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## 3.9 Handrails

1 Credit: Implement 1 of 3

- All stairways and ramps have a set of handrails at more than one height (e.g., one for adults and one for children).
  - All stairways and ramps have luminescent striping or integrated lighting on at least one set of handrails.
  - All stairways and ramps have tactile cues on all handrails, indicating the direction of travel and/or location.
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### 1. Overview

Handrails are safety devices that are designed to be grasped by the hand to prevent slips and falls. Handrails are used at stairways, ramps, and other areas where mobility support is required (e.g., corridors in medical facilities) to assist people with an unsteady gait or who have difficulty walking. Falling is the second leading cause of injuries and accidents (WHO, 2017). In general, the functional purposes of handrails are to provide users stability and directional guidance, help users pull up or lower themselves on a stair and ramp, provide visual cues to the presence of stairs and ramps, and reduce conflicts in ascent or descent of stairs and ramps by cueing users to stay to the side (Maki et al., 1998; Dusenberry et al., 2009).

Handrails are used in two ways: proactively and reactively. In proactive handrail use, the user maintains a consistent grip on the handrail, which improves their ability to recover balance in the event that the user's body is shifted forward or backward following a slip. In reactive handrail use, the user attempts to grasp the handrail after losing balance through a rapid reaching movement. This reach-and-grasp reaction increases the risk of injury due to twisting and torqueing of the body that occurs to grasp the handrail, and therefore is less effective for mitigating falls (Templer, 1992). Clearly, holding onto the rail proactively, such that a grip is secured before loss of balance can occur, will help reduce the likelihood of slipping and falling.

Usability requirements for handrails include design for graspability, reachability, and strength to withstand the loads placed on them during a fall. Building codes and standards have requirements that address all of these issues with the intent of ensuring that minimum conditions for safe use are met. However, they do not require some design strategies that can enhance safety further.

### 2. Issues to Consider

*Accommodating children and people of shorter stature:* The standard height of handrails required by most building codes for stairs and ramps is intended for adults of average height, thereby excluding people of shorter stature. Since children and short statured people have lower shoulder heights, the angle of arm flexion necessary to grasp a handrail is larger and uncomfortable. Users may be reluctant to use a handrail outside of their comfortable reach range. Therefore designers should consider installing an additional set of handrails at a shorter height. For instance, a lowered handrail should be installed in places



Figure 1: Handrail heights for children and adults at a children's museum. Source: Children's Museum of Pittsburgh

such as school and museum environments where children may be present (Figure 1). Research indicates that children prefer handrails to be located between shoulder and head height (Lueder & Rice, 2007). Handrails at an appropriate height allows for comfortable reach and grasp actions, and can withstand forces generated while users maintain balance.

*Accommodating older adults and people with low vision:* Studies on older adults indicate that the absence of handrails on ramps and stairs in public buildings is a common complaint (Wolfenbarger & Shehab, 2000). Handrails are perceived as a way of avoiding falls and can help reduce the fear of falling that is prevalent among older adults. Therefore handrails should be installed on both sides of stairs and ramps where possible. Including handrails can increase mobility support for those who require it, particularly when the path is wide, e.g., greater than 78 inches.

Handrails should also have features that enhance visibility and usability. Vision loss/impairment decreases a user's ability to notice handrails, especially when handrails are the same color as adjacent materials. Non-visible handrails can also reduce accuracy when a user reacts to imbalance by reaching for a handrail. The use of color, contrast, and lighting to make handrails stand out against its surroundings can increase a user's awareness of the presence and location of handrails for effective use. A new aspect of research on handrail use shows that interactive handrail components can enhance balance reactions and prevent falls, particularly for older adults who are more at risk of falls. Such components can include the use of flashing lights and verbal prompts to attract attention to handrails and facilitate proactive grasping (Maki et al., 2008) (Figure 2). Additionally, the use of tactile cues on handrails can provide location information and alert users about the approach and/or end of stairs and ramps that can enhance usability for people with vision loss or impairment.



*Figure 2: Multi-modal handrail cueing intervention has visual and auditory cues to increase user awareness of handrails and affect handrail use behavior. Image adapted from Maki et al. (2008).*

### 3. Related Standards

[International Building Code \(IBC\) \(2015\)](#), provides the criteria for handrails on stairways and ramps in public spaces and refers to ICC/ANSI A117.1 for the technical details.

[ICC/ANSI A117.1 \(2017\)](#), provides the technical requirements for handrail design, including height, size, shape, and gripping surfaces for handrails on stairways and ramps.

[ADA Standards for Accessible Design \(2010\)](#), provides the technical requirements for making handrails accessible, including handrail height requirements for adults and children, rail dimensions, and gripping surfaces. These standards state that handrails should be located 34-38 inches above finish floor with an added handrail at 28 inches when children are the primary users of a space. They also mandate that handrails along a ramp or stairway be continuous with extensions into landings.

[ASTM E2072 – Standard Specification for Photoluminescent \(Phosphorescent\) Safety Markings](#), referenced by 2015 IBC, provides the minimum requirements for photoluminescent markings of vertical escape routes, including stairways and ramps. These standards describe minimum luminance values for a variety of materials common in the built environment. These

standards also cover installation methods of photoluminescent markings and performance requirements such as slip resistance.

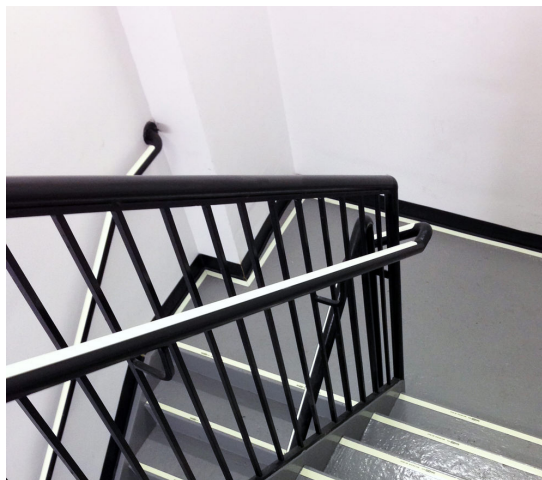
#### 4. Measurement and Verification

In addition to meeting all requirements for accessibility, the following elements should be verified to ensure a handrail's conformance to the UD Standards: handrails should be provided at the standard height and a lowered height for adults and children, stairways and individual steps should be visually salient, and handrails should offer tactile information for users with low vision. Handrail height is measured vertically from stair nosings or ramp surfaces to the top of the rail, and should be consistent across the full length of a stair or ramp system. The standard handrail height for adults is 34-38 inches, and for children, it is 28 inches. The upper and lower handrails should be spaced apart by 9 inches to prevent entrapment. Handrails should not rotate and should be secured firmly in place.

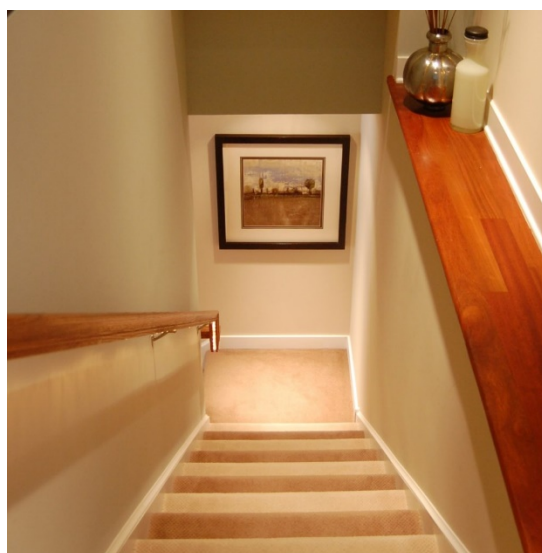
Handrails should be evenly illuminated and visible in both light and dark conditions. Luminescent striping or integrated lighting can increase handrail visibility in dark settings (Figure 3). Under normal lighting conditions, handrail materials with an illuminance contrast value of 30% or greater increases handrail visibility against the surroundings. Handrail tactile cues should conform to existing ways of communicating with people who have visual impairments by containing raised characters and braille. Such tactile cues should be placed on the top side of a handrail near its end(s). Tactile cues may include a raised domed button that is 0.4-0.5 inches (10-12mm) in diameter and 0.15-0.19 inches (4-5mm) high.

Handrails should also be easy to grasp. High graspability can be obtained on circular shaped handrails with 1.25 to 2 inches diameter, which facilitate the user's "power" grip. Research indicates this type of locking action is most effective for mitigating falls and cannot be obtained on rectangular or other shaped handrails that require a "pinch grip" (Maki, 2011).

#### 5. Design Considerations



*Figure 3: Luminescent striping on stairway handrails. Source: SUMAIndustries*



*Figure 4: Lighting is installed inside the handrail that connects to a motion sensor on stairway in LIFEhouse™.*

1. *All stairways and ramps have a set of handrails at more than one height (e.g., one for adults and one for children).* Handrails installed at both heights will enhance reachability and graspability for adults and children of all heights. A comfortable height is required to promote effective use of handrails and mitigate falls.
2. *All stairways and ramps have luminescent striping or integrated lighting on at least one set of handrails.* In low or dark settings, luminescent striping or integrated lighting on a handrail can increase its visibility and alert users to its presence (Figure 3). The primary safety feature of stairs and ramps should be visible in all lighting conditions (Figure 4). Handrail visibility is critical, especially in spaces with high traffic volume that require careful attention to gait, stepping performance, balance support, e.g., means of egress stairways.

*All stairways and ramps have tactile cues on all handrails, indicating the direction of travel and/or location.* People with visual impairments often rely on tactile cues and their sense of touch to move through a building. Tactile indicators on top of handrails provide additional guidance to support this population in navigating to a location, as seen in Figure 5.



Figure 5. Indicator on handrail is used to identify the location of a stairway.

## 6. Definitions

The following definitions are adapted from [IBC \(2015\)](#)

Handrail	A horizontal or sloping rail intended for grasping by the hand for guidance or support
Ramp	A walking surface that has a running slope steeper than one unit vertical in 20 units horizontal (5-percent slope).
Stairway	One or more flights of stairs, either exterior or interior, with the necessary landings and platforms connecting them, to form a continuous and uninterrupted passage from one level to another.
Tactile Cues	An object that can be perceived using the sense of touch.

## 7. References

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