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RESEARCH PAPER

Wheelchair accessibility: Descriptive survey of curb ramps in an urban area

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Abstract

Purpose. To determine the extent to which curb ramps in an urban area met a set of wheelchair accessibility guidelines.

Method. For each of 79 intersections in an urban area, we collected data about eight accessibility characteristics, based on existing guidelines. A total score (0–8) was calculated for each intersection, based on the number of criteria met.

Results. Of the 79 intersections assessed, 98.7% had curb ramps. Of the curb ramps, 53.8% provided direct lines of travel from the sidewalks to the crosswalks, 93.6% were $\geq$915 mm in width, 43.6% had ramp slopes $\leq 4.8^\circ$ (1:12), 57.7% had gutter counter-slopes of $\leq 2.9^\circ$ (1:20), 26.9% had smooth transitions ($\leq$13 mm) from the curb ramps to the gutters, 85.9% were free from irregularities and 100% were free from drainage grates. The mean ($\pm$SD) total score was 5.6 ($\pm$1.1). Only 2.6% of the intersections met all eight criteria.

Conclusions. Although curb ramps were usually present at intersections, only a small proportion of them met all of the accessibility criteria evaluated. This finding has implications for those responsible for installing and maintaining curb ramps and suggests that wheelchair users and their caregivers should learn the wheelchair skills needed to overcome such accessibility barriers.

Keywords: *Curbs, accessibility, wheelchairs, rehabilitation*

Introduction

Accessibility to public areas is a well-recognised facilitator of participation for people with disabilities, especially those who use wheelchairs for mobility [1–13]. One common potential barrier in the built environment is where wheelchair users who are moving along elevated sidewalks make the transition to an intersecting road surface to cross the road. There is a risk of the wheelchair user tipping over or falling from the wheelchair, as well as the risk of being struck by road traffic [14–18].

At road intersections, existing guidelines suggest that there should be a means to ease the transition from the elevated sidewalk to the road for pedestrians and wheelchair users [19–24]. Among the options available, the curb ramp is a common one. Most often in a curb ramp, the surface gradually slopes downward from the sidewalk to the gutter level (Figure 1). The curb ramp may be perpendicular, parallel or diagonal to the curb.

Despite the widespread recognition of the importance of curb ramps and the availability of comprehensive guidelines regarding their design, we have observed a number of intersections in our city (and other cities we have visited) with a variety of design or maintenance problems that might present barriers to wheelchair users. The purpose of this preliminary descriptive survey was to determine the extent to which curb ramps in an urban area of our city met a set of wheelchair accessibility guidelines.

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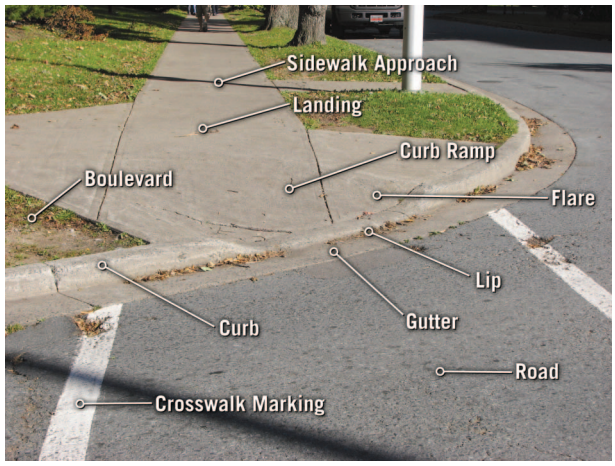

Figure 1. Representative intersection of sidewalk and road, including a diagonal curb ramp.

Methods

Intersections sampled

For the purpose of this study, we defined an intersection as where a sidewalk met an intersecting road. All data were collected from street intersections in an urban area that included university, hospital and residential buildings in Halifax, Nova Scotia, Canada. The borders of the area were defined as Coburg/Spring Garden Road, Tower Road, South Street and Oxford Street. Seventy-nine intersections were randomly selected within that area.

Measurements

From existing guidelines [19–24], we selected eight criteria (Table I) on which there appeared to be consensus and that we considered were important and relevant to wheelchair users. The criteria are described below.

1. *Was a curb ramp present?* We defined a curb ramp as when the sidewalk sloped down gradually towards the road at the intersection rather than ending with an abrupt drop off the curb. The criterion was a categorical measure of whether a curb ramp was present.
2. *Was the curb ramp aligned with the crosswalk?* Wheelchair users should be able to move along a straight path from the sidewalk onto the road en route to the corresponding curb ramp on the other side. Diagonal and parallel curb ramps require the wheelchair user to alter his or her path to use the ramp. This is inconvenient for both the wheelchair user and for pedestrians who are taking a more direct route. Diagonal curb ramps can also be dangerous because, to approach the ramp–gutter transition at right angles, they may require the user to follow a path that takes them outside the crosswalk and potentially into the path of moving vehicles. The criterion was a categorical measure of whether the curb ramp allowed wheelchair users to access crosswalks without having to turn to the left or right.
3. *Was the width of the curb ramp ≥915 mm?* The curb ramp needs to be wide enough to accommodate wheelchairs of different widths. We measured the width of the curb ramp with a tape measure at the bottom of the slope between the two points where the curb ramp began to flare upwards towards the sidewalk level. If the ramp was on a curve, the measurement was taken along a straight line between the points at the edges of the ramp that were closest to the road. The criterion was that the curb ramp width should be ≥915 mm.
4. *Was the slope of the curb ramp ≤4.8° (1:12)?* Slopes that are too steep can be difficult for the wheelchair user to manage [25,26]. Tips and falls are common on steep slopes [27]. We measured the slope of each curb ramp (to the nearest 0.1°), parallel to the direction of travel, with an 18-cm-long inclinometer at the bottom of the curb ramp (just above the lip, if any) and 1 m further up. A mean of the two values was calculated. The criterion was that the mean ramp slope should be ≤4.8° (1:12).
5. *Was the counter-slope of the gutter ≤2.9° (1:20)?* The gutter slopes in the opposite direction to the slope of the curb ramp, to direct water off

Table I. Curb ramp accessibility measure.

Criterion	Score*
1. Curb ramp present?	
2. Provided a direct line of travel from the sidewalk to the crosswalk (i.e., whether the curb ramp allowed wheelchair users to access crosswalks without having to turn to the left or right)?	
3. Width ≥915 mm?	
4. Ramp slope ≤4.8° (1:12)?	
5. Gutter counter-slope of ≤2.9° (1:20)?	
6. Smooth transition from the curb ramp to the gutter (lip height ≤13 mm)?	
7. Free from irregularities (i.e., ones that would require a wheelchair user to change direction to avoid the irregularity or ones that would interrupt a wheelchair's forward movement)?	
8. Free from drainage grates?	
Overall score: **(0–8)**	
Comments	

*1, criterion met; 0, criterion not met.

the road and toward drainage grates. We measured the slope of the gutter with the inclinometer in one location, directly in front of the gutter–ramp junction, on a line from the middle of the curb ramp to the middle of the road. The criterion was that the gutter counter-slope should be $\leq 2.9^\circ$ (1:20).

6. *Was the transition from the curb ramp to the gutter a smooth one?* Smooth transitions reduce the difficulty of getting on or off the ramp and decrease the likelihood of a tip or fall when the casters meet an obstruction [27]. However, commonly there is a small lip at the bottom of the slope that is intended to keep water in the gutter moving toward the drainage grate. A level square ruler was used for the measurement of any lip identified. The lip height was measured (in mm) from the gutter to the top of the lip at points 1/3 and 2/3 of the width of the curb ramp. The mean of these two values was determined and reported as the average lip height. The criterion was that the average lip height (if any) should be ≤ 13 mm.
7. *Was the path free from surface irregularities?* The different sections of the sidewalk-road transition are usually structurally separate and may be composed of different materials (e.g., concrete curb and asphalt road). It is not uncommon for the junctions between sections to become uneven over time (e.g., due to the effects of frost, erosion or wear). Potholes, cracks, depressions or elevations within or at the junctions between segments can cause the wheelchair to tip over or cause the occupant to fall from the wheelchair [27]. The criterion was a categorical measure of whether the path from the sidewalk to the road was free of any significant irregularities (i.e., ones that would require a wheelchair user to change direction to avoid the irregularity or ones that would interrupt a wheelchair's forward movement).
8. *Was the path free of drainage grates?* A drainage grate can cause tips and falls, either because the grate and surrounding surfaces are of uneven height or because a wheel can drop into an opening in the grate surface. Although the design and orientation of the openings can reduce the likelihood of the latter, it is preferable that the drainage grate not be in the wheelchair's path. The criterion was a categorical measure of whether the path was free of drainage grates.

Procedure

At each intersection, the measurements of distance and slope were performed and each criterion was scored categorically (a score of 1 if the intersection met the criterion and 0 if it did not). Digital photographs were taken. Qualitative measurements were based on the consensus of two investigators (SB, BM).

Data analysis

Descriptive statistics were calculated. Percent compliance was determined for each criterion and for a combination of all eight characteristics. The scores for each of the eight criteria were also summed to produce an overall score (0–8) for each curb ramp. Statistics related to Criteria 2–8 were only assessed for intersections where there was a curb ramp.

Results

The compliance levels and descriptive statistics are shown in Table II and illustrated in Figure 2. Of the

Table II. Compliance of curb ramps with accessibility guidelines.

Criteria	*n*	Mean ($\pm$SD) value	Compliance	
			n	Percentage (%)
1. Curb ramp present	79	NA	78	98.7
2. Provided a direct line of travel from the sidewalk to the crosswalk	78	NA	42	53.8
3. Width $\geq$915 mm	78	Mean: 136.6, Median: 121.0, SD: 57.8, Range: 79–419	73	93.6
4. Ramp slope $\leq 4.8^\circ$ (1:12)	78	Mean: 6.3, Median: 5.2, SD: 3.3, Range: 0.6–16.4	34	43.6
5. Gutter counter-slope of $\leq 2.9^\circ$ (1:20)	78	Mean: 2.7, Median: 2.5, SD: 2.5, Range: -5.4 to 9.0	45	57.7
6. Smooth transition from the curb ramp to the gutter (lip height $\leq$13 mm)	78	Mean: 19.1, Median: 20.5, SD: 11.1, Range: 0–38.5	21	26.9
7. Free from irregularities	78	NA	67	85.9
8. Free from drainage grates	78	NA	78	100
Overall score	78	Mean: 5.6, Median: 6.0, SD: 1.1, Range: 3–8		

NA, not applicable; SD, standard deviation.

79 intersections assessed, 98.7% had curb ramps. Of the curb ramps, 53.8% provided direct lines of travel from the sidewalks onto the crosswalks, 93.6% were ≥915 mm in width, 43.6% had ramp slopes ≤4.8° (1:12), 57.7% had gutter counter-slopes of ≤2.9° (1:20), 26.9% had smooth transitions (≤13 mm) from the curb ramps to the gutters, 85.9% were free from irregularities and 100% were free from drainage grates. The mean (±SD) overall score was 5.6 (±1.1). The frequency distribution of overall scores is shown in Figure 3. Only 2 (2.6%) of the intersections met all eight criteria. An example of a noncompliant curb ramp is shown in Figure 4.

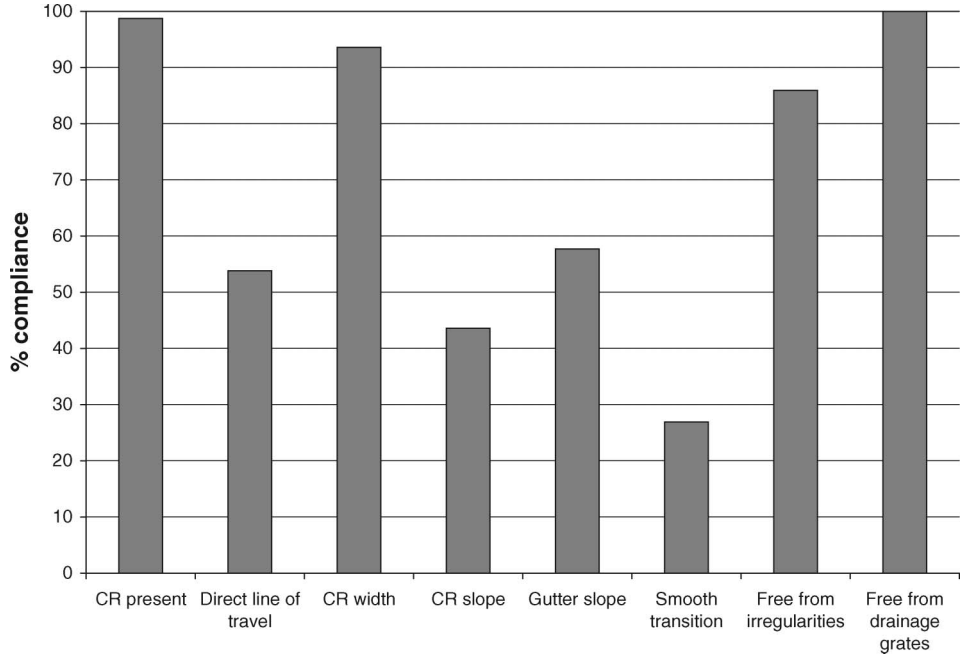

Figure 2. Percentage compliance of curb ramps (CRs) with each of eight accessibility criteria.

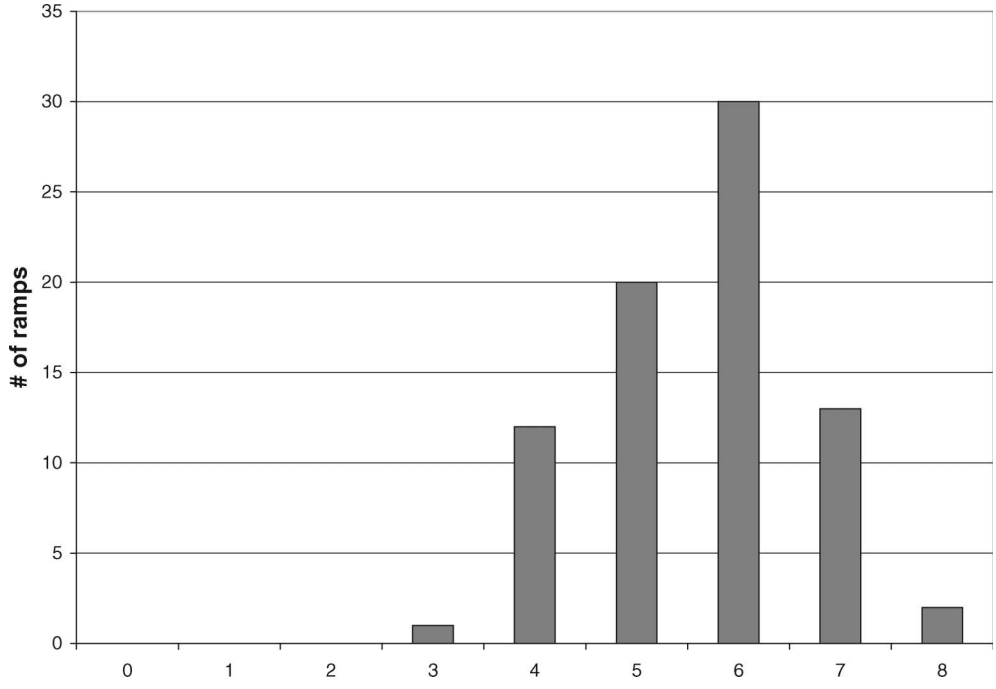

Figure 3. Frequency distribution of the number of curb ramps that achieved overall scores of 0–8.

Figure 4. This diagonal curb ramp would require a wheelchair user to take a path outside the crosswalk marking. A lip is present at the ramp-gutter junction and there are surface irregularities.

Figure 5. This steep diagonal curb ramp is shared by two sidewalks. A wheelchair user approaching from either direction would need to alter his/her direction to access the crosswalk and this path might extend beyond the crosswalk markings. There is a smooth gutter-ramp transition.

Discussion

The results of this survey corroborated our impression that intersections often fail to meet accessibility guidelines. Indeed, only 2.6% of the ramps evaluated met all eight characteristics. However, on the positive side, as Figure 3 illustrates, 61% of the intersections scored $\geq$6 of a possible 8 and the mean score was 5.6.

For the eight criteria, the compliance rates ranged from 26.9 to 98.7%. Curb ramps were present at almost all (98.7%) of the intersections assessed. For most wheelchair users, even a curb ramp with some problems is preferable to managing a curb (usually $\sim$15 cm high in our city) without a ramp.

Of the curb ramps, only about half (53.8%) provided a direct line of travel from the sidewalk onto the crosswalk. This was often because the curb ramp was of the diagonal type, with two sidewalks sharing the access to the same curb ramp (Figure 5). Even with very wide diagonal curb ramps that wrapped around a corner, a wheelchair user would need to change direction to approach the ramp–gutter transition squarely.

Most (93.6%) of the curb ramps were $\geq$915 mm in width. The variability and range of values was large. Less than half (43.6%) of the curb ramps met the ramp slope criterion of $\leq$4.8° (1:12) and slopes of up to 16.4° were found. A slightly greater percentage (57.7%) of curb ramps met the gutter counter-slope criterion of $\leq$2.9° (1:20). The greater the counter-slope of the gutter, the more abrupt the transition is from the curb to the gutter or vice versa. Some of the gutter slopes were negative values (i.e., the slope of the gutter was in the same direction as the slope of the curb ramp), which would not be expected to cause problems at the transition.

Only about one-quarter (26.9%) of curb ramps had a smooth transition ($\leq$13 mm) from the curb ramp to the gutter. The mean value of the lip heights was 19.1 mm and values ranged from 0 to 38.5 mm. Even a 13 mm lip can interrupt the forward movement of a wheelchair and cause a tip or fall. Concerns about the flow of water in the gutter are legitimate ones; the collection of water, ice and debris at the bottom of a curb ramp can present accessibility barriers and danger for wheelchair users and pedestrians alike. However, there are design options (e.g., the use of drainage grates on both sides of the curb ramp) that can minimise this constraint.

The majority of curb ramps were free from irregularities and drainage grates (85.9 and 100%, respectively). The latter criterion might be considered a special case of the former. The two criteria might well be combined for future studies.

There were a number of limitations of this study that should be considered when interpreting the findings. The sample size was small. The area surveyed was selected for convenience. The results of this survey are specific to the area studied and caution must be used when generalising the data to other areas within our city or to other cities. However, the boundaries contained a university, a large hospital complex and a rehabilitation centre. If anything, one might expect a higher level of wheelchair accessibility in such an area than in predominantly residential or business areas of the city.

Our study was a cross-sectional one, which is a common study design for accessibility issues [3–7, 11,12,28]. We recognise that the accessibility of intersections varies over time (e.g., because of weather conditions or erosion). Another limitation

was that we only used a subset of the existing guidelines [19–24], for practical reasons. Our focus was on wheelchair accessibility. We recognise that intersection designers must also take into consideration other users (e.g., people with low vision, for whom texture, different colors and visual contrast can be helpful, or people who use ambulation aids), other objectives (e.g., traffic flow and water drainage) and cost considerations.

Although the criteria we selected had excellent content and concurrent validity (by virtue of being elements of guidelines from different sources), the reliability and construct validity for the criteria are unknown. For instance, our data did not allow us to confirm that the potential problems we identified would cause real problems for wheelchair users. Although the curb ramp slope criterion was $\leq 4.8^{\circ}$ (1:12), Sanford et al. [25] found that most manual wheelchair users who were at least moderately independent in the community could handle a 9-m ramp that was much steeper (1:8). Similarly, Canale et al. [26], on the basis of assessments with 140 wheelchair users, recommended a maximum slope of 1:10 for 3-m ramps. Also, the guidelines on which we based our criteria were North American ones. Although relevant to an assessment of compliance in a Canadian city, these data must be generalised with caution in other parts of the world. However, the issue of wheelchair accessibility at road intersections is a fairly universal one. We believe that the criteria we chose could and should be applied anywhere that an elevated sidewalk for wheelchairs or pedestrians intersects a road used by vehicles.

Future studies should include comparisons among different zoning regions (e.g., residential, downtown core or rural) and should be carried out in other cities. A more comprehensive survey should include such elements as the dimensions of sidewalk approaches and landings above the curb ramp, the slope of flares on the sides of the curb ramps, the extent of cross-slope and the presence of detectable warnings for people with visual impairments.

Despite the study limitations and the need for further research, our study results have implications for those who design, build and maintain curb ramps. It seems that there should be better quality-assurance measures to ensure the greatest possible compliance with standards when the curb ramps are installed. Furthermore, a system of periodic inspection should be used to identify curb ramps that become problematic over time.

Our findings also have implications for the wheelchair-provision process [29]. Until the built environment is more accessible and to assist in wheeled mobility in the natural environment, wheelchair users and their caregivers should be provided with training to overcome the obstacles that they commonly encounter. This can be realised through the implementation of a structured, evidence-based training program [30–33] to teach useful skills such as pothole manoeuvering, steep ramp ascent and obstacle clearance.

Conclusion

Although curb ramps were usually present at intersections in an urban area of our city, only a small proportion of them met all of the accessibility criteria evaluated. This finding has implications for those responsible for installing and maintaining curb ramps. Until the environment is more accessible, wheelchair users and their caregivers should learn the wheelchair skills needed to overcome such accessibility barriers.

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