isUD™

innovative solutions for **Universal Design**

DESIGN RESOURCE

3.3

Circulation

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1. Overview

The most common physical difficulty reported by Americans is movement (Altman & Bernstein, 2008) Data from the National Health Interview Survey show that between 2001-2005, 21.7 percent of adults age 18 and over had difficulty with basic movement such as walking, bending, reaching, or using the hand and fingers (Altman & Bernstein, 2008). Research demonstrates the benefits of design features such as smooth and barrier-free circulation routes, including ease of movement, independence, and reducing risk for people with disabilities and mobility limitations (Clarke et al., 2008; Imrie, 2000).

Research indicates people with intellectual disabilities have double the unintentional injury risk than the general population (Sherrad et al., 2004). The increased risk to this population, along with those with physical disabilities, and older adults, is likely due to physical issues and co-occurring disabilities such as reduced functional capacity, decreased stamina, higher rates of epilepsy, and inappropriate environments that do not accommodate user needs (Steinman, Pynoos, & Nguyen, 2009; Tinetti, Franklin Williams, & Mayewski, 1986) (Slayter et al., 2008). Poor environmental conditions can not only restrict mobility for people with disabilities but also contribute to the disablement process (Clarke et al., 2008). Thus, it is also important to consider the role the design of circulation spaces plays in reducing injuries by preventing falls and accidents (Day, 2003)(Finlayson et al., 2010)(WHO, 2008).

The way in which people move through a space directly determines their experience and affects the success of a design. This is especially true in museums, libraries, assembly spaces, airports, and other transit stations where efficiency and accuracy in the movement of people is desired . Visual environmental factors such as light, color contrast, visual patterns, and markings can influence the user's perception of circulation spaces and bring attention to inherent hazards. Attention to these issues can improve a user's experience, mood, and positive emotional responses (Norman, 2007).

Circulation routes play an important role in fostering social integration. Festinger et al. (1950) identified the role that proximity and opportunities for daily informal interactions play in friendship formation. People who live and work in proximity to each other are more likely to engage in face-to-face contact, which in turn increases the opportunity to know each other, identify shared interests, and rely on mutual support. There are two kinds of proximity – close distance and functional proximity defined by mutual paths of use, e.g., using the same drinking fountain or entry (Steinfeld et al., 1977). The location of informal socializing spaces and shared spaces is therefore an important consideration in the design of circulation spaces. Planning circulation routes and the location of shared spaces to increase face to face contact will lead to more friendship formation, particularly where building inhabitants share interests, social roles, and backgrounds (e.g., age, work roles, parenting, etc.). Providing seating at intersections is a good way to increase interaction because it provides an "affordance" that encourages people to hang out and talk.

2. Issues to Consider

Passage Width: Narrow circulation routes are all common barriers to wheelchair use (E Steinfeld, Paquet, D'Souza, Joseph, & Maisel, 2010) (isUD™ Design Resource 2.1 Clear Floor Space). The circulation space necessary to accommodate wheeled mobility users will be based on the type of wheeled mobility device (manual, power, scooter) and expected frequency of use by wheeled mobility users. For example, in a hospital or airport one would expect much more wheeled mobility use than in a school.

Primary routes must provide enough space for a wheelchair user to pass an ambulatory person along the entire route. In facilities where many people are expected to be moving through circulation spaces simultaneously, the passageway should provide enough space for two people using wheeled mobility devices to pass each other and turn around anywhere along the route. See Design Resource 2-2 for information on the space required for maneuvering a wheelchair in circulation routes.

Narrow circulation paths also restrict the ability of people to socialize while moving through a building. People who are deaf and use sign language or lip read need to be far enough apart that they can see gestures and facial expressions for effective communication. They require as much space as two wheeled mobility device users passing each other.

Circulation spaces should be designed to facilitate pedestrian movement at normal speed and minimize crowding, conflict, and travel distance. The actual width of circulation pathways should therefore be planned to accommodate the expected traffic flow by allowing enough space for wheelchair users and ambulatory people to pass one another without brushing against others, or the need to move aside or make contact with the wall or edge of paths (Braaksma & Habicht, 1984). Involuntary touching and crowding may cause psychological stresses. Therefore, adequate personal spacing is important. In general, people maintain a distance of 6 inches from a lateral wall or edge of a pathway, including corridors and stairways, which is called the “edge effect” (Pauls, 1984) that should be considered in traffic flow design. Small or narrow space for two-way traffic flow limits people’s pacing distance and the ability to pass slower moving people (Fruin, 1971).

Pathway Surfaces: A major source of long-term injury for wheeled mobility users is high levels of vibration on circulation paths that are used regularly. Heavily textured pavements, rough and uneven surfaces, large cracks and other sources of vibration should be avoided (Chwalik-Pilszyk, Ziemianski, & Kozien, 2022).

Floor and ground surfaces should be even and smooth to provide a safe and comfortable passage for wheelchair users. Eliminating uneven and bumpy surfaces on the path of travel reduces trip hazards and the risk of injury to people during wheeled mobility.

- Certain types of paving can increase vibrations of the person sitting in the wheelchair and the mechanical work required to propel over those surfaces (Wolf, Cooper, Pearlman, Fitzgerald, & Kelleher, 2007). These include cobblestones, rough tiles, bark chips, shredded rubber, and other surfaces with many joints.
- Small unit paving materials like brick and other masonry, if carefully designed, can result in lower amplitude in vibration than conventional concrete pavement. The size of the cracks between units and the bevel on the edge units are critical factors affecting vibration.

- Minimize changes in level and edges to create smooth floor transitions and minimize bumps, such as at carpet edges and doors.

Slip Resistance: Surfaces that are excessively smooth increase the risk of slips and falls (Feldman & Chaudhury, 2008).

- Avoid high gloss finishes and consider how the combination of finish, texture, and sealer affect slip resistance.
- Products applied to floor surfaces may require intermittent replacement and may not provide a permanent solution.
- Tactile warning surfaces are helpful for people with low vision to detect curbs and elevation changes, but some products may be slippery and increase the risk of falls for others.

Wear and surface contaminants may reduce the slip resistance of a product over time and increase fall risks. Due to the variability of slip resistance in different products, designers are responsible for ensuring that floor product specifications conform to **ANSI/NSFI B101.3-2012**, the current floor safety specification for slip resistance in the U.S. But compliance with current standards may not be sufficient, additional guidelines should be referred to when designing for appropriate slip resistance (Kim, Hsiao, & Simeonov, 2013).

More research is needed on the design of anti-slip devices and flooring products to prevent slips and falls in indoor and outdoor environments (Nemire et al., 2016). Although products may be labeled as slip resistant, the type of slip meter that is used to test slip resistance can produce unreliable results, particularly under wet conditions. This has created a great deal of confusion for making safety assessments (Hsu et al., 2016). Designers should be aware of the issues and choose floor products that are most suitable, and meet criteria supported by recent scientific research. For example, detectable warning surfaces that are used to provide visual cues to visually impaired people can present problems with safety and negotiability, particularly in rain and snow (Lee, 2011; O'Leary et al., 1995).

The Toronto Rehabilitation Institute (TRI) has developed the Maximum Achievable Angle (MAA) test method that can measure slip resistance from footwear and ice by measuring the full human gait cycle. It is among the very few valid test methods for slip resistance in existence and based on human performance rather than physical properties alone (Hsu et al., 2016). TRI reports that most footwear (90%) do not have adequate traction to prevent slipping on winter surfaces, exacerbating the fall problem.

Visual Environment: The interior design of buildings can influence our visual perception of space. Since we rely on environmental cues to find our way in and around buildings, the design of floor and wall surfaces should be legible, intuitive and support wayfinding while minimizing discomfort and risk of injury. Floor and wall surfaces should avoid visually distracting patterns. For example, colors and patterns that obscure the edges of steps or other changes in paving levels may create false perceptions of level changes and cause visual confusion (Figure 3). People with disabilities tend to gaze downward during navigation and use views of the floor and their periphery to guide their movement. Such complex visual patterns can obscure hazards and prevent people from noticing important wayfinding cues such as signage against a highly figured wall pattern. Simple patterns can help reduce perceptual disorientation by helping users organize the visual information in space and make wayfinding decisions.

Lighting, contrast, color, and texture can all help to increase visibility of circulation spaces and help people avoid getting lost in buildings, if used effectively. In facilities with complex corridor systems, it may be helpful to vary the wall treatments, colors, patterns, artwork, and/or materials to help orient users. However, there should not contain highly figured or patterned floor and wall surfaces that cause visual clutter or distraction. One study showed significant effects of legible environments on the happiness of elderly residents in group housing settings (Weisman, 1981).

Making Glazing Visible: Glass walls and doorways are common features in contemporary buildings that are designed to increase visibility of interior and exterior spaces. For example, the use of transparent glass walls for the enclosure of fire exit stairways can increase visibility and awareness of stairway locations in buildings and influence levels of physical activity. However, transparent glass walls and doors are hazardous for people with visual impairments and even for the fully sighted person who may not notice their presence or mistaken them for an opening and walk into the glass. According to the National Safety Council (NSC) and the National Glazing Association, an average of 320,000 injuries occur every year due to people impacting glass in doors, windows and curtain walls. Large unobstructed glass panels, particularly those without visible frames that are directly in the path of pedestrians, can easily be mistaken for door-less openings (*see* Appendix A, *Figure 4*) (National Institute of Building Science, 2015).

Informal Gathering Spaces: Research indicates there are differences in the social use of space between groups of people that should be considered in circulation space design. For instance, social proximity or face-to-face interaction has more impact in homogeneous (e.g., similar age, interests, etc.) populations than in heterogeneous populations (Altman & Chemers, 1986). Informal spaces should be designed to support social interaction, respect privacy and be consistent different cultural expectations.

Vertical Circulation: Accessible paths of travel for wheelchair users should be integrated into the main pattern of building use. This eliminates the stigma of “back door and separate access.” It also makes it easier to find accessible routes and increases user safety by lessening the probability that people at risk will use stairways instead of mechanical circulation or ramps. Moreover, the ADA does not allow the accessible route to be more inconvenient than the inaccessible route. Where the alternative path of travel is non-adjacent, clear signage should be placed at the stairway pointing in the direction of accessible routes.

3. Related Standards

2009/2017 ICC/ANSI A117.1, provides the technical criteria for accessible routes, including but not limited to floor surfaces, clear floor space, doorways, stairways, ramps, and elevators.

2010 ADA Standards for Accessible Design, Although many of the ADA requirements have been incorporated into the IBC and state/local building codes, the 2010 ADA regulations should be checked when the state/local codes specify less accessibility, since it provides a ‘safe harbor’. However, where the ADA provides less criteria, the IBC/ANSI/NFSI standards should be referenced, for example slip resistance.

ANSI/NFSI B101.3-2012, is a nationally recognized consensus standard that provides guidance for slip resistance testing of all hard walking surfaces. It includes a widely accepted test method and specifies the procedures and devices for the measurement of wet dynamic coefficient of friction (DCOF) that can be used in both the laboratory and the field. The B101 Standard should be referenced when specifying floor products. The standard includes a list of certified products that meet current slip resistance standards for walkway safety.

Visual Environment Design Guidelines, provides guidance for design of lounges, waiting areas, interior circulation spaces, and architectural glazing and fenestration. These guidelines have recommendations for marking glazed surfaces to make them visible. Currently, the International Building Code and OSHA regulations do not have requirements to mark glazing.

4. Measurement and Verification

To ensure that circulation spaces are universally designed, check for the following key elements in the measurement and verification plan for circulation spaces (*see Appendix A, Table 1*): Circulation route width, accessible vertical circulation, floor and wall surfaces, and rest areas; Circulation pathways should be clearly marked and wide enough to accommodate wheeled mobility continuously in and around buildings; Routes and corridors should consider the width of the body and shoulder and body sway for ambulatory people and the width of the wheelchair and steering tolerance of wheelchairs in the calculation of the circulation width; Elevators and/or ramps should be positioned at a short distance away from stairways; Floor surfaces should be specified for smooth textures, not contain any rough or raised edges, and be slip resistant; Glass wall surfaces should be clearly marked to increase their visibility; Rest areas should be measured for accessibility and usability.

By using ANSI/NFSI B101 Standard for walkway safety and product specification guidelines like the NFSI's list of certified "high-traction" products, along with taking the time to measure and verify these circulation components, designers and facility managers will better achieve universal design, accessibility, and better usability of building spaces.

5. Design Considerations

i. *Primary routes are wide enough to allow an ambulatory person to pass a person using a wheeled mobility device.* To accommodate 95% of users for both occupied length and width dimensions simultaneously, a bivariate analysis is preferred (D'Souza et al., 2010). Using this method, the minimum clear floor area dimensions recommended are: 820 mm. x 1420 mm. (32 in. x 56 in.) for manual chair users, 850 mm. x 1480 mm. (33.5 in. x 58 in.) for powered chair users, and 860 mm. x 1440 mm. (34 in. x 57 in.) for scooter users. For applications where all of three types of mobility devices (i.e., manual chair, powered chair and scooters) need to be accommodated, the largest of the occupied length and width values across the three device categories should be used. Thus, a "universal space" to accommodate 95 % of the total population would be 860 mm x 1480 mm (34 in. x 58 in.) (isUD™ Design Resource 2.1 Clear Floor Space & 3.6 Doors). *See Appendix A, Figure 1*

ii. *Circulation spaces are at least 6 inches (150 mm) wider than the clear floor space, except where they pass through doors.* Circulation spaces should provide adequate clear floor space for wheeled mobility users but also additional space to provide tolerances for maneuvering. An additional 6 inches of maneuvering space clearance will be sufficient (isUD™ Design Resource 2.1 Clear Floor Space). *See Appendix A, Figure*

5

iii. *Stairs and escalators have an adjacent ramp, elevator, or inclined moving walkway.* Accessible modes of vertical circulation should be provided for people who cannot negotiate stairs and steps. These other modes should be nearby and not separated from stairs and steps if they are within the general circulation path. Choice in vertical travel should be available to the user for convenience and ease of access to facilities and spaces (Russell, Dzewaltowski, & Ryan, 1999). *See Appendix A, Figure 6*

iv. *Circulation spaces are smooth and slip resistant.* Rough textures present injury risks from tripping. Selecting textures that are even will facilitate use of wheelchairs, reduce injuries due to vibrations, and reduce tripping hazards for non-wheelchair users. Floor products should be checked for slip resistance levels to ensure safety of circulation paths. In existing areas of uneven brick or cobblestone, the ground surface can be modified by inserting tracks of smooth pavement to make them more accessible to wheeled devices.

v. *Transparent walls or doors along circulation spaces have a railing or other visual indicator to alert building users to its presence.* Visual indicators applied to the glazing, such as horizontal rails, separation bars or equivalent can help to mitigate the walking hazards posed by architectural glass. Other methods include chemical etching, sandblasting, adhesive strips, decals, paint, or other opaque marking on the glass surface. The department of labor specifies that safety markings be applied in 2 locations: one between 30" and 36" above finish floor and one between 60" and 66" above finish floor to make the glass visible for young and old, short people and tall people and even pets. The marking design shall be at least four inches in height or at least 12 inches in horizontal dimension if the marking is less than four inches in its least dimension. *See Appendix A, Figure 4*

vi. *Circulation spaces do not have floors or walls with visual patterns that distort perception.* Simple visual patterns help increase user's perception of spaces and facilitate an intuitive, easy and efficient passage for the way-finder. Highly figured or patterned materials on floors could be mistaken for steps or changes in floor surface, such as stripes or geometric patterns, and should be avoided. On stairways, continuous carpeted stair runners with such designs may camouflage the edge of the tread and create a fall hazard. *See Appendix A, Figure 3*

vii. *Circulation spaces have seats with an adjacent clear floor space where primary routes intersect.* Movement can be tiring for some people. Rest areas should be provided to accommodate individuals who need to stop frequently and manage their needs. These rest areas should accommodate people using wheeled mobility devices and should be conveniently located at route intersections to allow for rest along primary routes rather than at a distance from main circulation paths. Rest areas can also support formal and informal interactions, while addressing personal preferences relating to seating arrangements. For example, sociopetal furniture arrangements aim to create seating that faces each other, while sociofugal supports users that may want to face away from others. Increased comfort and satisfaction is achieved when both are provided (Edward Steinfeld, Maisel, & Lavine, 2012). *See Appendix A, Figure 7*

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7. Appendix A

Clear Floor Space

Design Guidelines for People Using Wheeled Mobility Devices

MINIMUM CLEAR FLOOR SPACE REQUIRED

MANUAL, POWER, & SCOOTER

W = floor space width, units: mm (in.), L = floor space length, units: mm (in.)

percent accommodated		MANUAL (276 participants)	POWER (189 participants)	SCOOTER (30 participants)
< 50%	50%	W: 678 (27) | L: 1154 (45)	W: 695 (27) | L: 1183 (47)	W: 616 (24) | L: 1203 (47)
≥ 50% & < 75%	75%	W: 718 (28) | L: 1227 (48)	W: 750 (30) | L: 1288 (51)	W: 712 (28) | L: 1274 (50)
≥ 75% & < 90%	90%	W: 761 (30) | L: 1314 (52)	W: 802 (32) | L: 1360 (54)	W: 810 (32) | L: 1369 (54)
≥ 90% & < 95%	95%	W: 786 (31) | L: 1362 (54)	W: 827 (33) | L: 1414 (56)	W: 837 (33) | L: 1435 (56)
≥ 95%				

- - - - = ADA-ABA requirement of 1220 (48) x 760 (30)

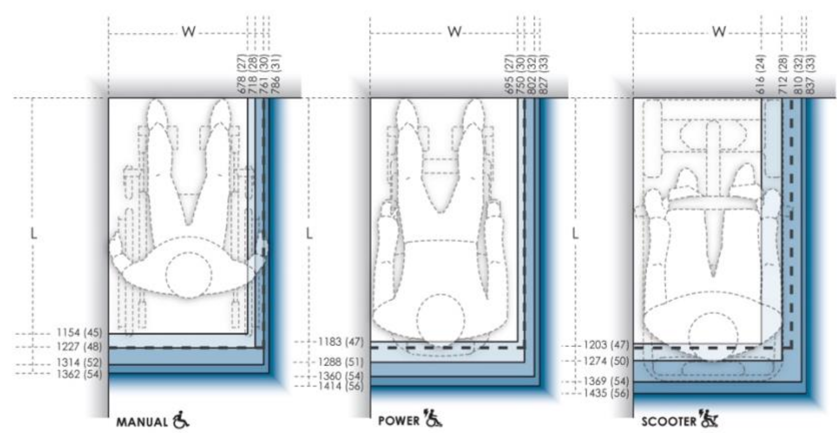

Figure 1: *Different levels of accommodation are shown. The different amounts of access depend on the length and width allotted.*

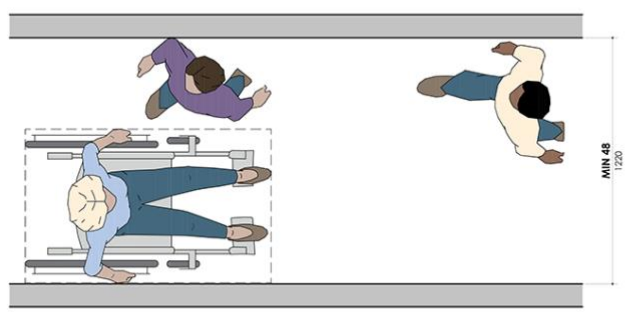

Figure 2: *Primary route width*

Figure 3: *Complex patterns on pavement*

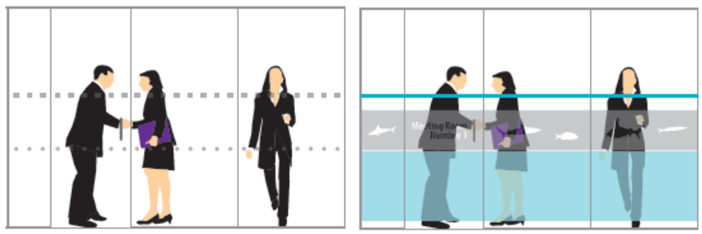

Figure 4: *Basic compliant manifestation example (left) more elaborate manifestation example (right). Source: [ARC Window Films]()*

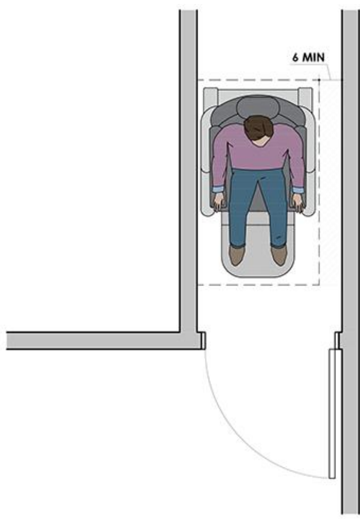

Figure 5: *Circulation spaces are at least 6 inches (150 mm) wider than the clear floor space, except where they pass through doors.*

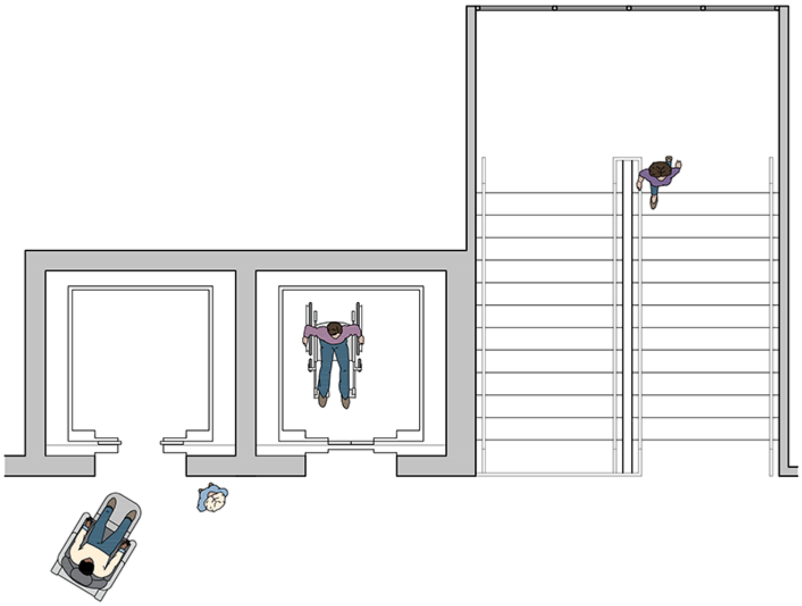

Figure 6: *Stairway with adjacent elevator*

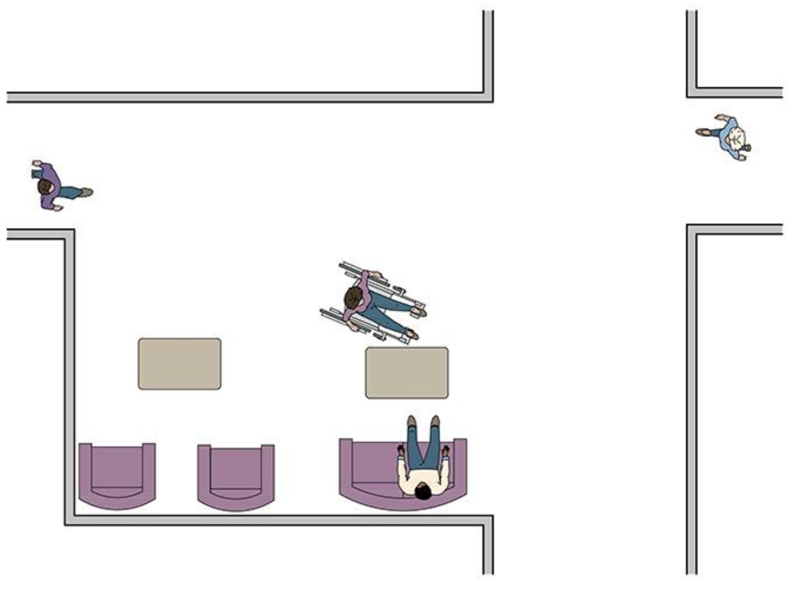

Figure 7: *Circulation spaces have seats with an adjacent clear floor space where primary routes intersect.*

Table 1: *Design considerations and measurement and verification activities.*

Design Consideration	Measurement & Verification
Circulation route width	Provide adequate clear floor space in two-way traffic flow Include a tolerance clearance for movement of people and wheelchairs
Accessible vertical circulation	Reduce travel distances between stairways and accessible vertical circulation systems
Floor surfaces	Check for smoothness of flooring materials in circulation spaces Test for high level of slip resistance of floors Ensure that the floor does not present illusions and distracting patterns
Glazing	Include visual indicators on transparent glass walls Ensure that wall surfaces do not distract from critical visual cues
Rest areas	Provide comfortable seating at strategically located rest areas