Zebra Crossing Pilot Scheme Technical Literature Review

NTA Cycle Design Office

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Delivering a better world

Quality information

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1. Introduction

1.1 Brief

The NTA has tasked the Cycle Design Office (CDO) with carrying out a review of international experience and relevant research to investigate the implementation of a pilot scheme for zebra crossings without pedestrian crossing beacons.

The need for the pilot schemes arises from the desire to increase the number of safe crossing locations for pedestrians and active travel use in a cost-effective and sustainable manner. By providing a fixed traffic sign alternative to flashing beacons, new crossings could be quickly and easily implemented without the need for electricity connections – reducing installation costs, construction time and ongoing operational costs.

This report provides international examples and considers the specifics of road rules and regulations in each jurisdiction and the potential implications for applicability to the Irish context.

1.2 Background

The Department of Transport has sought to investigate the provision of these pilot schemes and, with the support of the NTA, intends to assess the feasibility of applying the experience from other countries where these measures are in place to the Irish context.

Some work has already been undertaken on potential alternative arrangements of zebra crossings, which will help to inform the pilot. Transport Infrastructure Ireland (TII) has commenced a pilot study into high-visibility uncontrolled (“courtesy”) crossing markings. Further details are provided in Section 4 of this report.

1.3 History of Pedestrian Crossing Beacons

Pedestrian crossing beacons were first introduced in the UK in 1934 to signal the presence of a pedestrian crossing by the then Minister of Transport, Leslie Hore-Belisha; hence, they are often referred to as belisha beacons. The black and white stripes, which in combination with pedestrian crossing beacons form a zebra crossing, were not introduced until the 1950s; and so initially, only the beacons marked pedestrian crossings. Other countries adopted pedestrian crossing beacons, with New Zealand being the most prominent adopter outside the UK and Ireland.

2. Zebra Crossing Elements and Regulations

2.1 Zebra Crossing Elements

The Traffic Signs Manual[1] defines a zebra crossing as a set of pedestrian lines, transverse lines, stripes, and pedestrian crossing beacons. The combination of these elements together constitutes traffic sign RPC 001. Zebra crossings are not signalised crossings but are considered priority-controlled pedestrian crossings. A zebra crossing may be accompanied by zigzag markings and terminal lines to indicate the controlled area where vehicles are not permitted to park.

Tactile paving is usually installed at zebra crossings to aid people that are blind or vision impaired. A standard L-shaped pattern with red colour blister paving, used for signal-controlled pedestrian crossings (and described in *Guidance on the Use of Tactile Paving Surfaces*[2]) is typically provided at zebra crossings.

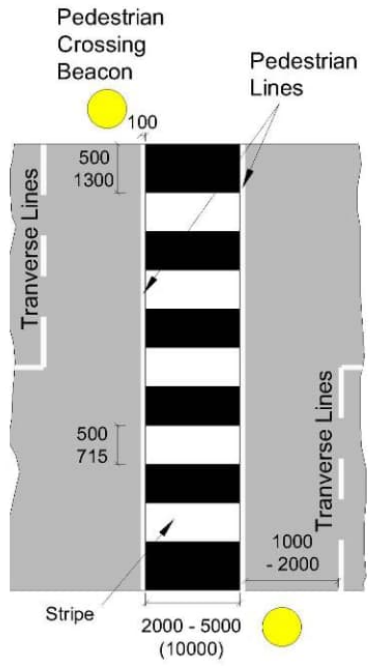


Figure 2.1: Zebra Crossing Layout (Image: Traffic Signs Manual, Chapter 7)

In many countries across the world zebra type crossings do not require pedestrian crossing beacons. Instead, fixed traffic signs and road markings may be used alongside different rules of the road. Examples from Europe, North America, Australia and New Zealand are referenced in Section 3 of this report.

2.2 Road Traffic (Signs) Regulations

The regulations relating to the constituent elements of a zebra crossings are provided in S.I. No.331 of 2012. The elements are as described in section 2.1 above.

The regulations for yielding right of way at a zebra crossing are contained in S.I. No. 332 of 2012. Article 8, sub-article 6 states that '*A driver of a vehicle approaching a zebra pedestrian*

[1] Traffic Signs Manual: https://www.trafficsigns.ie/tsm-cur

[2] Guidance on the Use of Tactile Paving Surfaces: https://www.gov.uk/government/publications/inclusive-mobility-using-tactile-paving-surfaces

crossing where traffic sign number RPC 001 (zebra pedestrian crossing) is provided shall yield the right of way to any pedestrian who has commenced crossing the road at the zebra pedestrian crossing.'

2.3 Non-prescribed Zebra Crossings

Non-prescribed zebra crossings are those crossings which do not fully conform to the required signage and road markings. For example, crossings with zebra road markings but no belisha beacons. The most common example of these are crossing points within private property, such as shopping centre car parks. These come in different configurations, with or without flashing beacons or traffic signs; however the one consistent feature is the striped road markings.

Figure 2.2: Non-prescribed zebra crossings in shopping centre car parks – The Square, Tallaght (left) and Liffey Valley Shopping Centre, Clondalkin (right). (Images: Google Street View)

Figure 2.3: Non-prescribed zebra crossings on private roads – Weir Street, Bandon (left) and Harbourmaster Place, Dublin (right). (Images: Google Street View)

3. International Examples

3.1 The Netherlands

Pedestrian crossing beacons are not provided at zebra crossings in the Netherlands. Instead, pedestrian crossing signs[3] are usually, but not always, located at the crossing which is always marked by black and white stripes. Pedestrian crossings are generally sited on roads with a speed limit of 50km/h or less. They are typically used at mid-block locations, as shown in Figure 3.1, and some priority junctions.

It should be noted that the traffic sign used at a pedestrian crossing is classified as an information sign. Advance pedestrian crossing warning signs are prescribed but are typically not used in urban locations.

A variant of the pedestrian crossing sign which includes a fluorescent border is used where visibility of the crossing needs to be enhanced. Visibility can be increased further by use of an illuminated sign on a cantilever pole, as shown in Figure 3.2. Additional road markings, in the form of a converging block pattern, can be provided in advance of the crossing, as shown in Figure 3.3.

The regulations relating to pedestrian crossings are contained in the Regulations on Traffic Rules and Road Signs (RVV 1990)[4]. Article 49, subsection 2 of the Regulations requires that drivers must give way to pedestrians and drivers of a disabled vehicle who are crossing or apparently about to cross a pedestrian crossing.

Figure 3.1: Typical pedestrian crossing layout, Nijmegen (Image: Google Street View)

[3] Road Traffic Signs and Regulations in the Netherlands: https://puc.overheid.nl/rijkswaterstaat/doc/PUC_133604_31/1/

[4] RVV 1990: https://wetten.overheid.nl/BWBR0004825/2021-07-01#HoofdstukII

Figure 3.2: Pedestrian crossing with additional signs to increase visibility, Rotterdam (Image: Google Street View)

Figure 3.3: Converging road markings on approach to crossing, Amsterdam (Image: Google Street View)

3.2 France

Pedestrian crossing beacons are not used at pedestrian crossing locations in France. Typically, a pedestrian crossing comprises striped road markings only (see Figure 3.4). A pedestrian crossing information sign can be provided if required, but this appears to be the exception rather than the rule. Signs are typically installed at locations with raised crossings, as shown in Figures 3.5 and 3.6. Pedestrian crossings are generally sited on roads with a speed limit of 50km/h or less. These unsignalized pedestrian crossings are used at mid-block locations and at priority junctions. In city centres, they are used extensively at priority junctions.

The regulations relating to pedestrian crossings are contained in the French Highway Code (Code de la route)[5]. Article R415-11 requires all drivers to yield the right of way, if necessary, by stopping, to pedestrians regularly crossing a roadway or clearly showing the intention to do so.

[5] Code de la route, Article R415-11: https://www.legifrance.gouv.fr/codes/article_lc/LEGIARTI000037411323

Figure 3.4: Typical urban pedestrian crossing layout, Paris (Image: Google Street View)

Figure 3.5: Raised pedestrian crossing with traffic signs, Paris (Image: Google Street View)

Figure 3.6: Raised pedestrian crossing with traffic sign in rural town in France (Image: Google Street View)

3.3 Germany

Germany does not install beacons as part of their pedestrian crossings. German pedestrian crossings typically comprise the combination of striped road markings and pedestrian crossing signs (see Figures 3.7 and 3.8). They are generally sited on roads with a speed limit of 50km/h or less.

Section 26 of the German Road Traffic Regulations (StVO)[6], Section 26, subsection 1, states that at pedestrian crossings, vehicles must allow pedestrians as well as users of wheelchairs to cross the carriageway when they have clearly indicated their intention to do so. Vehicles may then approach only at a moderate speed; if necessary, they must wait.

Figure 3.7: Pedestrian crossing layout, Berlin (Image: Google Street View)

Figure 3.8: Pedestrian crossing signs with blue and white pole sleeves, Cologne (Image: Google Street View)

[6] Straßenverkehrs-Ordnung (StVO), Section 26: https://www.gesetze-im-internet.de/stvo_2013/BJNR036710013.html

3.4 Austria

Austria employs a similar pedestrian crossing layout to Germany (see Figure 3.9). A variant on this sign is used where parallel cyclist and pedestrian crossings are provided. Like in the Netherlands, signs can be supplemented with a fluorescent border to increase their visibility, as shown in Figure 3.10.

Figure 3.9: Typical pedestrian crossing layout, Graz (Image: Google Street View)

Figure 3.10: Parallel cycle and pedestrian crossing layout, Vienna (Image: Google Street View)

3.5 Italy

As with the other European examples, Italy does not install beacons as part of their unsignalized pedestrian crossings. In Milan, there are many unsignalized pedestrian crossings installed. Not only are these installed at mid-block locations along main roads (see Figure 3.11), but they are often installed directly in line with junctions with no traffic signs (see Figure 3.12). The crossings do not typically have a controlled zone on the approach to the crossings, as demonstrated by the vehicles parked up to the crossing point in Figure 3.11.

Figure 3.11: Mid-block pedestrian crossing layout, Milan (Image: Google Street View)

Figure 3.12: Side road pedestrian crossing layout, Milan (Image: Google Street View)

In some locations, for example in school zones, there are bar markings placed across the road, which increase in thickness and decrease in spacing on approach to a zebra crossing. These are accompanied by warning signs for children crossing as shown in Figure 3.13.

Figure 3.13: Road markings on approach to pedestrian crossing at a school zone (Image: Google Street View)

3.6 Switzerland

In Switzerland, pedestrian crossings are marked with yellow stripes rather than white. Away from streets with high traffic volumes, the crossings typically do not have associated signs. In some instances, a zebra crossing sign is provided as shown in Figure 3.14.

Figure 3.14: Mid-block zebra crossing, Lucerne (Image: Google Street View)

In 2020, the City of Geneve implemented a pilot project to replace 250 pedestrian crossing signs with new signs which included female pictograms instead of the standard male pictogram[7]. There were six versions of the new signs installed throughout the city, as shown in Figure 3.15 below.

Figure 3.15: Female pictograms on pedestrian crossing signs (Source: Ville de Geneve)

3.7 USA

Standards in the USA vary depending on the state, but no state routinely installs pedestrian crossing beacons at zebra crossings, or crosswalks as they are known. Similarly, the legislation governing who has priority at crosswalks also varies. In nineteen states[8] vehicles are expected to stop and yield if a pedestrian is anywhere on the carriageway, while other states only require vehicles to yield if the pedestrian is on the same half of the carriageway occupied by the vehicle, but not if pedestrians are on the other half of the carriageway, meaning pedestrians are required to stop part-way across the road and wait for the traffic to pass. Figure 3.16 below shows a typical layout used in many states.

[7] https://www.geneve.ch/en/actualites/feminised-road-signs-city-geneva
[8] Pedestrian and Crosswalk Laws in all 50 States
https://www.mwl-law.com/wp-content/uploads/2018/10/PEDESTRIAN-AND-CROSSWALKS-50-STATE-CHART.pdf

Figure 3.16: Zebra markings and warning signs at priority junction, Washington DC (Image: Google Street View)

In some states, for example California and Ohio, supplementary flashing beacons are provided at crosswalks to improve visibility for drivers as shown in Figure 3.17. These are typically user-initiated devices (i.e. the user activates the crossing by using a push button).

Figure 3.17: Flashing Beacon at pedestrian crossing, Davis, California (Image: Lara Justine / Flickr)

3.8 Australia

Whilst the specific requirements vary slightly among states, belisha beacons are not used. Instead, non-illuminated traffic signs are provided, as shown in Figure 3.18. Additional signs are usually provided where the crossing includes elements like raised crossings.

Zebra crossings are generally used in urban areas (with a speed limit of 50km/h or less) or on slip roads within signalised junctions where speed limits can be higher. Zigzag markings may be used but these are not required, and application varies.

Figure 3.18: Zebra crossing with ramp, Melbourne (Image: Google Street View)

3.9 New Zealand

While New Zealand typically follows similar design guidance to Australia, in relation to zebra crossings it specifies that either belisha beacons or a reflectorised 'belisha beacon disk' must be installed[9] as shown in Figure 3.19. Warning signs are also required to be placed in advance of zebra crossing locations. Like Australia, the crossings in New Zealand are typically used in an area with a 50km/h speed limit or less, with specific approval required for installation on roads with a higher speed limit.

Figure 3.19: Crossing with flashing beacons and belisha beacon disks, Auckland (Image: Google Street View)

[9] https://www.nzta.govt.nz/resources/rules/traffic-control-devices-2004/#82

3.10 Summary of International Pedestrian Crossing Features

Table 3.1: Summary of Key Features

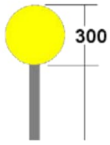
Country	Road markings on the crossing	Traffic signs or signals at crossing	Supplementary signs and markings	Use of raised table at crossing	Max. typical speed limit
Ireland	Black and white stripes	Mandatory flashing beacon 	Optional zigzag markings; often supplemented with flashing amber signals under the beacons.	On some crossings	50km/h
Netherlands	Black and white stripes	Pedestrian crossing information sign 	Sign can be supplemented with reflectorised, fluorescent backboard/border; illuminated signs on cantilever poles can be added to increase visibility; converging block road markings at decreasing intervals in advance of crossing.	Not typical	50km/h
France	Black and white stripes	Pedestrian crossing information sign on some crossings 	Typically, no supplementary signs or markings.	On some crossings	50km/h
Germany	Black and white stripes	Pedestrian crossing information sign 	Illuminated signs on cantilever poles may be added to increase visibility; blue and white sleeves may be added to the sign pole.	Not typical	50km/h
Austria	Black and white stripes	Pedestrian crossing information sign 	Sign can be supplemented with reflectorised, fluorescent backboard/border; sign variant available for parallel cyclist and pedestrian crossing.	Not typical	50km/h
Italy	Black and white stripes	Pedestrian crossing information sign 	Bar markings at decreasing centres in advance of school zones.	Not typical	50km/h

Table 3.1: Summary of Key Features (continued)

Country	Road markings on the crossing	Traffic signs or signals at crossing	Supplementary signs and markings	Use of raised table at crossing	Max. typical speed limit
Switzerland	Black and yellow stripes	Pedestrian crossing information sign 	Typically, no supplementary signs or markings.	Not typical	50km/h
USA	Black and white stripes	Warning sign 	Flashing amber signals can be added to crossing.	Not typical	50km/h
Australia	Black and white Stripes	Warning sign 	Indented bar markings used where crossing is on raised table	On some crossings	50km/h
New Zealand	Black and white stripes	Mandatory flashing beacon or belisha beacon Disk 	Warning sign required in advance of junction.	Not typical	50km/h

4. Research Studies

4.1 TII High Visibility Pedestrian Crossings Pilot Study

TII commenced a pilot study in 2019 to investigate the use of low-cost measures to improve safety at uncontrolled crossings using high-visibility crossing (HVC) road markings similar to those used throughout the European Union and the United States.

The aim of the pilot study is to determine if HVC road markings, at uncontrolled pedestrian crossings provide an improved safety environment compared to unmarked, uncontrolled pedestrian ("courtesy") crossings on a National Road in an urban core context.

The findings of the TII pilot study, when available, could provide insights of relevance to the zebra crossings without pedestrian crossing beacons pilot scheme. In combination, the two pilot schemes could greatly enhance the understanding of the applicability of alternative pedestrian crossing configurations to the Irish context.

4.2 Greater Manchester Side Road Zebra Crossings Research

The Greater Manchester Combined Authority commissioned a report by TRL (formerly known as Transport Research Laboratory)[10] to undertake research on non-prescribed zebra crossings on side roads. This research took place over 2 years and included off-road and on-street trials.

Figure 4.1: Non-prescribed zebra trial location, Manchester

This trial had access to police STATS19 collision data and categorised the zebra crossings as 'full' (prescribed markings, beacons, islands etc.) and 'non-full' (zebra markings only). Collision statistics were analysed between 2008-2017 but found that there was no significant statistical difference in collision statistics between 'full' and 'non-full' crossings. There were 16 collisions at 'full' crossings with islands, and 15 at comparator sites, and 24 collisions at 'full' crossings without islands against 23 at comparator sites.

Alternatives to zebra crossing markings were investigated. The study found that the zebra markings were the most recognisable to drivers.

Two sites were selected for on-street trials, where a non-prescribed zebra crossing was installed in line with the junction, just ahead of the give way (yield) markings. The sites had only the zebra markings installed without belisha beacons, as shown in Figure 4.1 above.

The report recorded only one near-miss in a sample of 196 at one of the sites, and statistical analysis noted that driver give way behaviour increased by around 30% at both sites, compared to the original layout where only give way markings were present, indicating that it was recognised as a crossing.

[10] https://activetravel.tfgm.com/walking/side-road-zebras/

The report noted that give way behaviour by motorists at the non-prescribed zebra crossings improved by a considerable margin at a statistically significant level when compared with the give way markings only, with an increase of 30% in the proportion of motorists giving way when they had not done so at the give-way markings. One site achieved 57% compliance and the second site achieved 71%. Although a significant level of non-compliance remains, the trials also assessed an interaction and conflict level, where the vehicles and pedestrian interactions were assessed and scored according to a progressively more serious risk level. There was an absence of change in interaction level, which the report authors noted as providing evidence that the remaining non-compliance levels did not appear to indicate a significant increase in risk with the non-prescribed zebra crossings, compared to a normal side road with give way markings.

It was noted that the give way compliance was lower for traffic turning right from the main road into the side road than it was for left-turning traffic. No analysis of this is given within the report. Potentially, this could be a result of pedestrians being obscured to right-turning traffic by other vehicles, who then commence the manoeuvre only to register the pedestrian's presence too late, or drivers may feel more at risk by not completing a right-turning manoeuvre and pausing to give way to pedestrians, perhaps feeling 'stuck' in the middle of traffic from multiple directions. If it is possible to question drivers using pilot sites, this may be a useful item on which to gather further information.

4.3 Poland Study

There is limited data available on driver compliance in yielding to pedestrians at crossings. Olszewski, Buttler et al [11] carried out a study in Poland at uncontrolled crossings (i.e. no signage or road markings). In 2013, Poland had the second highest pedestrian fatality rate among the EU countries. The study sites in Warsaw and Wroclaw were assessed for initial behaviour at the sites, and then again after active signage had been installed (SignFlash (SF) and Levelite (LL)). Driver behaviour was split into four categories: passing in front of pedestrians already on the crossing (A1); passing behind pedestrians already on the crossing (B); correctly giving way to pedestrians on the crossing (C); and vehicles entering the crossing while a pedestrian is waiting to cross (A2).

Table 4.1: Analysis of driver behaviour at pedestrian crossings in Poland

Site	Stage	Total number of encounters	Encounters per day	A1	A2	B	C	Total
Warsaw POW*	without SF	7088	591	3.9%	16.2%	15.4%	64.5%	100%
Warsaw POW*	with SF	6418	583	4.6%	15.9%	14.5%	65.0%	100%
Wrocław CEN	without LL	5388	770	11.4%	44.2%	7.6%	36.8%	100%
Wrocław CEN	with LL	5865	838	14.0%	36.4%	7.2%	42.4%	100%
Wrocław SWO	without LL	4425	316	15.1%	40.8%	7.2%	36.9%	100%
Wrocław SWO	with LL	3289	329	13.7%	33.9%	9.4%	43.0%	100%

*(both lanes)

Table 4.1 shows the analysis of driver behaviour before and after the installation of the active signage. Instances of drivers passing in front of a pedestrian at the crossing increased at two sites after the introduction of active signage, but drivers passing behind a pedestrian on the crossing decreased at two of the sites. The number of vehicles entering the crossing while a

[11] https://reader.elsevier.com/reader/sd/pii/S2352146516301739?token=8E4DA8E01E8781BCCDEC80B6AA3702363280AD530D57F1C6E2CED3D4E5729F0CE15AA8E5F930FC9D77135D04038E45EF&originRegion=eu-west-1&originCreation=20220117180942

pedestrian waited to cross decreased at all three sites, with the instance of vehicles correctly giving way to pedestrians also increased

Although no data could be found for driver compliance in France, it is noted that in 2018 France introduced a law that drivers refusing to give way to pedestrians crossing or waiting to cross a marked crossing would be liable to a fine of €135 and six penalty points on their driving licence.

5. Safety and Other Factors

A number of factors need to be considered prior to the implementation of a pilot scheme for the use of fixed signs at new zebra crossings in Ireland.

5.1 Visibility

A potential concern with not providing flashing beacons is the reduction in visibility of the zebra crossings for drivers approaching the crossing point (i.e. they may not realise there is a crossing point ahead). In the absence of beacons, it may be appropriate on certain roads to consider the use of enhanced visibility signs (i.e. signs with a fluorescent border as shown in Figures 3.2 and 3.10) and warning road markings similar to those in the Netherlands (as shown in Figure 3.3) to be installed on the approach to give drivers an additional warning on an upcoming zebra crossing. Additionally, as seen in Germany, it may be appropriate to consider installation of a warning sign (for example, using Irish TSM Sign W 140A 'Pedestrians Crossing') in advance of the crossing location. Figure 5.1 shows potential designs for zebra crossing signs for use in a pilot scheme. Figure 5.2 shows indicatively what the new signs at a typical zebra crossing in a low-speed, urban environment could look like.

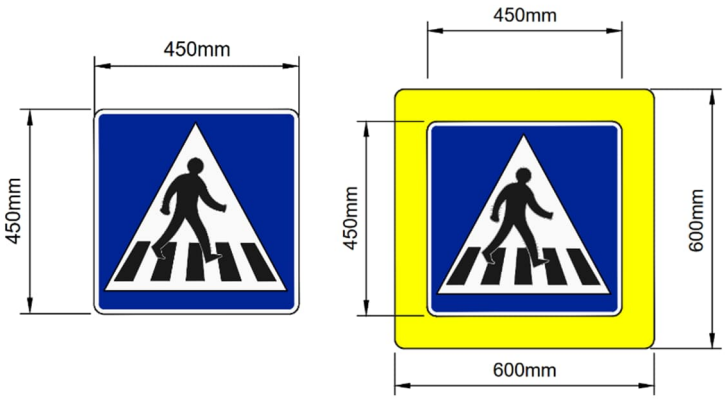


Figure 5.1: Sketch showing potential traffic signs for pilot scheme (a traffic sign with a fluorescent border could be used where visibility of the crossing needs to be increased.

Figure 5.2: Indicative image of zebra crossing with traffic signs (Background image: Google Street View)

5.2 Implications for People with a Disability

The Greater Manchester Combined Authority report on the non-prescribed crossings in Greater Manchester contained a Technical Annex on the implications for people with a disability[12]. Five groups were identified:

- Mobility impaired people (including wheelchair users);
- Deaf and hearing impaired people;
- Blind and vision impaired people;
- People with learning disabilities and cognitive disorders; and
- People with mental health conditions.

Mobility and hearing-impaired groups formed the largest group of consultees, with 24 and 17 responses respectively being provided. The other three groups each provided four responses.

The majority of the participants with a mobility impairment said that they would be likely to use a non-prescribed zebra crossing. Generally, participants responded positively about the effect of the proposed crossing, feeling it was better than not having any crossing, or that the markings were a good reminder for drivers to slow down, or that a shorter walking distance would make their trip easier. Those who said they would be less likely to use the crossing or found it inconvenient expressed concerns about not being seen by drivers, specifically referring to the lack of traditional zebra crossing features which would indicate to drivers to look out for pedestrians.

Respondents from the hearing-impaired group gave differing opinions as to how likely they would be to use the crossing. Seven were 'highly unlikely' or 'unlikely' to use these crossings; whilst eight were 'likely' or 'highly likely'. Although some participants felt the position of the crossing at the mouth of a junction, along the desire line, made their journey easier, others expressed safety concerns and uncertainty about priority. Similar to the mobility impaired group, they felt that drivers may not be aware of the crossing and may not see the pedestrian or stop in time. This was the main safety concern among this group of respondents as they are unable to hear oncoming traffic from behind them. The top three suggestions from participants were to move the crossing away from the junction, add warning signs for drivers, and to improve visibility of the crossing to drivers.

While three of the four participants who were blind or visually impaired said they would be 'very likely' to use the crossing, there were concerns about its proximity to the main road. In particular, the perceived risk that pedestrians who were blind or partially sighted could accidentally walk out into a lane on the main carriageway if they deviated from the crossing line. In particular, the importance of installing tactile paving correctly to ensure that pedestrians were directed across the crossing point accurately and safely was highlighted. Another factor that was raised was that the volume, speed and noise of traffic has a significant impact on the ability of blind people to detect when it is safe to cross. Traffic speed, volume, and noise at the junction should be considered when selecting appropriate pilot sites. These factors impact whether a blind or partially sighted pedestrian would use this crossing point or whether they would "indent" further into the side road before attempting to cross. Similarly, for mid-block crossings, volume, speed and traffic noise still impacts a blind person's ability to detect when it is safe to cross.

It is noted that a zebra crossing, whether prescribed or non-prescribed, does not emit an audible signal as is the case with other types of pedestrian crossing. This is because the audible signal is triggered when the push button is used and the signals change to the pedestrian green phase. As there is no push button at a zebra crossing, there is no way of triggering an audible signal. There is no readily available research into alternative ways of

[12] https://assets.ctfassets.net/xfhv954w443t/39uxhnw5J3A0SCiVhtaYRO/b8be00fce87458df27448d987a787e70/Technical_Annex_5_Implications_for_people_with_disabilities.pdf

alerting a visually impaired pedestrian that it is appropriate for them to cross. A report for The Guide Dogs for the Blind Association [13] in the UK, noted that the preference is for blind and partially sighted individuals to be provided with a controlled formal crossing, especially where vehicle flow rates are high. This preference is due to the ability to control the traffic by means of a push button. Where controlled crossings were not installed, the preference was for a zebra crossing, with an informal crossing (for example, tactile paving and a pedestrian island) being preferred if neither type of formal crossing were provided. It is also noted that respondents did not suggest that they found it too difficult to use a zebra crossing, and that they would rather a zebra crossing be present than no crossing at all.

Health care professionals and carers were interviewed on behalf of people with learning disabilities, cognitive disorders, and mental health conditions. Most participants across these groups felt that people with disabilities would tend to interact with the new crossing design as if it was a prescribed zebra crossing because the black and white stripes are recognisable and familiar. Within the Greater Manchester trial, the simplicity of the design (shown above in Figure 4.1) meant that most people would not be distracted or confused by having to complete additional tasks before crossing. Participants also responded positively to the location of the crossing on the desire line.

5.3 Innovations

A number of technical innovations have been developed over the past few years which aim to improve visibility of the crossing for drivers and ultimately make the crossings safer for pedestrians.

Portsmouth City Council installed a ‘first of its kind in the UK’ zebra crossing which lights up as pedestrians’ approach. The crossing was developed with a view of improving safety by making the crossing more visible, especially at night. The crossing works by utilising thermal cameras that detect pedestrians when they are about to cross, triggering the panels to light up.

A similar concept has also been installed in the Netherlands where the zebra road markings are replaced by an LED lightboxes. It was intended in 2016 to install more of these across the country however it is not clear if the trial has been continued.

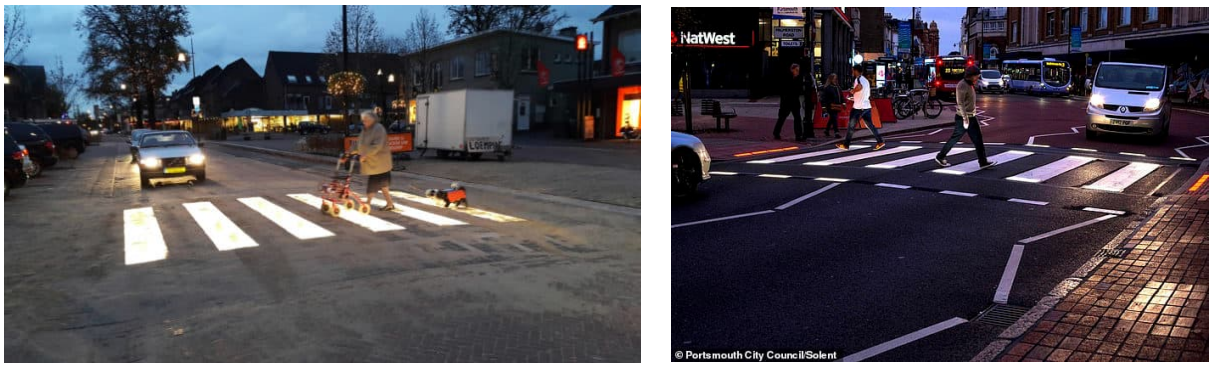


Figure 5.3: Lit zebra crossing in the Netherlands (left) and Portsmouth, UK (right)

First trialled in Iceland, several countries, including China, Australia and the USA, are testing road markings that create an optical illusion. These markings give the impression that the zebra crossing is in fact made up of blocks on the road.

[13] https://www.guidedogs.org.uk/-/media/project/guidedogs/guidedogsdotorg/files/about-us/what-we-do/research/road-and-street-crossings.pdf

Although at present there is no data as to the effectiveness of this style of crossing, anecdotal evidence suggests a reduction in approach speed and in turn the number of collisions. However, it is worth noting that as drivers become aware of this style of crossing, their effectiveness may reduce.

Figure 5.4: 3-D 'floating' zebra crossing

5.4 Climate Change

With an ever-increasing focus on climate change and the reduction of our carbon footprint particularly within the transportation sector, seemingly minor savings such as replacing a flashing beacon with a static traffic sign, when scaled up across a country, can make a significant difference in the long term. The compound effect of not requiring flashing beacons and supplementary flashing amber signals at new zebra crossings would result in a significant energy usage reduction and therefore an overall reduction in carbon footprint.

5.5 Cost and Time

By removing the requirement for flashing beacons, a significant cost saving may be achieved with an overall reduction in not only purchase and installation cost but also ongoing energy costs, as well as the operational cost associated with any ongoing maintenance. For example, if a column was struck by an errant vehicle, due to the electrical connections within beacons there may be a significant repair cost associated. There would also be an increased risk to maintenance personnel both in working with electricity, and in time spent working adjacent to a live carriageway. These risks could be mitigated by replacement of the beacons with a fixed traffic sign alternative solution. Introduction of new facilities can also suffer from drawn out timescales due to programming of electrical works. Removing the need for beacons will simplify delivery and enable more crossings to be provided in a shorter timeframe.

5.6 Rural Locations

Controlled crossings of any type are used less in the rural setting, often due to the difficulty and cost associated with bringing a power supply to the required location. By removing this requirement, it will become easier to introduce zebra crossings at more locations, with the impact of increasing safety of pedestrians and allowing pedestrians an additional comfort factor in crossing at a designated crossing point.

5.7 Road User Education

Education of the public will be a key to success. If the pilot study is deemed to be successful and a decision is taken to allow a fixed sign alternative to flashing beacons, it would be prudent to conduct a media campaign to explain the proposed changes and how this impacts road regulations for both drivers and pedestrians. It should also be seen as an opportunity to highlight the expected behaviour of drivers and pedestrians when approaching and using a zebra crossing. Close monitoring would also be required of all locations to assess safety and user behaviour.

5.8 Speed Limits

The examples of crossings from other countries referenced in this report suggest that zebra crossings are most suitable on streets with a speed limit of 50km/h or less. The Irish Traffic

Signs Manual states that ‘zebra crossings are not normally considered suitable for roads with a maximum speed limit greater that 50km/h’.

In addition to the existing speed limit, the actual speed of vehicles at a proposed crossing location is a key consideration. Speed surveys should be used to confirm that approaching traffic speeds are less than 50km/h.

County and City Councils have powers under the Road Traffic Act 2004 to make bye-laws to apply Special Speed Limits on public roads, generally for safety or capacity reasons, and to make orders for Special Speed Limits at Roadworks. For speed limits below 50km/h, the Special Speed Limits that may be applied are 40km/h, 30km/h and 20km/h. The 20km/h Special Speed Limit may only be used in specific circumstances, such as largely pedestrianised zones where little traffic is present. The 30km/h limit can be provided for housing estates as part of a Slow Zone, with specific signage for this. The speed limit at pilot sites could be reduced to either 40km/h or 30km/h, should this be required, provided that they are accompanied with appropriate ‘self-enforcing’ speed reduction measures.

6. Recommendations

6.1 Road User Hierarchy

New Rules of the Road should be considered that put pedestrians at the top of the road user hierarchy, so that pedestrians waiting to cross are given equal priority to those already crossing, and that drivers and cyclists 'must' give way to pedestrians.

> **It is recommended that the Rules of the Road be revised for all users.**

6.2 Pilot Trial Sites

All the countries reviewed in this report locate pedestrian and zebra crossings in locations with speed limits of 50km/h or less. This is similar to Irish guidance on the siting of zebra crossings.

> **It is recommended that the sites chosen for the pilot scheme are located within speed limit areas of 50km/h or less. In addition, speed surveys should be carried out in advance of the trial to confirm actual vehicle speeds are less than 50km/h.**

As discussed above, the ability to install zebra crossings without the need for an electrical power connection could have significant advantages for rural locations.

> **It is recommended that rural or edge-of-town sites are considered as part of the pilot scheme.**

In addition to standard mid-block/isolated crossings, suitable side roads, with the crossings to be located 'in-line' or close to the junction, should be trialled. This would be similar to the trail locations carried out in Greater Manchester and could perhaps be used to draw comparisons.

> **It is recommended that the sites chosen for the pilot scheme should include mid-block crossings and side road crossings.**

It is noted that other European countries do not typically have crossings on raised tables, although this does occur in Australia. It is recommended that the pilot scheme includes both raised/ramped and at-grade zebra crossings.

> **It is recommended that the pilot scheme sites should include at-grade and raised table crossings.**

6.3 Traffic Signs and Road Markings

In the Netherlands and Austria, pedestrian crossing signs with fluorescent borders are available for use where increased visibility of the crossing is required. The option to use signs with and without the high-visibility border should be available for use depending on road characteristics and traffic speeds.

> **It is recommended that traffic signs with a reflective fluorescent border should be included as part of the pilot scheme.**

In the UK and New Zealand, the post on which a belisha beacon sits is required to have black and white banding.

> **It is recommended that posts on which any zebra crossing signage is installed have black and white banding.**

6.4 Surveys, Audits and Monitoring

Prior to the implementation of a pilot scheme, appropriate surveys and audits should be undertaken to establish the existing conditions, assess the suitability of the chosen site. Suggested surveys include traffic counts, traffic speed surveys, Road Safety Audit (Stage 1/2 prior to pilot and Stage 3 following installation of the signs).

> **It is recommended that a comprehensive set of surveys are undertaken before and during the pilot scheme.**

Monitoring of the sites before and during the pilot will be required allow for assessment of the effectiveness of the interventions. Video footage should be gathered at the sites to understand movement patterns prior to and during the pilot. Conflict studies should also be undertaken to assess road user behaviour. User sentiment surveys should also be undertaken to assess how road users feel when using the new facilities.

> **It is recommended that a monitoring and evaluation methodology is prepared and implemented as part of the pilot scheme.**

Appendix A Outline Methodology for Monitoring and Evaluation

This section outlines a potential monitoring and evaluation methodology for the pilot scheme to evaluate the effectiveness of zebra crossings without flashing beacons. The proposed pilot sites are listed in Appendix B.

A.1 Before Pilot (4-week pre-implementation period)

- Capture raw video footage using CCTV cameras mounted at the proposed crossing locations for a period of 1 week.
- Carry out site visits during recording periods – record site conditions using site photographs, video, etc.
- Using the CCTV footage, extract a count of all road user movements, classified by user types (vehicles, cycles, pedestrians) for same 1 week used for the conflict study.
- Record vehicle speeds on all approaches to the proposed crossing location for same 1 week used for the conflict study.
- Undertake Road Safety Audit Stage 1/2.
- Assess historical collision record (for potential collision clusters, etc.).

A.2 Pilot Study (6-month trial period)

- Undertake Road Safety Audit Stage 3 when signs are installed at pilot sites.
- During month 2 of the trial period (following implementation), capture raw video footage using CCTV cameras mounted at the crossing locations and counterfactual sites[14] for a period of 1 week. Repeat the surveys on month 6 for a period of 1 week.
- Carry out site visits during recording periods – record site conditions using site photographs, video, etc.
- Carry out conflict studies and extract junction movements for 1 week in month 2 and month 6 of the 6-month trial period, using the following methodology:
  - An artificial intelligence algorithm to be used to identify times when road users are within the view of the cameras (i.e. times when a collision was possible); and
  - This video footage to be manually reviewed to identify non-compliance by drivers (failure to stop) and serious conflicts/near misses, which are recorded by time, directionality, road user and graded according to the scale of severity (ranging from controlled evasive manoeuvres to extreme emergency action).
- Using the CCTV footage, extract a count of all road user movements, classified by user types (vehicles, cycles, pedestrians) for same 2 weeks used for the conflict study.
- Record vehicle speeds on all approaches to the proposed crossing location for same 2 weeks used for the conflict study.
- Carry out user attitude interview/questionnaire surveys during month 2 and month 6 of the trial period.
- Prepare Interim Report following completion of month 2 surveys. Prepare Final Report following completion of month 6 surveys.

[14] The counterfactual sites will be existing zebra crossings with belisha beacons to provide a comparison to the pilot sites.

A.3 Presentation of Results

- Conflict study and traffic count/speed data is to be presented on a web-based dashboard which allows for interrogation and filtering of the data to present summary results;
- A summary of the key findings is to be included in written reports;
- An Interim Report is to be prepared following completion of month 2 surveys; and
- A Draft Final Report is to be prepared following completion of month 6 surveys and issued to NTA and DoT for comment. A Final Report is to be completed following receipt of comments and feedback.

Appendix B Pilot Scheme Details

B.1 Pilot Site Locations

Following research and consultation with various bodies, the following sites in Dun Laoghaire-Rathdown and Limerick will be used for the zebra crossing pilot scheme.

Dun Laoghaire-Rathdown:

- Marine Road
- Monkstown Crescent, Monkstown
- Pavilion Car Park Access

Limerick:

- St. Nessan's Park, Dooradoyle (St Pauls School Zone scheme)
- Springfield Drive, Dooradoyle (St Pauls School Zone scheme)
- Carrig Drive, Dooradoyle (St Pauls School Zone scheme)
- School Road, Lisnagry
- Railway Road, Castleconnell

B.2 Traffic Signs and Post Details

The following figures and provide details of the proposed zebra crossing traffic sign to be used at the pilot sites. Two options are available as shown in Figure B1: a 450mm sign to be used typically in urban locations and a 600mm sign which includes a fluorescent yellow border to be used in locations where increased visibility is required. Traffic signs should be mounted on posts with black and white pole sleeves as shown in Figure B2. At locations with restricted space the pole may need to be installed at the back of the footpath. A cranked pole should be considered in this case to ensure that the sign is visible from the carriageway.

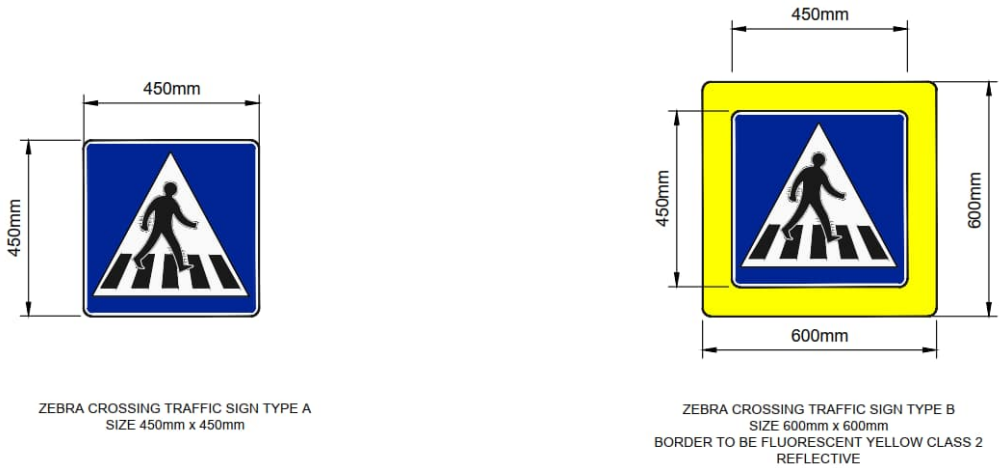


Figure B1: Proposed zebra crossing traffic signs

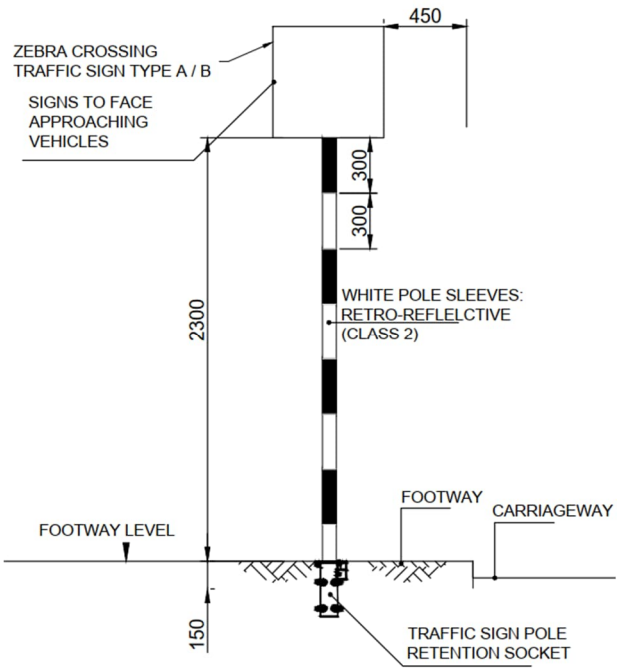


Figure B2: Traffic Sign Post Details