate Prior Accidents
- ✓ Review Maintenance and Inspection Procedures
- ✓ Assemble Facts (Complaint, Discovery)
- ✓ Evaluate Physical Evidence

SELECTING AN EXPERT

- ✓ Communications is the key to success in personal injury matters
- ✓ Factual interpretation and accurate analysis of information can be obtained only through a qualified expert
- ✓ Must be articulate and able to speak before a judge and jury
- ✓ Must be able to interpret information for the jury in simple terms

SELECTING AN EXPERT

What to look for:

- ✓ Education and Background
- ✓ Employment History
- ✓ Litigation Experience
- ✓ Appearance and Mannerisms
- ✓ Availability

USING THE EXPERT

Retaining an expert early can assist in case preparation and evaluation

- ✓ To identify issues and possible flaws in the case
- ✓ To provide assistance in preparing a comprehensive list of discovery information
- ✓ To assist the attorney and jury in understand the technical aspects of the case and evaluating the facts as measured by the national standards of care

DUTY OF CARE

- ❑ Warn passengers of hazards
- ❑ Properly train personnel
- ❑ Have safety inspections
- ❑ Update design standards
- ❑ Provide effective communications


Thank You
800-523-2319
Contact TASA
For Further Information