PASSENGER TERMINAL SAFETY PART I

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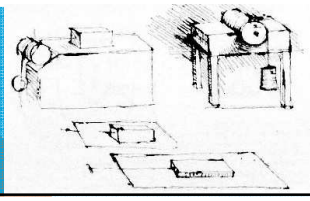
INTRODUCTION

- It is not unreasonable to expect that the walking environment in a passenger terminal is safe.
- Many passenger terminal mishaps are caused by unexpected changes in:
  - Geometry – holes, uneven surface, etc.
  - Characteristic property – coefficient of friction
  - Speed – moving walkway, etc.
- Sudden changes in the above do not offer obvious visual cues to attract a person's attention.

HISTORICAL PERSPECTIVE

He who trips and falls should not blame his foot …Ancient Chinese Proverb

- For thousands of years man has recognized the dangers of slipping, tripping and falling.
- The first reported slip, trip and fall accident dates back to our earliest oral and written history.
- 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

BABYLON - 1758 BCE

If a builder has built a house for a man and has not made his work sound, and the house which he has built has fallen down and so caused the death of the householder, that builder shall be put to death.

The Code of Hammurabi

EXODUS 21:33

If a person digs a hole, or uncovers a hole, and does not cover it over. If an ox or donkey falls into it, the one responsible for the hole must make restitution, restore the full value of the animal, to its owner. The dead animal remains the property of the hole digger.

Traditional Bible -1300 BCE
English Standard Version …2001

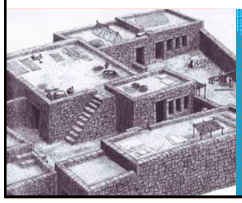
LEVITICUS 19:14

Do not insult the deaf or cause the blind to stumble.

Traditional
Bible, New Living
Translation …2007

DEUTERONOMY 22:8

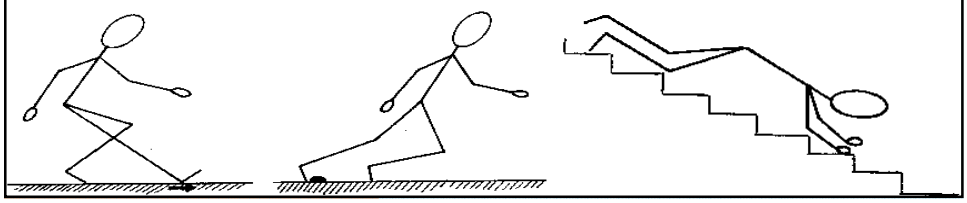
When you build a new house, you shall make a parapet for your roof, that you may not bring the guilt of blood upon your house, if anyone should fall from it.



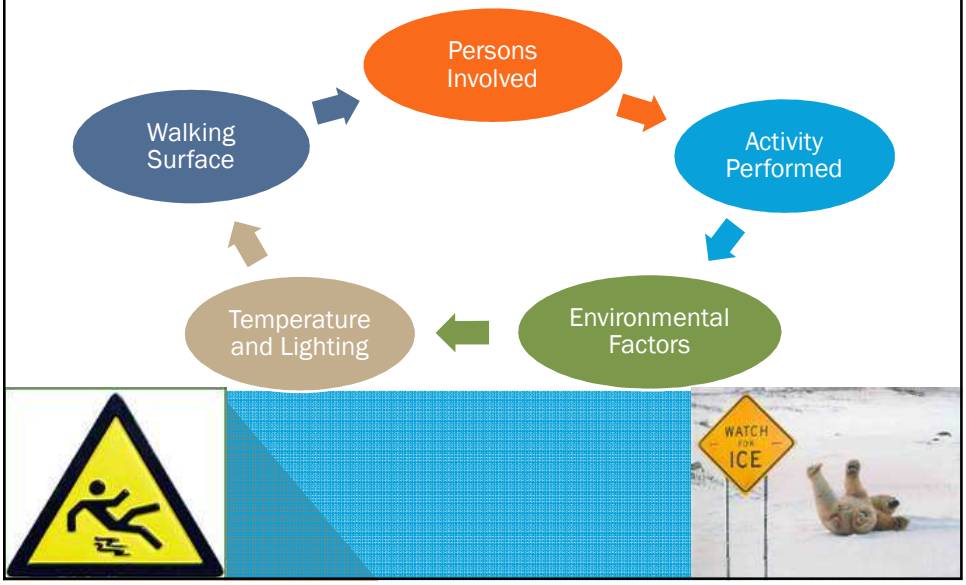
Traditional Bible
English Standard Version …2001

SLIPS, TRIPS AND FALLS

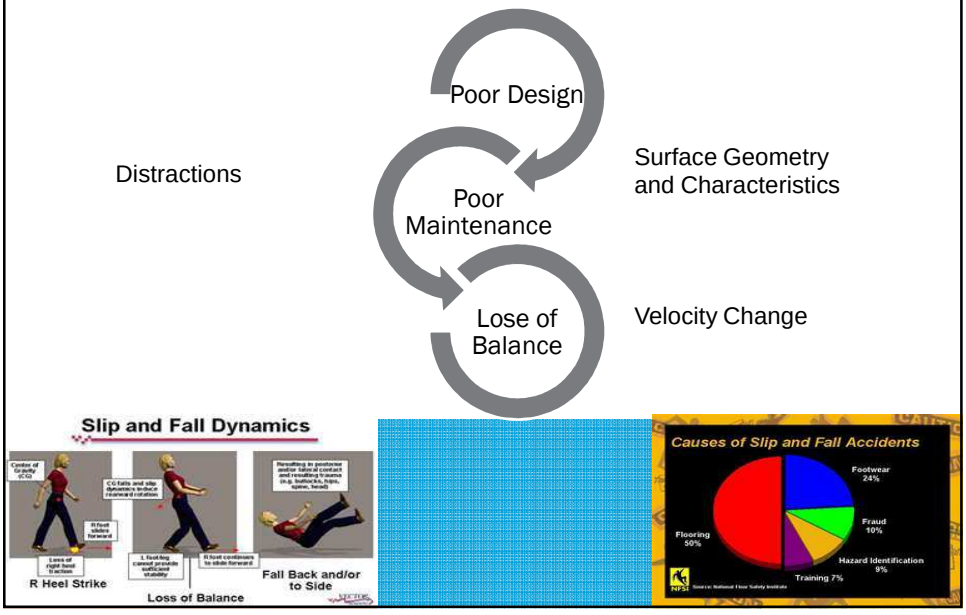
- Tens of thousands of passengers in terminals suffers slips, trips and falls each year and thousands occur each day.
- Cost to terminal operators and passengers is in the billions of dollars.



COMPONENTS OF A SLIP

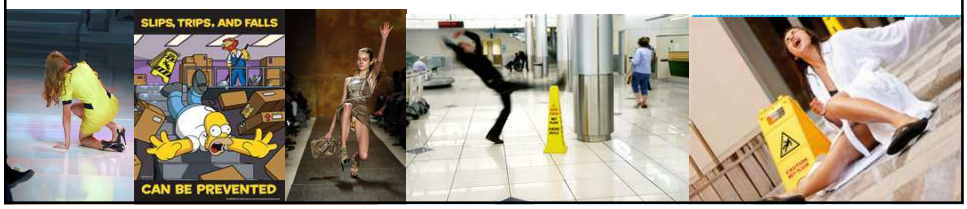


SLIP AND TRIP: CAUSES



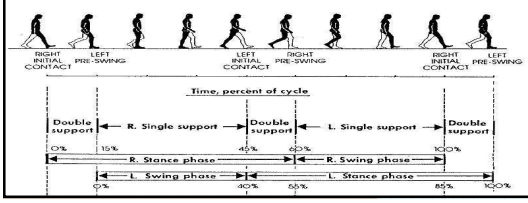
FALLS ARE CATEGORIZED

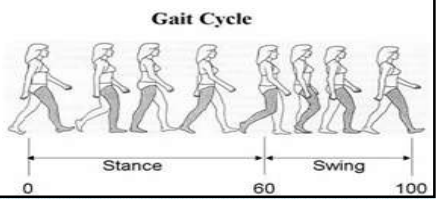
- Circumstances (on the level, on a slope, on steps/stairs, from height)
- Age of the person (healthy adults, children, older persons)
- Place (terminal, parking area)



FACTORS IN FALLING

Gait	Balance	Stature
Strength	Vision	Behavior





ENVIRONMENT AND FALLING

- Foot-ground interface.
- Presence of tripping hazards (obstacles in the pathway.
- Frictional characteristics (footwear and floor material.
- Surface condition (wet/dry contaminated).

FALL FROM HEIGHT

- Height of guard and balcony rails in relation to a persons center of gravity.
- Responsible for the most serious injuries.
- Unguarded edges or openings to a lower level.



FALLS INFLUENCED BY

Health	Fatigue	Medication
Alcohol	Environment	Activity

FALL OUTCOMES

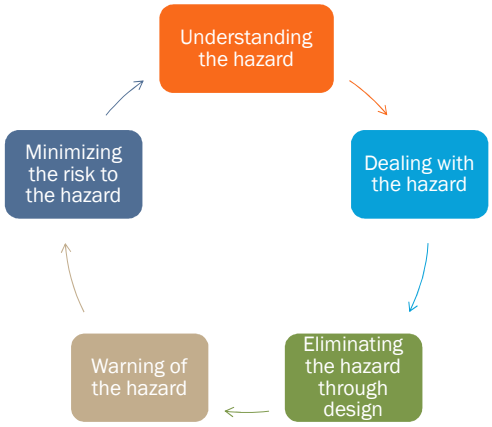
- Fall on the level – lower or upper limb fractures, sprains, back or head injuries.
- Falls from height – often serious, forces generated and severity depends on the distance of the fall and the contact surface.

ACCIDENT PREVENTION

Passenger accident prevention:

- Removing the hazardous condition
- Passive warning - signage
- Active warning – sound & visual alarms

ENGINEERING PRINCIPLES

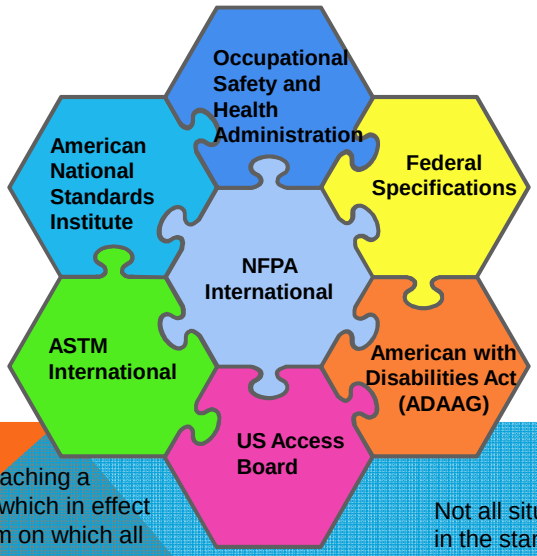


Reduction of Injuries and a Proactive Approach

ASPECTS OF TERMINAL FACILITIES

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

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.

PEDESTRIAN 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.

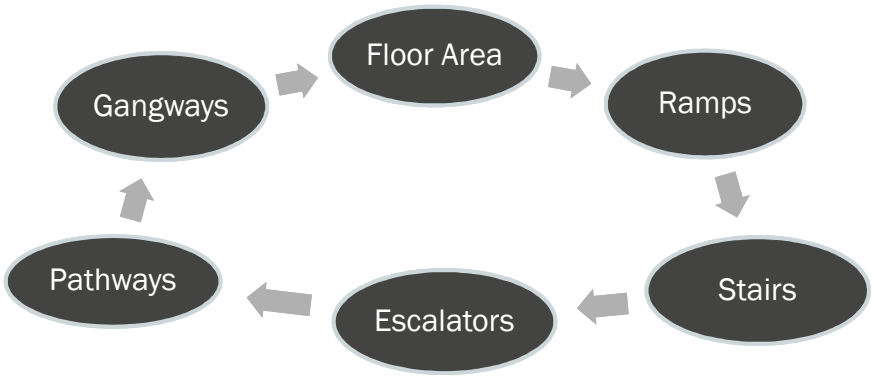
SAFETY BY DESIGN

The pathways within a terminal environment is a critical element in the safe design of the passenger circulation system.

GOOD DESIGN

- ✓ Good design in the form of regularly aligned pathways in an easy-to-understand layout is the best method to provide orientation cues for pedestrians (especially young people, elderly, impaired or disabled).
- ✓ When placing non-visual information it has to be considered that many pedestrians are going to be unfamiliar with the railroad environment.

TERMINAL AREAS



Location of Slips, Trips and Falls

BEST PRACTICES

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

PEDESTRIAN INFORMATION NEEDS

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.

FLOOR AREA

- Interaction between the footwear, the flooring material and the contamination that govern slip potential.
- Most floor areas present an acceptable slip risk when dry and free of slippery substances.

PATHWAYS FOR PASSENGERS

- 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

GANGWAY: Definition

OSHA 1915.4:

The term "gangway" means any ramp-like or stair-like means of access provided to enable personnel to board or leave a vessel including accommodation ladders, gangplanks and brows.

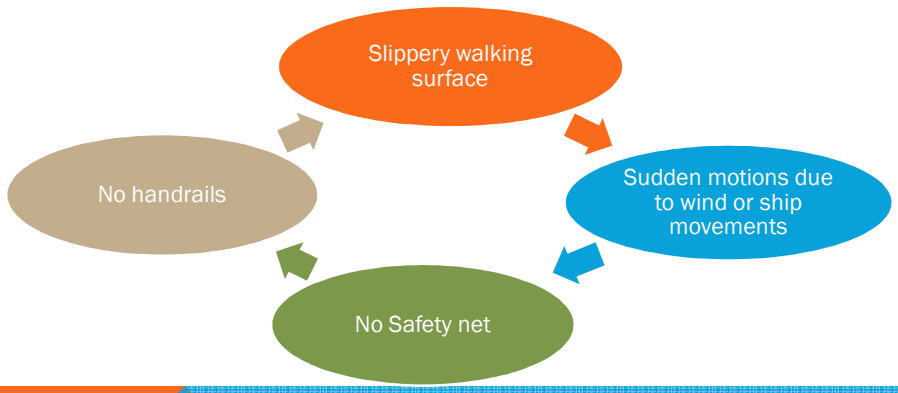
GANGWAY: Standards

- Occupational Safety & Health Administration (OSHA) 1918
- Occupational Safety & Health Administration (OSHA) 1915
- American with Disabilities Accessibility Guidelines (ADAAG) 15.2
- Architectural Barriers Act (ABA) 1003
- National Fire Protection Association (NFPA) 415/417
- American Society of Mechanical Engineers (ASME)
- Society of Automotive Engineers (SAE)
- American Society of Civil Engineers (ASCE)
- American Institute of Steel Construction (AISC)
- MIL-DTL-22342E

GANGWAY: Requirements

- Comply with variety of geometrical requirements (width, slope, landing etc.)
- Adequate strength.
- Maintained in safe repair and safely secured.
- Secured against shifting or slipping.
- Each side of the gangway should have a hand rail ...minimum height of 33" and a mid-rail.
- Rails should be of wood, pipe, chain, wire, rope or materials of equivalent strength
- Rails should be always kept taut.
- The gangway should be kept properly trimmed.
- Gangways overhanging water - a net or suitable protection should be provided to prevent falls to a lower level.
- Should be regularly inspected.
- Obstructions should not be laid on or across the gangway.

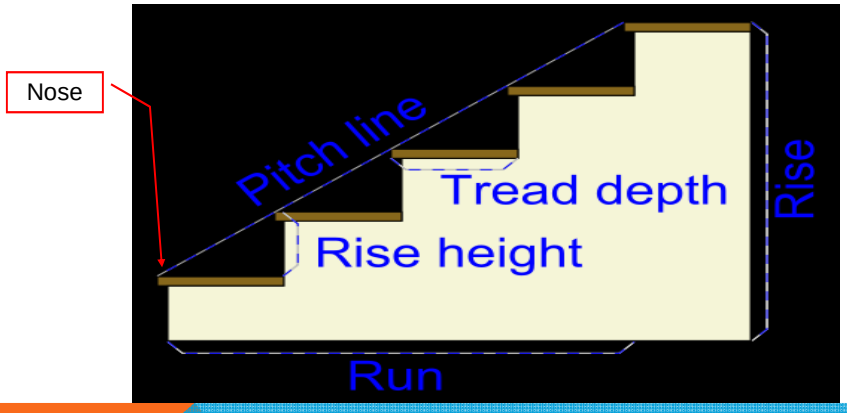
GANGWAY: Typical Accident



STAIR: Issues

- ✓ Designed in accordance with standards and codes.
- ✓ Consistent riser height and tread depth.
- ✓ Width to accommodate traffic.
- ✓ Scheduled inspections and preventive maintenance.
- ✓ No handrails.

STAIR: Definition



STAIR: Gallery

STAIR: Standards

- Occupational Safety & Health Administration (OSHA) 1918
- Occupational Safety & Health Administration (OSHA) 1915
- American with Disabilities Accessibility Guidelines (ADAAG) 15.2
- Architectural Barriers Act (ABA) 1003
- National Fire Protection Association (NFPA) 415/417
- State and Local Building Codes

STAIR: Materials

Stairs are made of any building material:

- Wood
- Concrete
- Glass
- Steel (or other metals)

STAIR: 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.

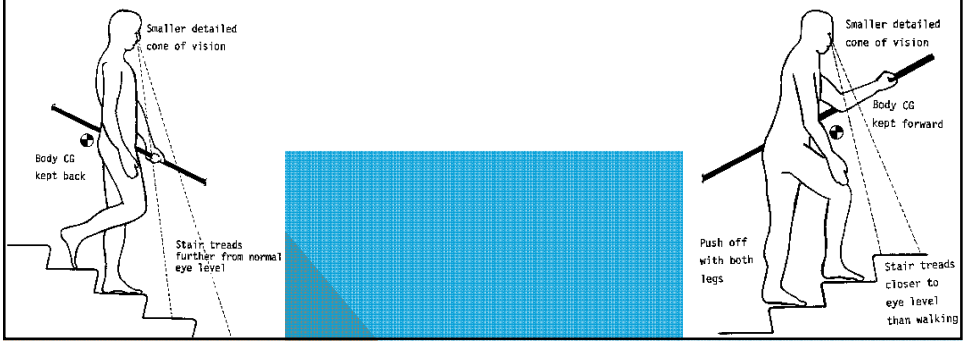
Dimensions varies depends on occupancy and use of the building.

STAIR: Requirements

- ✓ Required landing at the top and the bottom of the staircase
  - Width - Same as the stairway
  - Depth - 48” min.
  - Slope - 2% max.
- ✓ Maximum rise - 12ft
- ✓ Required signage leading to the stairway
- ✓ Required handrails usually on both sides

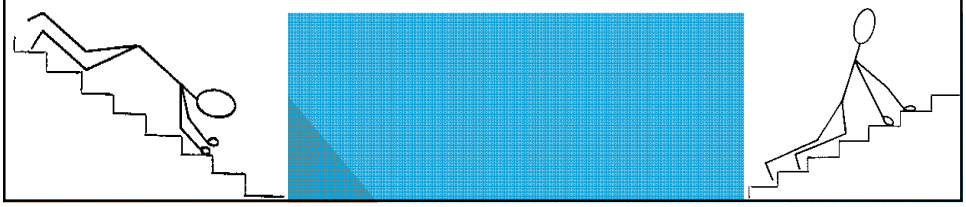
STAIR: Requirements

Handrails shall be provided on at least one side of each continuous run of treads or flight with four or flight with four or more risers.



STAIR: Typical Accident

- ✓ Uneven stairs
- ✓ Stair's edge is not visually detected
- ✓ No marking of stair's nose
- ✓ Slippery
- ✓ Environment (Illumination, wind)



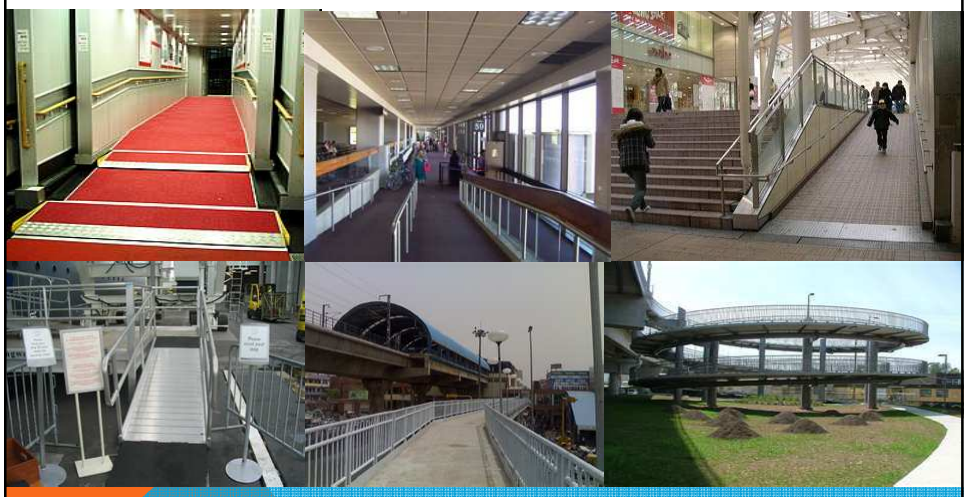
STAIR: Safety Enhancement

- ✓ Clear marking of the stair's nose.
- ✓ Visually easy to detect consecutive stair.
- ✓ High friction surface.

RAMP: Issues

- ✓ Combination of steep slope and low surface coefficient of friction
- ✓ Concrete that is worn smoothly or made smooth by attempts to beautify through the use of smooth materials
- ✓ Lack of handrails

RAMP: Gallery



RAMP: Standards

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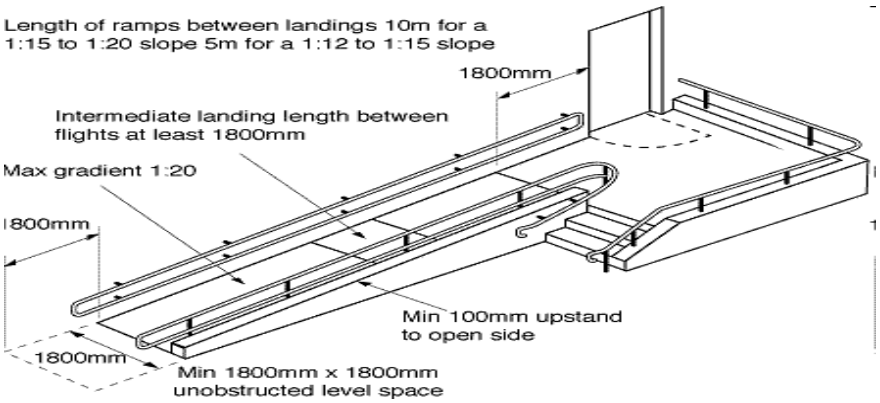
RAMP: Definition



RAMP: Requirements

- Handrails where required on ramps shall be continuous for the full length of the ramp.
- Maximum slope of 1:12
- Landing are required at :
  - The top of the ramp
  - Where doors open onto the ramp
  - Where ramps change direction

RAMP: Safety Enhancement

- High friction surface
- Clear marking at the start and end of the ramp

ELEVATOR: Definition

A hoisting and lowering mechanism, equipped with a car, that moves within guides and serves two or more landings.

ELEVATOR: Gallery

ELEVATOR: Standards

Occupational Safety & Health Administration (OSHA) 1918	Occupational Safety & Health Administration (OSHA) 1915	American with Disabilities Accessibility Guidelines (ADAAG) 15.2
ASME A17.1	National Fire Protection Association (NFPA) 415/417	State and Local Building Codes

ELEVATOR: Requirements

- ADA Compliant Handrails
- Hard and water resistant surface
- Controls, indicators, signage, two way communication, emergency stop, smoke detector, etc.
- Door kinetic energy, using average closing speed, shall not exceed 10J
- The force to prevent door closing is 30Lbs

ELEVATOR: Requirements

- Reopening devices should be installed
- Top Emergency exit should be provided
- Natural ventilation should be provided
- The vertical difference between the car platform and the door level cannot exceed 0.5”

ELEVATOR: Typical Accidents

- Door closes too quickly
- Doors closes with high force
- Uneven floors
- Abrupt starting/Stopping
- No handrails

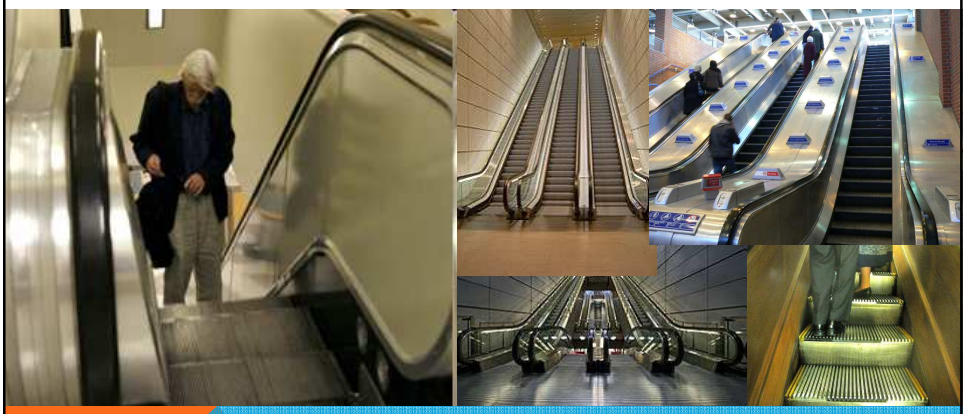
ELEVATOR: Safety enhancement

- Audio warning before door closure

ESCALATOR: Definition

A power driven, inclined, continuous stairway used for raising or lowering passengers.

ESCALATOR: Gallery



ESCALATOR: Issues

- ✓ Excessive speed
- ✓ Unequal stair and banister speed
- ✓ Stops suddenly
- ✓ Pedestrian does not use banister while walking on escalator
- ✓ Uncontrolled or unsupervised children
- ✓ Fingers or clothing caught

ESCALATOR: Standards

Occupational Safety & Health Administration (OSHA) 1918	Occupational Safety & Health Administration (OSHA) 1915	American with Disabilities Accessibility Guidelines (ADAAG) 15.2
ASME A17.1	National Fire Protection Association (NFPA) 415/417	State and Local Building Codes

ESCALATOR: Requirements

- Moving handrails at the same speed of the stairs
- Entry and exit zones should be clear
- Tight dimensions requirements
- Maximum speed of 100ft/min
- Caution signs are required

ESCALATOR: Typical Accidents

- Entry and exit falls
- Cloth being caught causing fall
- Abrupt starting/Stopping
- Sticking fingers in the moving handrail

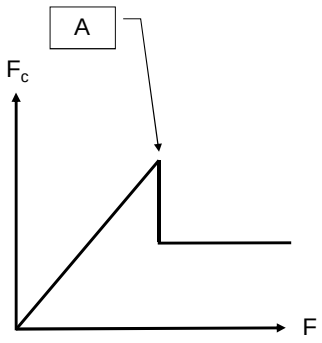
ESCALATOR: Safety Enhancement

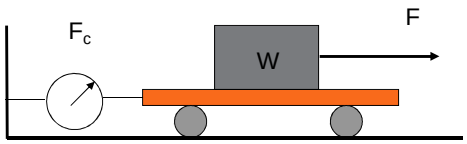
- Audio warning at the entrance and the exit.

FRICTION: Definition

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

FRICTION: Definition





At point A the block starts sliding on the surface

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
W – Normal force

FRICTION: Definition

The coefficient of friction, μ_s, characterizes the resistance of the surface to slippage. Its value depends on:

- Surfaces material
- Surface condition
- Surface texture
- Physical/Chemical interaction between surfaces

FRICTION: Minimum Requirements

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

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

FRICTION: Standards

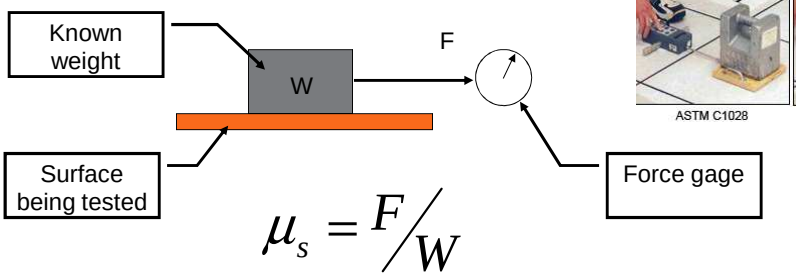
- Occupational Safety & Health Administration (OSHA) 1918
- Occupational Safety & Health Administration (OSHA) 1915
- American with Disabilities Accessibility Guidelines (ADAAG) 15.2
- ASTM
- National Fire Protection Association (NFPA) 415/417
- State and Local Building Codes

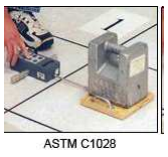
FRICTION: Typical Accidents

- Low coefficient of friction
  - Inherent
  - Surface contaminated (dirt)
  - Wet
- Sudden transition from high to low coefficient of friction

FRICTION: Measurements

- ASTM C-1028 – Pull test





$$\mu_s = F/W$$

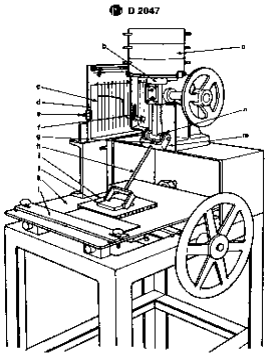
System has to be calibrated using a calibration tile

FRICTION: Measurements

- ASTM E 303 – British pendulum tester

FRICTION: Measurements

- ASTM F 489 – James Machine



Good for lab environment

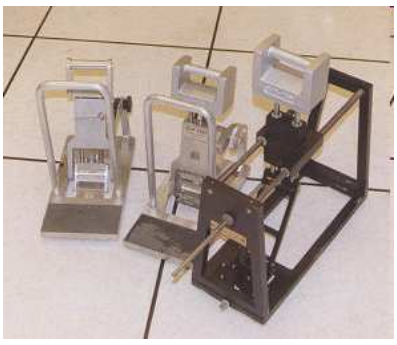
FRICTION: Measurements

- ASTM F 1679 – English XL

Standard was dismissed due to poor repeatability

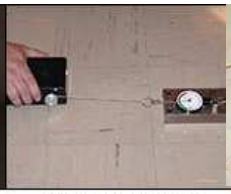
FRICTION: Measurements

- ASTM F 1677 – Brungraber Mark II



FRICTION: Measurements

ASM 825



National Slip Meter

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 and many more.
- The expert has to pick up the relevant standard for the particular case.

FRICTION: Measurements

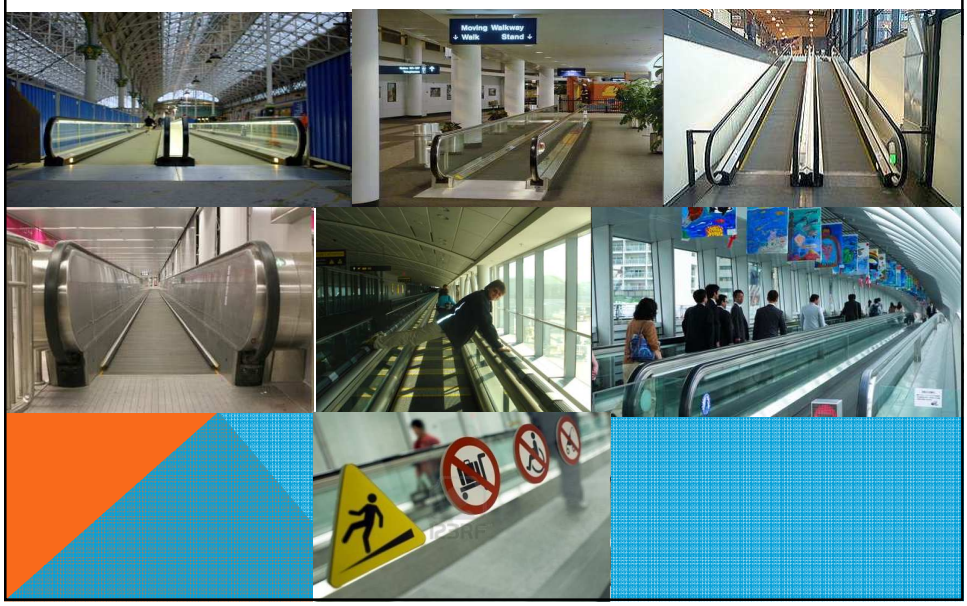
Difficulties:

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

MOVING WALKWAY: Definition

A type of passenger-carrying device on which passengers stand or walk, and in which the passenger-carrying surface remains parallel to its direction of motion and is uninterrupted.

MOVING WALKWAY: Gallery



MOVING WALKWAY: Standards

- Occupational Safety & Health Administration (OSHA) 1918
- Occupational Safety & Health Administration (OSHA) 1915
- American with Disabilities Accessibility Guidelines (ADAAG) 15.2
- Architectural Barriers Act (ABA) 1003
- National Fire Protection Association (NFPA) 415/417
- State and Local Building Codes

MOVING WALKWAY: Requirements

- Moving handrails at the same speed of the stairs
- Entry and exit zones should be clear
- Tight dimensions requirements
- Maximum speed:
  - 0° - 8° slope – 180 ft/min
  - 8° - 12° slope - 140ft/min
- Caution signs are required

MOVING WALKWAY: Typical Accidents

- Entry and exit falls
- Abrupt starting/stopping

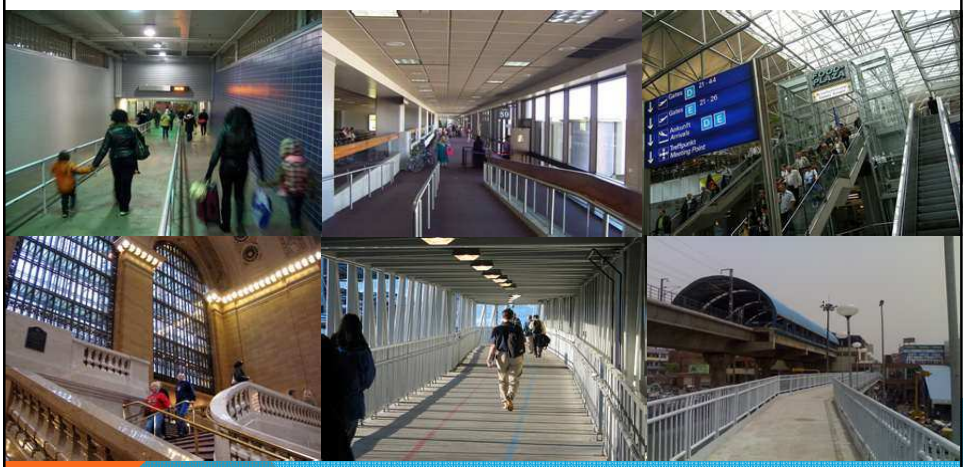
MOVING WALKWAY: Safety Enhancements

- Audio warning at the entrance and the exit.

HANDRAIL: Definition

A horizontal or sloping rail intended for grasping by the hand for guidance or support.

HANDRAIL: Gallery



HANDRAIL: Standards

Occupational Safety & Health Administration (OSHA) 1918

Occupational Safety & Health Administration (OSHA) 1915

American with Disabilities Accessibility Guidelines (ADAAG) 15.2

Architectural Barriers Act (ABA) 1003

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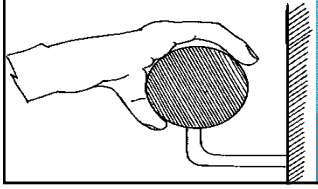
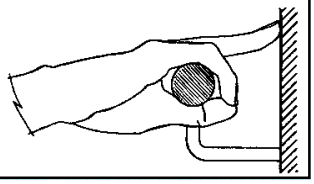




HANDRAIL: Requirements

- At least 34” above leading edge of the tread (max. 38”)
- Circular cross-section with minimum 1.25” diameter(max. 2”) or perimeter of 6.25” with 0.75” clearance for fingers in both sides(graspable)
- 88” or wider stair way requires one or more intermediate handrails

HANDRAIL: Requirements

- Should extend at least 12” beyond the top and the bottom riser
- Support 200 lbs per square foot
- Should have guards on the open side

HANDRAIL: Typical Accidents

- No handrail extension – user has no indication for first or last stair and he misstep.
- Rails are far apart
- Not able to grasp the rail

HAZARD ANALYSIS

- ✓ Used in the system safety process to allow a railroad to evaluate hazards in the various modes of operation.
- ✓ The purpose is to:
  - Identify safety hazards and their causes
  - Determine hazard severities/probabilities
  - Recommend corrective action to correct procedures and resolve design problems
  - Provide documented evidence of compliance with design, code, or specification requirements to management.

HAZARD PREVENTION

Root causes	Causations	Accident investigation	Safety inspection practice
Design and construction	Written procedures	Tracking accidents	Safety program

PREVENTIVE MEASURES

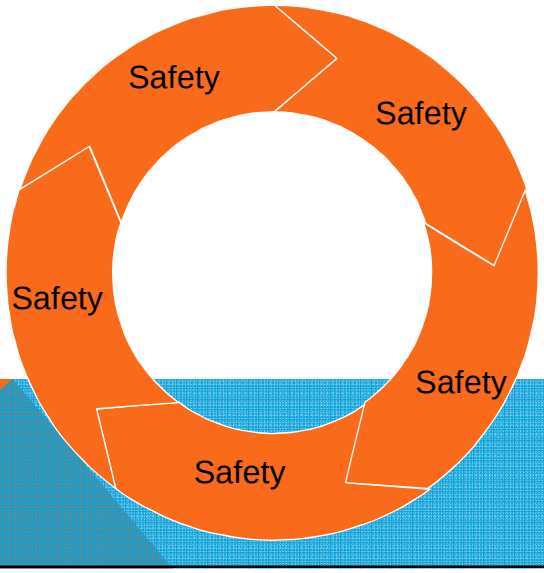
Preventive measures to eliminate the hazard are quite simple:

- Passive and active devices
- Information systems
- Cleaning, maintaining and repairing the pathways

DUTY OF CARE

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

MOST IMPORTANT




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