

THE UNIVERSALLY ACCESSIBLE INTERSECTION

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ABSTRACT

The National Department of Transport's Vision of the Public Transport Action Plan encourages the utilisation of Bus Rapid Transit (BRT) as part of Integrated Rapid Transport Networks (IPTN's), in conjunction with rail and conventional bus systems that can still play a role where they are appropriate and cost effective. The roll out of BRT is currently being pursued in all of the major cities in South Africa and by a variety of infrastructure consultants.

The directive from NDOT is that the infrastructure and services of these BRT systems are universally accessible (UA). The intersection is the area where passengers access the BRT system or gain safe access across the street, and it is where the most focus and input is required to accommodate all users regardless of disability.

The numerous consultants working on the various systems have interpreted the UA guidelines in different manners. This paper presents a case for a particular approach to creating the "universally accessible intersection", based on a set of design principles and guidelines.

1. INTRODUCTION

Universal Access (UA) is bringing a new way of thinking to the world shifting from prioritising motor vehicles to prioritising people. It is becoming increasingly important to create and update facilities that all people can use regardless of a disability. This entails certain design specifications that need to be added to walkways, buildings and public transport to make these facilities accessible to everyone.

With the aim to increase the safety of pedestrians, UA becomes incredibly important when designing intersections as "approximately 35-40% of road deaths in South Africa are pedestrian deaths" (Arrive Alive, 2014). It becomes necessary to set up extra measures at intersections to increase pedestrian safety when crossing the road.

Along with the aspect of safety, UA needs to make intersections accessible for all people, regardless of disability, with disabled people making up 7.5% of the population in South Africa ⁽⁹⁾. It means that there needs to be a way for the visually impaired to locate pedestrian crossings from the sidewalk, for people with mobility aids, such as wheelchairs, to cross roads comfortably, and overall, making pedestrian crossings at intersections as easy to use for as many people as possible.

These UA intersections are becoming increasingly necessary with the increase of implementation of Bus Rapid Transit systems in South Africa. It means that engineers, town planners and architects need to be aware of the facilities that should be installed to meet the UA requirements and so this paper presents a case for a specific approach to creating UA intersections based on fixed design principles.

2. UNIVERSAL ACCESS REQUIREMENTS AT INTERSECTIONS

2.1 Universal Access Design Guidelines

The South African Bureau of Standards (SABS) has created a guideline for applying Universal Access Design at intersections which encourages the usage of elements such as Tactile Guidance Surface Indicators (TGSI), wheelchair accessibility and audible signals to suggested design standards ^(7, 8). These principles are adapted from the Australian/New Zealand standards. Other countries have their own versions of Universal Access Design standards such as the UK, the USA and Japan.

Tactile Guidance Surface Indicators (TGSI) are textured paving blocks with circular or oblong protrusions that can be detected by a visually impaired person either underfoot or by a cane. The TGSI need to be placed in strategic positions to guide pedestrians and alert them to obstacles or hazards such as pedestrian crossings. These tactiles, under all lighting and weather circumstances, must be slip resistant, detectable and must contrast in colour or luminance so as to be noticeable by partially sighted pedestrians ⁽¹⁾. The design and dimensions for TGSI are displayed in Figure 1, where the difference between the guidance and warning tactiles is clearly shown. The guidance tactiles need to be placed with the bars parallel to the direction of the path. The warning tactiles must be placed at decision points and perpendicular to pedestrian crossings, with a 300mm buffer zone between the road edge and the pedestrian to increase safety.

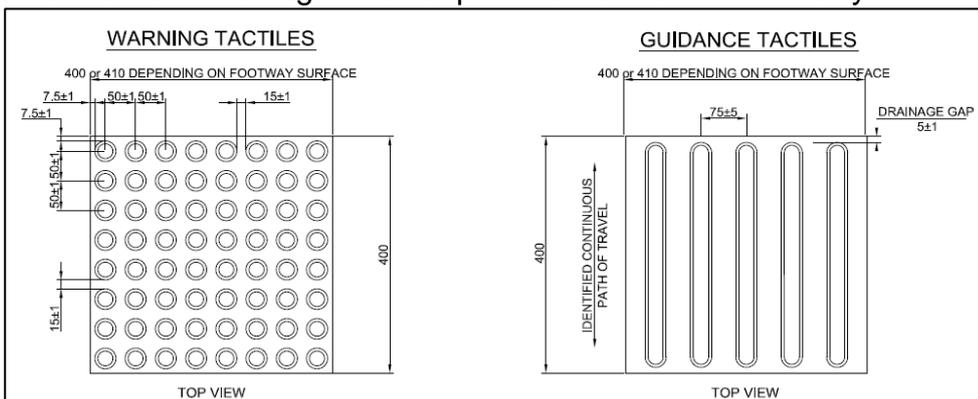


Figure 1: Dimensions and designs of warning and guidance tactiles ⁽³⁾

There are many choices when confronted with making pedestrian crossings accessible to wheelchair users. These choices include dropped kerbs and raised intersections or dropped intersections. A dropped kerb lowers a portion of the sidewalk to road level at the one end of the pedestrian crossing with a gradient of no more than 1:15 and a length of no more than 1520mm. Alternatively, the intersection could be manipulated by either raising the road to sidewalk height, or dropping the sidewalk to road level, both options creating a level pathway for wheelchair users.

At the intersection, the visually impaired person needs a way to identify that it is the pedestrian phase in the traffic cycle. The pedestrian operated signal needs to be placed within arm's reach of the warning tactiles at the entrance to the crossing with an audible signal to alert the pedestrian to cross the road when it is safe. The pedestrian crossing itself should have a width of at least 3000mm. It should be clearly marked by road markings, lights and/or signage to alert vehicles to pedestrians and increase visibility.

2.2 Overview of Universal Access Provision Required at Intersections

There is no uniform approach UA for intersections as each intersection comes with its own challenges and requirements. This means that the application of the design principles needs to suit the intersection's situation still ensuring that the crossing is safe, and easy to use for all people.

People using mobility aids such as wheelchairs need a way to get from the sidewalk to the pedestrian crossing without going down a drop ⁽²⁾. Dropped kerbs (Figure 3) are the most common method of installing wheelchair access when applying UA. The ramp needs to lead people directly onto the pedestrian crossing. This is a very cost effective design that allows more resources to be used for other UA design elements such as audible signals (Figure 2). This works in places with a low speed limit.



Figure 2: Pedestrian operated, audio signal ⁽⁴⁾



Figure 3: The design construction of a dropped kerb ⁽⁴⁾

Raised pedestrian crossings (Figure 4) and raised intersections can be very effective for wheelchair access in that there is no change in gradient of the pathway. This type of



Figure 4: Raised pedestrian crossing

crossing is not only increases the visibility of the pedestrians but acts as a traffic calming method which makes it safer to use which is especially useful in places with high pedestrian activity such as malls and schools.

An alternate option is a dropped intersection which lowers the sidewalk to the level of the road ⁽¹⁰⁾. This eliminates the need for a dropped kerb and it encourages people to stay on the sidewalk and not walk in the road. It is useful in areas with large intersections and a high number of pedestrians, for example near a bus stop. Some sort of safety precaution such as fencing or bollards would be required between the road and the sidewalk because the low sidewalk might encourage cars to cut the corner, endangering pedestrians. The transition from sidewalk to roadway, however, is very difficult for visually impaired people to identify and so tactile paving would be essential. With this being said, there is very little literature that can be found on this application of UA design.

For roadways with high operating vehicle speeds, it is sometimes ideal for pedestrians to bypass the road completely and make use of a pedestrian bridge. The bridge needs to be completely accessible by means of a lift or a series of ramps with rest points along the way. This type of UA intersection is rather costly to construct, but it is very safe as the threat from traffic is eliminated.

Some innovative UA applications have begun emerging all over the world. In countries such as Australia and Germany, vibrating buttons along with audible signals have been installed to assist hearing impaired people. In other parts of the world, pushbuttons with audible messages have been installed to tell people their location and when it is safe to cross the road⁽⁶⁾. These innovations are continually changing and improving the universal accessibility of cities and their surroundings.

3. INTERNATIONAL PRECEDENT FOR UNIVERSAL ACCESS PROVISION REQUIRED AT INTERSECTIONS

3.1 Review of Best Practice/Case Studies

The cases below have many similarities in that the intersections found in these cities generally make use of contrasting coloured tactile paving, dropped intersections and advanced audio and visual signals to ensure that the intersections are UA compliant.

3.1.1 *Berlin (voted the Most Accessible City 2013)*

This city encourages the use of Non-Motorised Transport (NMT) and public transport. The facilities available to walk or cycle to either the destination or the train/bus station are fully UA compliant in the city centre.

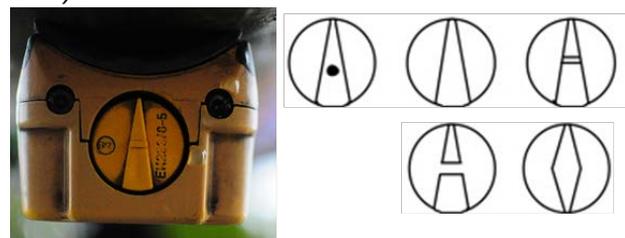


Figure 5: Pedestrian crosswalk button with symbols

Many advances have been made to make the intersections understandable and easy to use. For example, most pedestrian push-buttons have a tactile symbol either underneath or on top of the device to tell visually impaired people what type of crossing is ahead (Figure 5), the button vibrates when it is the pedestrian phase in the traffic cycle and could even prolong the crossing time. The range of tactile symbols in Figure 5 are defined as follows (from left to right): crossing with requisition, simple crossing, crossing with pedestrian island, crossing over railway track, two way crossing.

3.1.2. *Tokyo*

Tokyo is making many UA advances in light of hosting the 2020 Paralympics. The intersection in Figure 7 is a fully accessible intersection with yellow tactile paving and wide lanes for crossing. The pedestrian only phase which is longer than usual pedestrian crossings and 'X' shaped pedestrian crossing in the middle of the intersection meaning that people can walk the route that they want to in a zone without the threat of motorised vehicles. This design is also universally accessible for wheelchair users because the dropped intersection removes the obstacle of a grade transition and instead provides a relatively flat surface to ride over.

Although the facilities may be accessible to all people, the high density of pedestrians using this crossing can be incredibly overwhelming for disabled people and thus may put

them off the idea of using the facilities. This design also only works in the city centre with lots of business and people as it can channel up to 250,000 people a day in Tokyo.



It is a design that has been adapted by many countries and although this example is not where the design was first used, it is one of the most famous examples of a scramble crossing.

Figure 6: Shibuya crossing (Chensiyuan, 2012)

3.1.3. London

London has implemented a system called Pedestrian Split Cycle Offset Optimisation Technique (SCOOT) that is an adaptive traffic control system. It uses cameras to estimate how many people are waiting at a pedestrian crossing and adjusts the time required for people to cross accordingly which increases the safety of the crossing and can also benefit people with disabilities who may take longer to cross the road. The traffic signals display the amount of time left to cross the road (Figure 7).



Figure 7: Countdown traffic signal

London has also implemented a scramble crossing at Oxford Circus which is completely accessible by means of a dropped intersection and audible signals. This crossing is in close proximity to many shops and services which disabled people can then access. Due to the nature of the city, the narrow roads and cobbled paving makes many areas difficult to implement UA design.

3.1.4 Berlin

In Berlin, Potsdamer Platz showcases (Figure 8) wide crossings on a dropped intersection. It makes use of tactile paving with contrasting colour to help visually impaired people and the gentle slope makes the crossing more pleasant for wheelchair users. The variety of signals provided



Figure 8: Pedestrian and bicycle facilities, Potsdamer Platz

at the crossing let all people know that it is safe to cross the road and these include audio signals, visually signals and vibratory buttons. Left turners, by law, have to yield to pedestrians crossing the road.

The lower kerbs make the shallow ramp gradient easier to achieve and the bike lane next to the pedestrian walkway forms space between pedestrians and cars so even though the kerbs are lower, cars are less likely to park or ride on the pavement. The design approach can be adjusted to intersections in the city as well as in the suburbs in places with lots of space. It provides the facilities with sufficient space to deal with a crowd of people and not be too overwhelming.

4. UA DESIGN AT BRT INTERSECTIONS IN SOUTH AFRICA

4.1 Application of UA Design Requirements to BRT Intersection Design

The application of universal access principles to the design of intersections has been applied to a very preliminary level within South African cities, the major interventions being dropped kerbs at a very low percentage of intersections. In general, provision has been focused on provision of road space for cars, with little or no effort to even providing adequate sidewalks.

The National Department of Transport's Vision of the Public Transport Action Plan encourages the utilisation of Bus Rapid Transit (BRT) as part of Integrated Rapid Transport Networks (IPTN's), in conjunction with rail and conventional bus systems that can still play a role where they are appropriate and cost effective. The roll out of BRT is currently being pursued in all of the major cities in South Africa and by a variety of infrastructure consultants.

The directive from NDOT is that the infrastructure and services of these BRT systems are universally accessible (UA). The intersection is the area where passengers access the BRT system or gain safe access across the street, and it is where the most focus and input is required to accommodate all users regardless of disability.

As a result, the implementing cities have appointed UA advisors who have been overseeing and reviewing the application of the UA guidelines to intersections, bus stations and bus stops. Despite the fact that there are relatively few qualified UA consultants with the country, the consistent application of the UA guidelines has been varied. In fact, cities, together with the UA consultants have been experimenting with the application of UA devices and their interpretation of the guidelines has resulting in these variations.

Cape Town has implemented UA facilities along the MyCITI network, and has been a significant testing ground for the application of the UA guidelines. Subsequently, Rustenberg and Tshwane have implemented UA facilities along their pilot routes. Ethekewini (Durban) and Ekurhuleni Municipalities are constructing their pilot routes at a time where there is a drive from NDOT for consistency in the interpretation and application of the UA guidelines.

4.2 Lessons Learnt/Issues and Constraints Identified

With the implementation of UA intersections through South Africa many issues and constraints have been identified that need to be addressed in future designs. This is

important to do as it aims to evolve UA to the point where everything is accessible to everyone.

Tactile paving comes with its own lessons learnt as visually impaired people cannot always identify the difference between warning and guidance tactiles making having both redundant. They also cannot identify the difference in more than one tactile paths if the angle between the paths is smaller than 45⁰.

Although tactile paving is so effective in guiding and alerting visually impaired people to hazards, it is not ideal for people in wheelchairs. According to wheelchair athlete, Tanni Grey-Thompson ⁽⁵⁾, tactile paving is very uncomfortable to ride over and can even throw a wheelchair off balance, causing embarrassment. Government issued standards often do not account for this and as a result tactile paving is installed without second thought. This is an issue that needs to be addressed either by using the tactiles in a more efficient way or by altering the design of the tactiles to reduce the discomfort and potential hazard caused by the protrusions.

In general, kerb cuts, or dropped kerbs, are generally poorly implemented with the tactile paving installed skew, leaving a potential threat of guiding visually impaired pedestrians into the middle of the intersection area or ramps that are too steep which could cause wheelchair users to lose control of their chair. Even so, the alternative of a dropped intersection could also come with problems such as inadequate drainage. A flooded crossing is not ideal for anyone and so the implementation of a dropped intersection must cater for adequate drainage.

At the intersection, there needs to be a place for wheelchair users to wait for the pedestrian phase once they've pressed the Accessible Pedestrian Signal. Waiting on a ramp is inconvenient as the wheelchair tends to roll down and waiting at back of ramp is too far to ride to cross the road before the end of the pedestrian phase.

Pedestrian crossings should be prioritised over pedestrian bridges where possible due to expense and because people would rather walk across the road than take a detour (in SA especially).

5. PROPOSED UA INTERSECTION DESIGN PRINCIPLES

Based on the need to have a rational and standardised approach to the design of the Universally Accessible intersection, it was necessary to develop a set of principles to guide the design. The Ekurhuleni IRPTN team were tasked with developing templates for various types of intersections encountered along the BRT route, and in order to develop these templates, the principles were necessary.

5.1 Operating conditions of road being crossed

Before designing an at-grade crossing for all users, a decision needs to be made whether it is prudent and safe to allow pedestrian (regardless of ability) to cross at grade. Factors that influence this decision are the number of traffic lanes to be crossed (before reaching the median or far side of the crossing), the operating speed of the traffic, the form of traffic control (stop, yield or traffic signal control) and the road hierarchy (Freeway, expressway, arterial, distributor etc).

Freeways and expressways are characterised by higher speeds (>80 km/h) and intersections that are grade separated. In general, pedestrians are discouraged from crossing these types of routes at grade, and hence, these routes are not ideal location for BRT interventions.

BRT routes are predominantly located in the medians of arterials, where speeds range from 60 to 80km/h. Arterials generally have medians and hence two stage crossings are typical. Arterials typically have two or maybe three lanes per direction of travel and intersections are typically signalised junctions. Due to the demand for stopline capacity at the signalised intersections, dedicated turn lanes are provided which increase the number of lanes to be crossed by pedestrians. At some point, it becomes unsafe for all users to cross more than a certain number of lanes between one point of refuge and the next. In addition, there is a point where it becomes counter-productive to cross pedestrians at grade, as the length pedestrian phase required may result in so much lost time for the junction, that additional stopline capacity is warranted to counteract this lost time, which in turn increases the crossing distance.

On lower order roads speeds are generally 60km/h and crossing widths rarely exceed four or five traffic lanes.

Therefore, the principle of road operating conditions has been formulated as follows:

- Where BRT routes are placed in medians of or adjacent to freeways or expressways, all pedestrian crossings should be grade separated.
- Where BRT routes are placed in medians of arterials with crossing distances of greater than 5 lanes (including the bus lane), pedestrian crossings across the arterial should be grade separated.
- In order to be universally accessible, grade separated crossing may require the installation of lifts, where vertical elevation of the bridge or subway above or below the roadways exceeds 2 metres.

5.2 Layout and placement of devices for at grade crossings

As discussed previously, the layout and placement of universal access devices must maximise the ability of those with disabilities to safely negotiate the crossing of streets. At the time of the writing of this paper, various experimental TGSI layouts and placements were being tested by disability groups. Therefore, the findings, conclusions and recommendations emanating from tests was not available for this paper, and will be the subject of a further paper.

Hence, the principles put forward in this paper for the layout and placement of devices at at-grade intersections were made without the benefit of these tests, but were made from the collective experience of universal practitioners and traffic engineers.

Therefore, the principles of the layout and placement of universal access devices at intersections is as follows:

5.2.1 *Intersection launch areas (four quadrants of the intersection)*

- Where the width of the intersection launch area is too narrow (due to the presence of obstructions such as buildings) to allow adequate gradients (< 1:15 but preferably 1:20) for ramps to dropped kerb sections, the entire sidewalk should be dropped on the approach to the intersection launch area, and the entire intersection launch area is to be dropped.

- Where the width of the intersection launch area is adequate to allow gradients (< 1:15 but preferably 1:20) for ramps to dropped kerb sections, the option exists to either provide these ramps and dropped kerb sections, or to drop the entire sidewalk on the approach to the intersection launch area (the entire intersection launch area would then be dropped).
- From a universal access perspective, the option to have the entire intersection launch dropped is preferable, as it provides a uniform surface for the placement of TGSI, and the launch areas are flat rather than ramped, which is preferable for wheel chair users.
- Where the entire launch area is lowered, care must be taken to ensure that the bellmouth is clearly defined and that the entire launch area is adequately drained. In CBD environments, it may be preferable to not place any barrier kerb along the section of the bellmouth between the crossings, however in more industrial or peri-urban environments where turning vehicles could venture onto the intersection launch area, it may be necessary to place a barrier kerb (or even a low newjersey barrier) along these sections.

5.2.2 *Median areas*

- The entire median area linking one crossing launch point to the next, should be lowered.
- On arterial roads it is preferable to stagger the crossing to force the two stage crossing of these roads by pedestrians.

5.2.3 *Free flow left turn lanes*

In general, unsignalised free flow left turn lanes are a hazard to pedestrians with disabilities (not to mention able pedestrians), as speeds through these lanes are often high and sight lines may be obscured.

- Wherever possible, free flow left turn lanes should be removed and left turn traffic taken through the intersection using a left turn lane.
- Where the left turn volumes are too high to be taken through the intersection, the free flow left turn lane should be signalised. The principles applying to the lowering of launch areas and medians should be applied to the free flow left turn lane launch area and triangular free flow left turn island.

5.2.4 *Placement of crossings on the intersection bellmouth*

- It is preferable to separate the launch areas of the two crossings (i.e. the main and sidestreet crossings), as it improves the legibility of the TGSI layout, prevents the crossing from being on the full curvature of the bellmouth and prevents pedestrians from attempting to cross two streets in one movements (without using the intersection launch area).
- For smaller intersection bellmouth radii, it is preferable to divide the curve into three sections and not to place either of the crossings in the middle section of the curve.
- For larger intersection bellmouth radii, it may be preferable to divide the curve into five sections and not to place either of the crossings in the middle fifth of the curve.

5.2.5 *Placement of TGSI's and other devices on the intersection launch area:*

- A double row of 400mm by 400mm decision tactiles should be placed across the entire crossing width and perpendicular to the crossing, at a minimum spacing of 300mm from the road edge.

- The stop sign or signal pole should be placed on the stop line or nearside pedestrian crossing line, and should be located so that a pedestrian standing on the double row of decision tactiles can reach out and touch the pole.
- At signalised intersections, the signal pole situated adjacent to the double row of decision tactiles should be equipped with an audio tactile pedestrian crossing device.
- A single row of 400mm by 400mm directional tactiles should be placed as a tail into the intersection launch area, perpendicular to the second last decision tactile on the side closest to the traffic signal pole with the audio tactile device (or the stop sign). This single row of tactiles should be taken to the back of the launch area to effectively intercept any visually impaired person operating with a cane.

As discussed previously, the exact pattern and use of TGSI's between crossing points and along the approach sidewalks to the intersection, are currently under investigation and subject to the findings of the disability user group tests. This paper has therefore stopped short of developing principles for the layout/pattern of TGSI's.

6. SUMMARY OF FINDINGS AND RECOMMENDATIONS

With the roll out of the IRPTN system around the country it is imperative to ensure that the networks are universally accessible so that no person with disabilities is excluded from making use of the system to travel and move about their cities. It has become apparent that no set of clear principles exists for the design of intersections on BRT corridors, and such this has created room for a variety of approached and lack of consistency.

Universal access facilities and devices can only be effective if they are implemented consistently and correctly. With this in mind, the above set of design principles for the universal access design of intersections has been formulated in order to ensure consistency and effectiveness of future installations.

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