



CONTINENTAL ZEBRAS: THEIR POTENTIAL APPLICATION IN SCOTLAND

Final Report



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TABLE OF CONTENTS

EXECUTIVE SUMMARY	4
1. INTRODUCTION.....	6
2. LITERATURE REVIEW OF DRIVER BEHAVIOUR AND ATTITUDES REGARDING CONTINENTAL CROSSINGS	7
2.1. Introduction.....	7
2.2. Key Findings.....	8
3. OBSERVATIONAL STUDIES AT EXISTING CONTINENTAL STYLE ZEBRA CROSSINGS ON PRIVATE ROADS IN SCOTLAND	10
3.1. Introduction and Background.....	10
3.2. Results.....	11
3.3. Driver Characteristics and Performance	13
3.4. Pedestrian Characteristics and Performance	15
3.5. Site Characteristics.....	15
3.6. The Feasibility of Introducing Continental Style Zebra Crossings on Public Roads in Scotland	15
4. ATTITUDINAL SURVEY	16
4.1. Introduction.....	16
4.2. Background.....	16
4.3. Pedestrian Decisions Regarding Where to Cross on the Urban Road Network.....	17
4.3.1. Traffic activity.....	17
4.3.2. Pedestrian delays.....	17
4.3.3. Additional journey time	18
4.4. Pedestrian Overall Perceptions of Safety at Crossings by Type	18
4.5. Zebra Crossings	19
4.5.1. Pedestrian priority at zebra crossings.....	19
4.5.2. Pedestrian perceptions of vehicle speeds at approaches to zebra crossing	20
4.5.3. Pedestrian behaviour in the vicinity of pedestrian crossings	20
4.5.4. Perceptions of Continental Style Zebra Crossings.....	21
5. LEGAL AND POLICY FRAMEWORK.....	22
5.1. Policy Framework.....	22
5.1.1. Walking strategy.....	22
5.1.2. UK pedestrian crossing guidelines and UK pedestrian crossing assessment procedures	22
b) Safety requirements	23
5.2. Legal Framework	24

5.2.1.	Background	24
5.2.2.	Signage and layout	25
5.2.3.	Non-prescribed signs and legal enforceability	26
6.	STAKEHOLDER CONSULTATIONS	27
6.1.	Background	27
6.2.	Stakeholder Engagement	28
6.3.	Similar Initiatives Elsewhere	29
7.	DRIVER PERFORMANCE ON THE APPROACHES TO CONTINENTAL STYLE ZEBRA CROSSINGS	29
7.1.	Introduction	29
7.2.	Use of a Driving Simulator to Measure Driver Performances on the Approach to Continental Style Zebra Crossings	30
7.2.1.	Methodology	30
7.3.	Driving Simulator Experiment	31
7.4.	Experimental Procedure	33
7.5.	Analysis of Data	34
7.5.1.	Inferential test for statistical significance	36
7.5.2.	Interpretation and results	38
7.5.3.	Signal controlled crossing	38
7.5.4.	General observations	38
8.	CONCLUSIONS AND RECOMENDATIONS	39
8.1.	Background	39
8.2.	Potential Benefits	39
8.3.	Safety Issues	40
8.4.	The Introduction of Continental Style Zebra Crossings in Scotland	40
8.4.1.	Attitudinal issues	40
8.4.2.	Potential operational characteristics of continental style zebra crossings in Scotland ..	41
8.4.3.	Scottish trials of continental style zebra crossings and driving simulation initiative ...	41
8.5.	Recommendations	41

List of Tables

Table 2. 1 Key findings from the literature review	8
Table 3. 1 Summary of the results of observational studies of existing continental style crossings in Scotland and Spain	12
Table 3. 2 Factors affecting driver yielding rates	14

Table 5. 1 Proposed non-prescribed signs for trial CSZ crossings in Scotland	25
Table 6. 1 Stakeholder in zebra crossing design	27
Table 7. 1 Arrangement of crossings in each simulation	35
Table 7. 2 ANOVA test results	37
Table 7. 3 ANOVA post-hoc comparison results	37

List of Figures

Figure 3. 1 Driver yielding rates at the Spanish site and the five Scottish sites	13
Figure 4. 1 Safety perception and type of crossing facility.....	19
Figure 4. 2 Pedestrians perception of driver behaviour at zebra crossings	20
Figure 4. 3 Support for introducing continental style zebra crossings in Scotland (n=175).....	21
Figure 5. 1 Sketch plan and proposed layout for the trial continental style zebra crossings	26
Figure 7. 1 Driving Simulator set-up	32
Figure 7. 2 The continental style zebra (TL,TR) and the Belisha crossing BL,BR) – drivers views....	33
Figure 7. 3 Data table from a participant slowing to a stop	35
Figure 7. 4 The ANOVA interaction diagram showing the condition means and 95% confidence intervals for braking times at different crossing types	37

EXECUTIVE SUMMARY

In urban areas of Scotland, over half of pedestrians killed or seriously injured were crossing the road at locations other than either junctions, zebra crossings or signalised crossing installations. The distances between formal pedestrian crossing facilities are often over 600m. As a consequence, many pedestrians either have to walk further, or chose to cross at locations without a formal crossing in order to avoid increasing their journey time.

In the UK both zebra and signalised crossings require electrical power. This often makes crossings expensive to install, and Scottish road authorities frequently find that the number of requests for formal crossing facilities greatly exceeds the number that may be installed within allocated budgets. By contrast, in continental Europe the spacing between crossings is frequently much shorter. Continental style zebra crossings do not have flashing Belisha Beacons and do not require electrical connections, which makes them cheaper to install.

Under the Scotland Act 2016, the Scottish Government now has the power to make its own regulations with regard to traffic signs. In Scotland, measures to encourage walking have been the focus of many

recent policies and guidelines. In this context, the introduction of additional formal lower costs crossing facilities may allow Scottish road authorities to significantly increase the number of formal crossings on the urban street networks. Therefore, the purpose of this study was to assess the feasibility of installing continental style zebra crossings in Scotland. The study was supported by two local authority partners: Glasgow City Council, who were keen to trial continental style zebra crossings at two locations in the city, and Aberdeenshire Council.

It is anticipated that many of the requirements in the current UK designs guidelines (Dft, 2019) might apply to continental style crossings. The guidance states the need for sufficient street lighting, along with maintaining adequate sight-lines on the approaches to zebra crossings. This makes it necessary to prohibit parking on the approaches. The guidelines also suggest that one of the main objectives of any proposed pedestrian crossing installation should be safety. Past research into zebra and continental style crossings show that number of collisions between pedestrian and cars would increase if such crossings were installed at sites without traffic calming. However, research also shows that a reduction in collisions might be anticipated if zebra crossings are installed with traffic calming measures.

Traffic calming requirements together with prohibiting parking and upgrading streetlighting may affect the cost and feasibility of introducing continental style zebra crossings to Scotland. It is recommended that, in order to fully understand the pros and cons of introducing continental style zebra crossings, Scottish local authorities are involved in in-depth discussions about feasibility, demand and budgets. The findings relating to traffic calming suggest that continental style zebra crossings may be safe in the low-speed environments currently being generated by the widespread introduction of 20mph speed limits on the Scottish urban road network. This is worthy of further investigation.

Continental style zebra crossings operate in a similar way to conventional zebra crossings. In an attitudinal survey, 55% of respondents did not know that drivers approaching a conventional zebra crossing did not have a legal duty to stop for pedestrians who are waiting to cross, but who had not set foot on the crosswalk itself. Only 54% of respondents in the attitudinal study felt safe when using existing zebra crossings and only 46% felt safe when using existing continental style zebra crossings in locations such as supermarkets and retail parks. Furthermore, 57% of respondents were against the introduction of continental style zebra crossings in Scotland. This suggests that there may be significant opposition to the introduction of continental style zebra crossings on the Scottish urban road network.

In the current study, observations were made of pedestrian and driver behaviour at continental style zebra crossings located on private roads in shopping centres and retail parks in Scotland and compared to a continental style zebra crossing within a low-speed environment in Spain. The results indicated that driver yielding behaviour at the Scottish sites was similar to driver yielding behaviour at the Spanish site.

A driving simulator was used to gain an understanding of how continental style zebra crossings would operate on public roads in Scotland. The results suggested that Scottish driver behaviour on the approach to a continental style zebra crossing would be similar to their behaviour on the approach to a conventional zebra crossing.

The above two findings indicate it would be desirable to undertake full scale trials of continental style zebra crossings on urban roads within low-speed environments in Scotland. In the current study, it was not possible to undertake on-street trials due to the absence of legal enforceability associated with the new signage required for such installations. Further discussion with Transport Scotland is required to find a legal and policy solution that will allow on-road trials.

1. INTRODUCTION

In urban areas of Scotland, over half of pedestrians killed or seriously injured were crossing the road at locations other than junctions (with or without pedestrian crossing facilities), zebra or signalised crossing installations. The distances between formal pedestrian crossing facilities are often over 600m and diverting to cross at such facilities may cause a considerable increase in a pedestrian trip length when on a relatively short walking trip. This proportionate increase might be considered unacceptable if the same trip was made in a vehicle. As a consequence, many pedestrians choose to cross at locations, without a formal pedestrian crossing, in order to avoid increasing their trip lengths.

Both UK zebra crossings and UK signalised crossing installations require electrical power. This often makes such installations costly and Scottish road authorities frequently find that the number of requests for new formal crossing facilities greatly exceeds the number which may be installed within the budget allocated. In contrast, in continental Europe, the spacings between continental crossings are frequently much shorter and they are only identified by crosswalk road markings and crossing signs. With such crossings, there are no ‘Belisha Beacons’ (flashing amber lights) or zigzags on the approaches. However, there are usually the equivalent of double yellow lines on each approach, and they should only be installed where there is adequate visibility on the approaches to the crossing and where there is high quality street lighting to ensure pedestrian visibility at night. In the UK, this type of crossing would not be legal on public roads. However, similar crossings are often found on UK private roads within shopping centres and business parks.

Under the Scotland Act 2016, the Scottish Government now has the power to make its own regulations with regard to traffic signs, including alternative pedestrian crossings. **The purpose of the current study is to assess the feasibility of making such continental style zebra (CSZ) crossings legal for use on the Scottish road network.** This includes assessing the impact of such crossings, in Scotland, on pedestrian safety, attitudes and experience. The outcomes of this study are also relevant to other parts of the UK.

The study was undertaken by Edinburgh Napier University's Transport Research Institute and Transform Scotland. It was partially funded under an award from the Rees Jeffrey Road Fund.

There were six key elements to the study: -

1. An initial literature review to establish whether or not there are aspects of Scottish road conditions and driver behaviour that are so different from other European countries that they would make CSZ crossings unworkable.
2. Carrying out field observations at five continental style crossings on private roads in Scotland in order to identify possible differences in operation between these crossings and the operation of a Spanish continental crossing installation located on a public road within a low-speed environment. This would assist in determining whether or not it was feasible to carry out field trials of CSZ crossings in urban areas in Scotland.
3. Undertaking a literature review and a postal based attitudinal survey in order to gain an understanding with regard to both how and why pedestrians make decisions with regard to crossing a road and driver attitudes to, and perceptions of different types of crossing facilities.
4. Facilitating discussions with key stakeholders including the Scottish Government and local authorities.
5. Development of a potential legal and policy framework for the introduction of trial CSZ crossings in Scotland involving Transport Scotland and road authorities.
6. If the study into the five CSZ crossings on private roads in Scotland indicated that they operated in a similar way to a continental crossing in Spain, the intention was to undertake full-scale trials. This would involve observations of the operation of trial CSZ crossings installed in Glasgow and Aberdeenshire. Unfortunately, the inability under current legislation to legally enforce pedestrian priority at CSZ crossings meant that this element of the study was replaced with use of a driving simulator to evaluate driver performances on the approach to CSZ crossings and conventional crossings

The current report provides an overall summary of these elements together with recommendations. More detailed individual reports, for the various elements of the study, may be found in the Appendices to this report.

2. LITERATURE REVIEW OF DRIVER BEHAVIOUR AND ATTITUDES REGARDING CONTINENTAL CROSSINGS

2.1. Introduction

A literature review was conducted in two parts. As indicated earlier, the objective of the initial review was to assess whether there are aspects of Scottish road conditions and driver behaviour that are so different from other European countries that they would make CSZ crossings unworkable. Detailed

results of the initial literature review are provided in Appendix A. The subsequent parts of the literature review including safety, legal and policy issues are reported in Section 4, Section 5 and within the remaining Appendices.

2.2. Key Findings

The criteria for the initial literature review were limited to documents published between 2004 and 2019 and covered before and after interventions; experimental and quasi-experimental studies (i.e. studies with some form of control or comparison group), reviews and qualitative research. It was updated in 2022 to encompass recent research on this topic, including the results of on-street trials of continental style zebra crossings in Manchester.

The review proved challenging because of the absence or scarcity of evidence in providing answers to elements of the research project. Seventeen studies were identified that met the inclusion criteria. Most of these were peer reviewed (Table 2. 1).

Table 2. 1 Key findings from the literature review

Key Finding	Strength of Evidence
There are few studies which address driver attitudes and behaviours with regards to any types of pedestrian crossing let alone continental zebra crossings (Davis, 2019).	Strong
Sweden passed a law in 2000 which made it obligatory for drivers to give way to pedestrians at uncontrolled crossings. The aim of the Act was to improve access for pedestrians. Waiting time for pedestrians decreased by two thirds. The proportion of vehicles which stopped for pedestrians increased from 20% to 50% (Thulin, 2007, 2006; Zegeer and Bushell, 2012).	Strong
Overall, for all countries studied, research finds that for drivers who yield to pedestrians attempting to traverse a zebra crossing most prefer to reduce speed rather than stop, whereas pedestrians feel safer when drivers stop (Sucha et al., 2017).	Strong
Speed management is the keyword to pedestrian safety (LINTU, 2007)	Strong
Driver willingness to give way increased significantly in two on-street trials of CSZ at side roads junctions in Manchester, UK (the majority of drivers gave way with the crossing, while less than half did so without). However, giving way was significantly lower for vehicles turning right into the side-road than for those turning out (Jones et al., 2021).	Strong
In Sweden and elsewhere, at unmarked and uncontrolled crossings, pedestrians are reported to be more cautious i.e., there is risk compensation as they are more alert to the overt risks at such locations (Thulin, 2007, 2006).	Medium
Dutch research notes that crossing locations (including zebra crossings) are safer than locations without any facilities (SWOV, 2010)	Medium

Key Finding	Strength of Evidence
In Poland almost 30% of pedestrian injury accidents took place at non-signalised zebra crossings. Crossings on divided roads are significantly more dangerous: the risk of a fatal outcome is 4.11 times greater than on a one-way road (Olszewski et al., 2015)	Medium
Removing a parked vehicle in front of the crossing would produce a larger benefit than advanced yield markings on the carriageway. USA research found that drivers were much more likely to yield when they had a clearer line of sight, allowing the driver to perceive the presence of the pedestrian and respond accordingly. This finding was applicable at both midblock and T-intersection crossings (Leden et al., 2006; Samuel et al., 2013).	Medium
USA research suggests that drivers at unmarked crossing locations appear less likely than drivers at marked crossing locations to yield the right-of-way to pedestrians (Mitman et al., 2010).	Weak
For midblock locations, USA research suggests that continental markings and bar pairs are considerably more readily detected by drivers than transverse markings during daytime conditions. Overall, driver participants preferred these two types of crossing for detection of a pedestrian crossing (Fitzpatrick et al., 2014).	Weak

The most significant findings of the review are as follows: -

First, if CSZ crossings are to be introduced in Scotland, these should be initially restricted to roads with 20mph speed limits in order to improve pedestrian safety. This is especially important regarding mid-block locations as also is testing their effectiveness against comparable locations with no formal crossing.

Second, in most situations drivers do not like to yield to pedestrians seeking to cross at zebra and other non-signalised crossings. Lower speed limits and some low-cost changes in design are likely to increase compliance with yielding. At present, if the pedestrian wants to get priority on the zebra crossing, they have to be 'bold' and 'force' the approaching vehicles to brake.

Third, Sweden has set an example, having introduced Vision Zero in 1997 which sets out to eliminate road traffic deaths and serious injuries. Sweden then introduced the 2000 Act requiring drivers to give way at zebra crossings (as well as auditing and reducing crossing numbers across Sweden) to contribute towards the Vision Zero goal. Scotland might consider similar legislation following successful piloting of CSZ crossings.

Fourth, a clear line of vision for drivers passed parked vehicles has been shown to increase driver yielding to pedestrians on non-signalised crossings. Ongoing research in testing CSZ crossings would benefit from minimum standard clearance (such from a marked 'yield' line) from parked vehicles.

Fifth, there is a confusing array of perspectives in the literature regarding which types of non-signalised crossings are safer, taking into account pedestrian exposure, volumes motorised traffic, posted speed limits, and other key variables. Clarifications as to which types of crossings are safer may be hard to provide at least universally given cultural and other factors which vary between countries. Nonetheless, greater efforts internationally by road safety research organisations and commissioners could help. This needs to include assessments of exposure time as a denominator as casualty numbers alone are insufficient to provide a clear assessment of risk by crossing types for a given posted speed limit.

Sixth, there is some evidence that risk compensation may be at work regarding the safety of zebra crossings in comparison with other forms of crossings, that is, that users of zebra crossings feel protected by the crossing design and perhaps less cautious which may contribute to an increased casualty rate at such crossings in contrast to other crossing types. Simple and relatively cheap countermeasures to enhance the safety of CSZ crossings could include advanced yield markings as well as reduced parking close to crossings.

3. OBSERVATIONAL STUDIES AT EXISTING CONTINENTAL STYLE ZEBRA CROSSINGS ON PRIVATE ROADS IN SCOTLAND

3.1. Introduction and Background

The initial literature review (Section 2) established that pedestrian safety at zebra crossings depends mainly on driver compliance and vehicle speed. Furthermore, the review concluded that, generally, drivers do not like to yield to pedestrians seeking to cross at zebra and other non-signalised crossings. This section reports on the second part of the study which involved observations of driver-pedestrian interactions at five existing CSZ crossings installed on private roads within commercial developments in Scotland. It also involved comparisons with the operational characteristics of a continental style crossing located in a low-speed environment on a public road in Catalonia (Spain). It was hoped that the results of such observations would assist in assessing the feasibility of introducing CSZ crossings on Scottish public roads.

The methodology involved undertaking video recordings at the five selected Scottish CSZ crossings, on private roads, over six hour periods between October 2018 and December 2018, capturing images of the crosswalks and the immediate vicinity during the time periods when pedestrians were either approaching a crosswalk, waiting to cross or on the crosswalk itself at the same time as one or more vehicles were observed to be approaching the crosswalk.

These recordings were then used to identify the circumstances in which an approaching driver chose either to yield to a pedestrian at the crossing or to continue without stopping. It also involved

investigating pedestrian behaviour at the crossings. Full details of this observational study are presented in Appendix B.

3.2. Results

A summary of the site details, considered in the study, and the observational results is provided in Table 3. 1. It should be noted that, with regard to Site 4, the crossing was located on a significant radius, which restricted driver sight lines to the crossing when on the approaches. As a consequence, driver observations, for the site, were not included in the Scottish averages associated with driver behaviour.

Table 3. 1 Summary of the results of observational studies of existing continental style crossings in Scotland and Spain

Rank	1 highest	2	3	4	5	6 lowest		
Site Characteristics	Site	Site 1	Site 2	Site 3	Site 4	Site 5	Site 6	ALL SCOTTISH SITES Average
	Country	Scotland	Scotland	Scotland	Scotland	Scotland	Spain	
	Location	Super-market	DIY store	DIY store	Retail Park	Retail Park	Urban area	
	Private or public road	private	private	private	private	private	public	
	Crossing width (m)	2.5	3.3	3.3	3.2	3.7	11.2	
	Crossing length (m)	5.5	7.3	7.3	6.3	8.3	5.7	
	Pedestrians per hour	283	131	240	65	41	188	
	Vehicles per hour	348	462	310	199	603	749	
	Average Vehicle Speed	10to15kph	15 to20kph	10 to15kph	10to15kph	25to30kph	10to15kph	
	Vehicle/pedestrian ratio	1.2	3.5	1.3	3.1	14.7	4.0	
Pedestrians' Characteristics	%male	46%***	56%	60%	53%	46%	57%	52%
	%children	5%	12%***	5%	11%***	14%***	3%	9%***
	%older	28%***	19%**	5%***	15%	23%**	12%	18%**
	%lone pedestrians	54%***	30%***	44%***	44%***	34%***	71%	41%***
	%crossing with others (same direction)	67%***	72%***	70%***	97%***	73%***	37%	76%***
	%crossing with others (opposite direction)	30%*	14%**	22%	2%***	7%***	24%	15%***
Pedestrians' behaviour	%waited before crossing	34%	55%***	22%***	21%*	33%	33%	33%
	%distracted	11%***	10%***	3%***	40%***	17%*	7%	16%***
	%communicated with driver	11%***	33%*	42%***	44%***	49%***	27%	36%**
	%cross at crosswalk	85%***	96%***	90%***	96%**	99%	99%	93%***
	%thanked driver	11%	15%**	15%**	14%*	22%***	7%	15%***
Drivers' behaviour	%Stopped completely	64%	59%	61%	80%**	66%	61%	63% ^A
	%Drivers yielding to pedestrians (either stopped completely or slowed down)	96%	91%	95%	75%***	90%	94%	93% ^A

Comparisons with Spanish site: statistical significance notation *p<0.05 **p<0.01 ***p<0.001

^A For driver behaviour variables, Scottish sites average excludes site 4 as the site had poor driver sightlines to pedestrians approaching the crossing

3.3. Driver Characteristics and Performance

The objective of installing any pedestrian crossing facility is to safely establish pedestrian priority over vehicles at a designated location. In the case of CSZ crossings this requires drivers to yield to pedestrians by either stopping or slowing down. At four of the five Scottish sites, the percentage of drivers yielding to pedestrians ranged from 90% to 96% (Figure 3. 1). The percentage of Spanish drivers yielding to pedestrians was also within this range (94%).

Previous research in Scotland has found high driver yield rates at traditional zebra crossings. For example, 97% of drivers yielded at a zebra crossing installed in Edinburgh (Havard and Willis, 2012). Jones et al., (2021) found that propensity of drivers to give way increased significantly in the two on-street trials of CSZ crossings at side roads in Manchester; the majority of drivers gave way with the crossing, while less than half did so without. However, a number of previous studies conducted in other countries have found much lower levels of compliance at marked crossings: 30%-36% (Sucha et al., 2017); 30% (Johansson and Leden, 2007) and 32%-93% (LINTU, 2007). A study comparing the performance of pedestrian crossings in Finland and the UK (LINTU, 2007) found that UK drivers are less likely to violate right-of-way rules at zebra crossings as zebras are only used on low traffic volume sites.

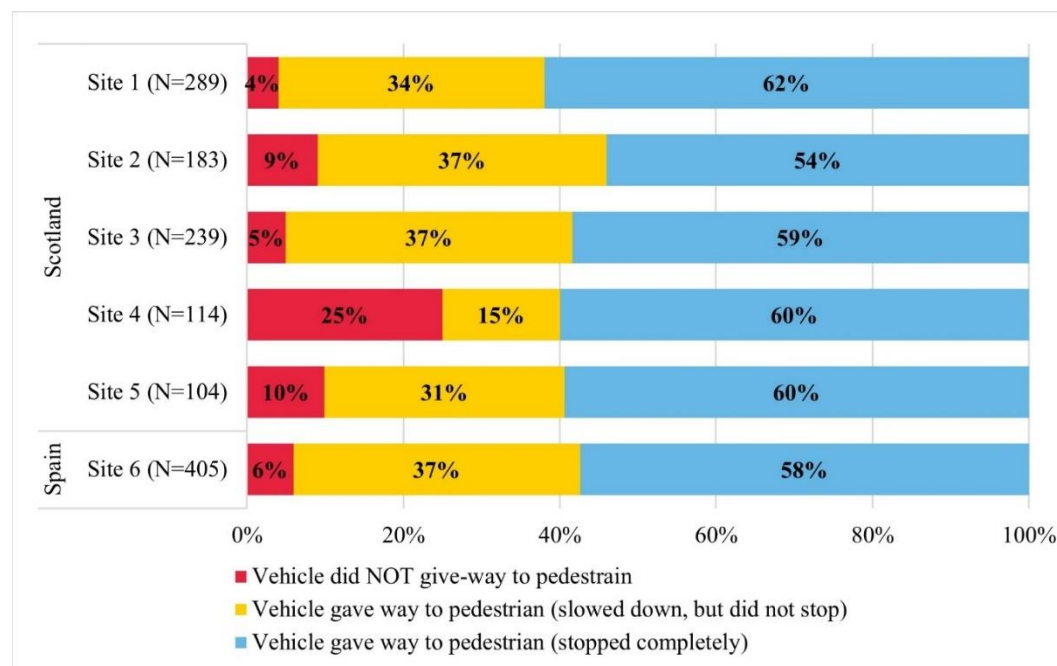


Figure 3. 1 Driver yielding rates at the Spanish site and the five Scottish sites

The observational study indicated that a number of factors affect the likelihood of a driver yielding including pedestrian asserting priority, vehicle approach speed and location of the pedestrian at the crosswalk. These are summarised in Table 3. 2.

Table 3. 2 Factors affecting driver yielding rates

Factor	Study finding	Supporting literature
Pedestrians asserting priority	There was a significant relationship between drivers being more likely to yield and pedestrians asserting their priority by crossing immediately on arrival at the crosswalk. This was the case for 4 of the 5 Scottish sites and for the Spanish site.	Previous research has also found that pedestrians who are more assertive tend to produce higher driver yielding rates (Schneider and Sanders, 2015; Harrell, 1993; Schroeder 2008; Schroeder and Roupail, 2011; Crowley-Koch and Van Houten, 2011).
Speed of approaching vehicles	The current study found that, at three of the five Scottish sites, there was an association between higher driver yield rates and lower approach speeds. However, all the Scottish sites were located in low-speed environments which might not be the case at any future on-street continental style crossing installations.	There have been numerous studies indicating that the yielding rate of drivers decreases significantly as vehicle speed increases (e.g., Katz 1975; Sucha 2018;). Schneider et al (2017) suggested that locations with more traffic and higher speeds may be perceived as ‘thoroughfares’ for drivers and, as a consequence, drivers may be less aware of pedestrians and be less concerned about yielding to pedestrians at a crosswalk. In addition, they suggest it is more difficult to yield to a pedestrian when travelling at a higher speed, since it requires seeing the pedestrian sooner and decelerating more quickly than when travelling slowly. Furthermore, on streets with more traffic and higher speeds, drivers may be hesitant to yield due to concerns about rear-end collisions.
Drivers stopping or slowing down	The current study found that for four of the five Scottish continental crossing sites, 63% of approaching drivers slowed down and 30% of drivers stopped to allow pedestrians to cross at the crosswalks. There were no significant differences between these observed percentages and those recorded at the on-street Spanish site.	Sucha (2018) highlights that pedestrians require a car to stop for them to feel completely safe, while drivers only prefer to lower their speed, probably in order to save time and avoid driving off from a standstill.
Location of pedestrian	Pedestrians were significantly more likely to encounter a vehicle that gave-way to them if they were on the opposite side of road from the approaching vehicle. This was the case for 3 of the 5 Scottish sites and for the Spanish site.	Previous research (Gorrini et al., 2018) found that crossing from the opposite pavement (not nearside) was positively associated with driver yielding.
Communications between pedestrians and drivers	The study found that at four of the five Scottish sites attempts by pedestrians to communicate with drivers (eye contact or hand gestures) had no significant effect on the likelihood of drivers either stopping or slowing down.	Early studies (Persson, 1988; Katz et al, 1975) found that drivers gave-way more often when the pedestrian did not stop at the kerb or look at the approaching vehicle. The driver may view this as an indication that the pedestrian is unaware of the driver’s presence and/or less likely to give-way to the vehicle. In contrast, some recent research suggests that pedestrians’ gestures, smile, and stare improve driver yielding rates at zebra crossings (Zhuang et al 2014; Guéguen et al 2015 Guéguen et al 2016).
Pedestrian age and gender and presence of other pedestrians	There was limited or no association found between a driver deciding whether or not to yield to a pedestrian and the age and gender of pedestrians or presence of other pedestrians at the crosswalk.	This was in contrast to previous research which found that the presence of children or elderly was positively associated with driver yielding (Al-Kaisy et al 2017, Sucha et al 2017). Similarly, numerous studies (Figliozzi et al 2016; Sucha et al 2017, Al-Kaisy et al 2017, Malenji et al 2019; Obeid et al 2017) have found that the number of pedestrians is positively associated with driver yielding rates.

3.4. Pedestrian Characteristics and Performance

Pedestrians arriving at a CSZ crosswalk, when vehicles are approaching, have a choice of either waiting or asserting their priority by crossing immediately. At the Scottish CSZ crossings, there was a large range in the percentage of pedestrians waiting. The average of 33% of pedestrians choosing to wait at the crossing was not significantly different from the 33% recorded at the Spanish site. (Sucha et al., 2017) indicated that vehicle speed, the distance of the vehicle from the crossing, traffic density, whether or not there were cars approaching from both directions, various signs given by the driver (eye contact, waving a hand, flashing their lights), and the presence of other pedestrians all influenced whether or not pedestrians waited at a crossing. It was noted that the percentage of Scottish pedestrians communicating (36%) and thanking drivers (15%) was significantly higher than those for the Spanish site (27% and 7% respectively).

3.5. Site Characteristics

The crosswalk widths of the five Scottish CSZ crossings considered in the study were all narrow and ranged from 2.5m to 3.7m. This is in contrast to the crosswalk width of 11.2m at the Spanish on-road site. Such a large width at the Spanish site would increase crossing conspicuity and approaching driver awareness. Sucha et al., (2017) found a significant relationship between the subjective feeling of safety and zebra crossing width: the wider the crossing, the safer the pedestrian feels. It may be that pedestrians felt safer at the wider Spanish crosswalk, which may have influenced their behaviour at the site. Alternatively, it may be that the driver may feel they are entering into a larger area of ‘shared space’ and act more cautiously.

Four of the five Scottish CSZ crossing sites had low pedestrian/car densities (less than 4 cars per pedestrian). The fifth site had 14.7 cars per pedestrian. Higher pedestrian volumes are associated with higher driver yielding rates (Stapleton et al., 2017). Sucha et al., (2017) found that the lower the pedestrian/car density ratio the higher the pedestrian’s subjective feeling of safety. The authors attributed this to either a ‘safety in numbers’ effect or to the cognitive aspect that that fewer cars are easier to manage when crossing the road.

3.6. The Feasibility of Introducing Continental Style Zebra Crossings on Public Roads in Scotland

There were no significant differences in the percentages of drivers either stopping (63%) or slowing down (30%) on the approaches to four of the Scottish CSZ crossings and the Spanish continental crossing (61% and 33% respectively) when pedestrians were either on the crosswalk or approaching the crosswalk. There was also no significant difference in the percentages of pedestrians waiting on arrival at the crosswalk (both 33%). This suggests that the safety performance of the Scottish installations may

be similar to the Spanish site and that it would be appropriate to consider field trials of CSCZ crossings on public roads in Scotland.

4. ATTITUDINAL SURVEY

4.1. Introduction

As indicated earlier, the spacings between formal pedestrian crossings on the urban street network in Scotland are often large and pedestrians are often faced with the choice of making a long diversion to cross a road at formal crossing or cross at a location without any formal pedestrian crossing. This section reports on an additional literature review and a postal based attitudinal survey which were undertaken in order to gain an insight into both how and why pedestrians make decisions with regard to crossing a road and driver attitudes to and perceptions of different types of crossing facilities. The attitudinal survey involved distributing questionnaires to 9,949 households in Glasgow and Aberdeenshire, during the week beginning 8th April 2019, and included questions covering pedestrian and driver perceptions and attitudes towards conventional zebra crossings, signalized crossings and CSCZ crossings. A total of 197 forms were completed and returned. A detailed report covering the literature review and attitudinal survey is provided in Appendix C.

4.2. Background

Past studies have found that pedestrian perceptions of safety can significantly influence whether or not residents walk in their local environment or neighbourhood (Miles, 2008). They have also found that the presence of pedestrian crossing facilities could reduce both the actual and perceived risk of vehicle crashes involving pedestrians (Bernhoft and Carstensen, 2008; Keall, 1995). Martin, (2006) noted that the choice of crossing places has a significant influence on pedestrian safety. Hine, (1996); Sharples, (2000); and Sisiopiku and Akin, (2003) have suggested that perceptions of convenience, risk and safety are important considerations of whether and where to cross the road and can influence the pedestrian's choice of route to their destination. Nevertheless, uncontrolled pedestrian crossings are frequently recognised as problematic locations in the urban road network because of the possible potential for creating conflicts between pedestrian and vehicles flows (Hakkert et al., 2002).

Havard and Willis, (2012) investigated pedestrians' road crossing behaviour and perceptions before and after the installation of a zebra crossing in Edinburgh, Scotland. Their research indicated that pedestrians were significantly more likely to use the location to cross the road, waited significantly less time to cross, and walked significantly more slowly after the zebra had been installed compared with before. Their qualitative findings suggested that people felt safer, less vulnerable to traffic and more confident when crossing the road after the zebra had been installed. This suggests that installing a marked crosswalk, such as a zebra crossing, can significantly enhance the road-crossing experience of pedestrians and therefore improve their overall walking journey.

As part of their study into non-prescribed zebra crossings at side roads in Manchester, Jones et al., (2021) investigated public perceptions around safety and priority when using a non-prescribed zebra crossing in comparison to having no crossing. They found that more than half of survey participants reported that they felt the non-prescribed zebra crossing was safe and would be more likely to cross than in situations where no crossing was present.

With reference to the attitudinal survey, consideration is now given to the following: -

- Pedestrian decisions regarding where to cross on the urban road network;
- Pedestrian overall perceptions of safety at crossings by type;
- Pedestrian perceptions of zebra crossings; and
- Pedestrian perceptions CSZ crossings.

4.3. Pedestrian Decisions Regarding Where to Cross on the Urban Road Network

The frequency of pedestrians crossing at informal crossing points will depend on the convenience of the existing formal crossing locations. In the current study, 66% of respondents agreed that current signalised crossings and zebra crossings were at convenient locations. Furthermore, over half (53%) of respondents agreed or strongly agreed that there were not enough crossing facilities at mid-block locations. In contrast, in a European study (Papadimitriou et al., 2012), 67% of respondents, many of whom would have lived in countries with continental style zebra crossings, were satisfied with the number of pedestrian crossings provided.

4.3.1. Traffic activity

The respondents indicated that their propensity to cross, away from formal crossings, depended on the level of traffic activity. Under heavily trafficked conditions only 17% of respondents indicated that they ‘often’ or ‘always’ crossed the road away from formal crossings. In contrast, under lightly trafficked conditions, 62% of all respondents indicated that they ‘often’ or ‘always’ crossed away from formal crossings. This is presumably because they feel it safe to cross at informal crossing points under such conditions. This is similar to the findings of a Scottish study conducted by Sharples, (2000). Hunt and Griffiths (1989) also found that when traffic volumes are very low, pedestrians tend to cross spontaneously, and not to go out of their way to use a crossing facility.

4.3.2. Pedestrian delays

In the current study, respondents were asked to estimate the average length of time that they wait to cross at informal crossing points. The results showed that 48% perceived that they waited more than 30 seconds and 19% perceived that they waited more than 60 seconds. Females and older pedestrians were significantly more likely to wait longer. Research suggests that pedestrian waiting times are positively correlated with dangerous pedestrian behaviours. Research suggests (Almodfer et

al., 2015; Hamed, 2001) that pedestrian waiting times are positively correlated with dangerous pedestrian behaviours. Pedestrians tolerate more risk (measured by smaller gap acceptance) as their waiting time, at the kerb, increases. It might be anticipated that the introduction of additional low-cost CSZ crossings on the urban road network would reduce the numbers of pedestrians having to wait for long periods to cross informally and hence reduce risky crossing behaviour.

4.3.3. Additional journey time

In the current study, respondents were asked what extra journey time they would be prepared to accept to cross at either a zebra crossing or a crossing with traffic signals. The responses indicated that 66% would be prepared to walk for up to two additional minutes in order to access a formal crossing point. However, 12% of respondents would not be prepared to walk any additional distance to access a zebra crossing and 9% respondents would not be prepared to walk any additional distance to access a signalised crossing. The introduction of a number of low-cost CSZ crossings would reduce additional journey times needed by pedestrians to access formal crossing points. Previous research has indicated that the most influential factor cited by pedestrians in making a decision to cross at a designated crossing location was the distance of the crosswalk to the desired destinations of pedestrians (Sisiopiku and Akin, 2003). In an earlier Scottish study, over 45% of respondents indicated that they would not use a formal crossing if it would take too long to do so (Sharples, 2000).

4.4. Pedestrian Overall Perceptions of Safety at Crossings by Type

With regards to perceived risk, the current study asked all respondents to rate how safe they felt when crossing the road at each type of crossing facility. It may be seen from Figure 4.1 that very few pedestrians reported feeling unsafe at signalised crossing facilities (5% mid-block; 6% junctions). However, 18% felt unsafe at conventional zebra crossings. This increased to 27% for those crossing at CSZ crossings.

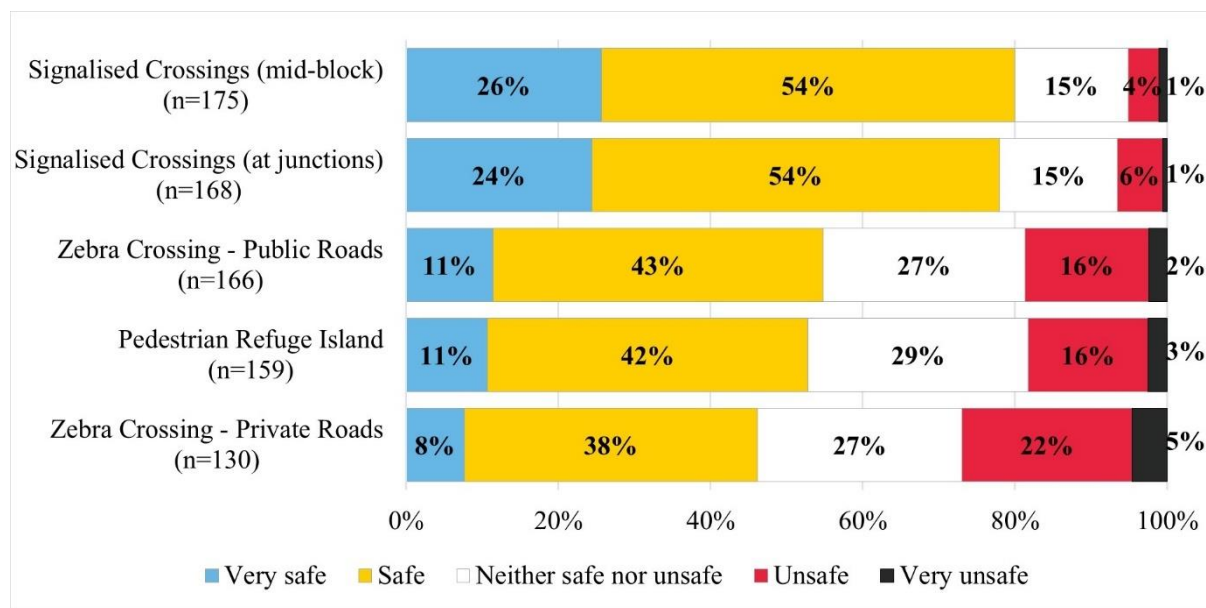


Figure 4. 1 Safety perception and type of crossing facility

4.5. Zebra Crossings

Given that pedestrian respondents felt less safe when crossing at zebra crossings, when compared to signalised crossings, consideration is now given to factors which might influence this perception

4.5.1. Pedestrian priority at zebra crossings

In the current study only 55% of respondents felt safe at zebra crossings. In the UK, priority at zebra crossings is assigned, in law, in accordance with Highway Code Rule 195. This requires drivers to give way once the pedestrian has set foot on the striped crosswalk. It also requires drivers to look out for pedestrians waiting to cross and be ready to slow down or stop to allow them to cross. Despite the definitive position of the Highway Code, the results of the household survey suggested that there was widespread confusion regarding who had priority at zebra crossings with 55% of the respondents indicating that they did not know that, legally, drivers approaching a zebra crossing do not have to stop for pedestrian who are waiting to cross but have not set foot on the crosswalk itself. This is reflected in the 79% of respondents who also indicated that they would either ‘always’ or ‘often’ wait until a driver stopped before stepping on to the crosswalk. Only 24% of respondents indicated that, as pedestrians, they ‘always’ or ‘often’ stepped onto the crosswalk to encourage drivers to either stop or slow down.

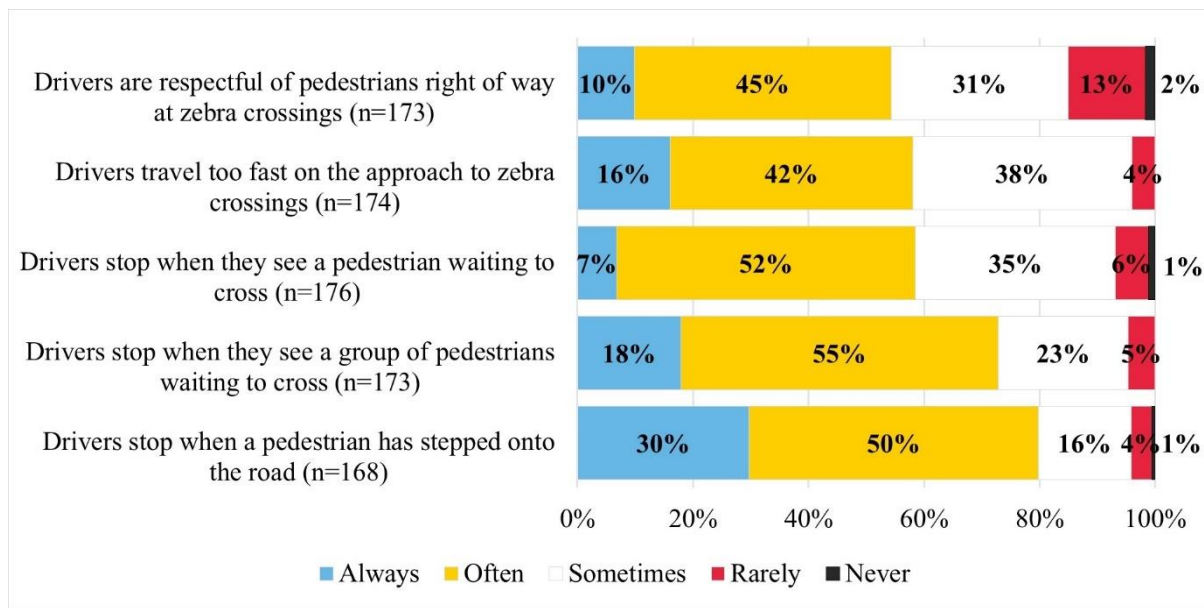


Figure 4. 2 Pedestrians perception of driver behaviour at zebra crossings

It may be seen from Figure 4. 2 that 46% of respondents who were pedestrians thought that drivers ‘sometimes’, ‘rarely’ or ‘never’ respected a pedestrian’s right of way on a zebra crossing. Conversely, 99% of respondents, who were drivers, agreed that they respected pedestrian rights of way at such crossings. This is similar to the 97% of drivers, in a UK wide study, who self-reported that they gave way to pedestrians at zebra crossings “often”, “very often” or “always” (Cestac et al., 2012). In the same study similar high percentages were reported in Estonia (96%), and Ireland (95%) with the lowest being found in Cyprus (80%) and Spain (69%). The authors noted that the frequency of giving way to pedestrians depends, to a certain extent, upon the legislation within each country.

4.5.2. Pedestrian perceptions of vehicle speeds at approaches to zebra crossing

With reference to Figure 4. 2, 58% of pedestrian respondents agreed that drivers ‘always’ or ‘often’ drove too fast on the approaches to zebra crossings. As well as assigning priority, Highway Code Rule 195 also requires drivers to look out for pedestrians waiting to cross and be ready to slow down or stop to allow them to cross. Várhelyi, (1998) reported differences between drivers observed and stated behaviour at zebra crossings in Sweden. It was found that 73% of drivers maintained or even increased speed, and in only 27% of cases did they slow down as required. At the same time the survey found that in 67% of cases, motorists say they ‘always’ or ‘very often’ slow down.

4.5.3. Pedestrian behaviour in the vicinity of pedestrian crossings

In the current study 11% of respondents agreed that they crossed the road close but not on the crosswalk at zebra crossings. Previous studies have identified that there is a relatively high risk for pedestrians crossing within 50m of a crossing facility (Preston, 1989). In 2017, 174 pedestrians were killed or seriously injured on pedestrian zebra crossing crosswalks in Great Britain and 86 were also injured within 50m of a zebra crossing (DfT, 2018). With regard to possible causation of pedestrian casualty

accidents within 50m of a zebra crossing (but not on the crosswalk), Downey et al., (2018) found that 89% of those coded with contributory factors were pedestrians and 11% were drivers. This reflects the fact that, in these circumstances, drivers have the right of way. The most frequently coded contributory factors for pedestrians, in this situation, were ‘failed to look’ and ‘careless, reckless or in a hurry’.

4.5.4. Perceptions of Continental Style Zebra Crossings

It may be seen from Figure 4.1 that only 46% of pedestrians felt ‘safe’ or ‘very safe’ when using CSZ crossings located on private roads in Scotland. This suggests that a low percentage of pedestrians would feel safe at similar facilities installed on public roads.

It may be seen from Figure 4.3 that, with reference to introducing CSZ crossings onto public roads in the UK, 57% of respondents were against introducing CSZ crossings onto public roads in Scotland and only 24% were in favour of their introduction (19% responded ‘maybe’). This suggests that there may be considerable public resistance to any such crossings which would have to be addressed before the widespread introduction of such facilities on the Scottish road network would be possible.

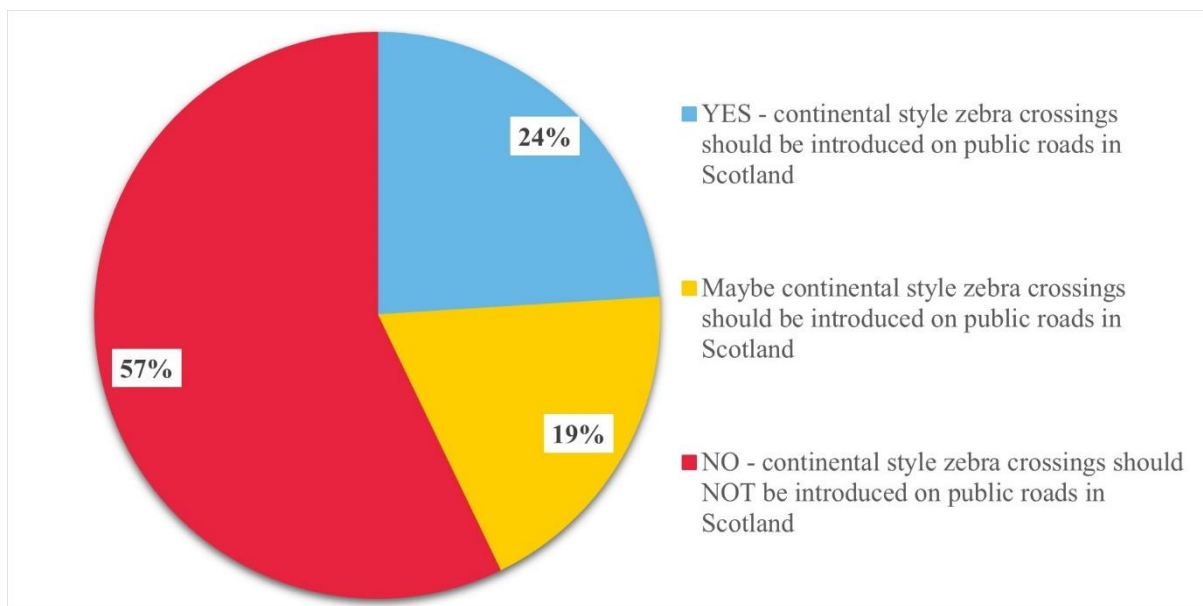


Figure 4. 3 Support for introducing continental style zebra crossings in Scotland (n=175)

Respondents were asked why they thought that CSZ crossings should or should not be introduced on private roads in Scotland. Those in favour of CSZ crossings were keen to prioritise pedestrians’ needs, encourage drivers to give-way to pedestrians and encourage walking. Comments were made suggesting CSZ crossings would be quicker, easier and cheaper to install than traditional zebras; they would provide roads authorities with more flexibility when providing formal crossing points for pedestrians and would be easier to implement where signalised crossings are not appropriate. Some participants highlighted the importance of CSZ crossings being installed at suitable locations such as areas with

traffic calming (low speeds and low traffic volumes) and design elements such as narrowing of the carriageway to increase visibility.

For those respondents who were against the introduction of CSZ crossings, many had concerns with regard to overall safety, visibility and driver yielding issues. CSZ crossings separate pedestrian vehicle conflicts in the same way as existing zebra crossings. It appears that there would be the same confusion regarding who has priority in terms of pedestrian vehicle conflicts. Those who had experience of using CSZ crossings in Europe felt that they were dangerous places, where drivers would not stop for pedestrians at the crossings. Measures to encourage drivers to stop were suggested such as enforcement, strict driver liability and/or awareness raising campaigns for both drivers and pedestrians.

5. LEGAL AND POLICY FRAMEWORK

5.1. Policy Framework

5.1.1. Walking strategy

A key objective of the study was to analyse the legal and policy framework for introducing CSZ crossings at a national and local level. The context, for the undertaking of the current study, is the personal, social and environmental benefits of walking. Walking reduces traffic congestion and pollution and is beneficial to individuals' health and wellbeing. Consequently, measures that encourage walking have been the focus of a number of recent policies and guidelines including: The National Transport Strategy 2 (Transport Scotland, 2020); Climate Change Plan (Transport Scotland, 2020); and The Draft National Planning Framework 4 (Scottish Government, 2022). The vision of the National Walking Strategy (Scottish Government, 2014) is for '*a Scotland where everyone benefits from walking as part of their everyday journeys, enjoys walking in the outdoors and where places are well designed to encourage walking*'. Making streets easier to cross is an important aspect of encouraging more walking and the Strategy emphasises the importance of addressing physical barriers to walking such as non-existent or inappropriate crossing arrangements. With reference to trunk roads in Scotland, the Scottish Good Practice Guide for Trunk Roads (Transport Scotland, 2013), suggests that Transport Scotland can no longer support the use of zebra crossings because they are unsuitable for visually impaired pedestrians. Presumably this sentiment would also apply to CSZ crossings as well.

5.1.2. UK pedestrian crossing guidelines and UK pedestrian crossing assessment procedures

It is important that, within the policy framework, due consideration is given to current UK guidelines and assessment procedures associated with the introduction of pedestrian crossings.

a) Sight distances and street lighting

For daytime operations, the UK pedestrian crossing guidelines (DfT, 2022) require that a minimum sight distance for drivers is provided on both approaches to any proposed crossing, based on 85

percentile approach speeds. For night-time operation it is important that the crossing can be readily seen against the background of other lights and signs. Designers must therefore ensure that adequate street lighting is provided in accordance with BS 5489. At many sites this may require upgraded street lighting. During night-time operations, it is also important that approaching drivers are able to see pedestrians waiting to cross. This may require supplementary lighting. An important feature of CSZ crossings is that they are low-cost installations. However, if they are located on a section of road which would require the street lighting to be upgraded, this would increase the cost.

b) Safety requirements

The current guidelines (DfT, 2019) suggest that the three main objectives of any proposed pedestrian crossing installation should be safety, convenience, and accessibility. The guidelines state that a crossing that does not improve on all three objectives to some degree is unlikely to be satisfactory, and consideration of these criteria will form an important part of the assessment process. There is also a recognition that the provision of a crossing alone will not necessarily lead to an improvement in safety.

Unfortunately, although practitioners are asked to consider safety aspects of pedestrian crossings, the current guidelines (DfT, 2019) provide no methodology to determine possible safety benefits of zebra crossings. It is presumed that this is because there is little published UK research on the subject.

(i) Safety of zebra and continental style zebra crossings without traffic calming measures

One of the earliest studies into marked pedestrian crossing safety which would include zebra and CSZ crossings (Herms, 1970) found that there was almost a two-fold increase in pedestrian risk when compared with unmarked crossing sites. In the UK, Landles and Lloyd, (1982) considered before and after pedestrian crashes at 62 zebra crossings and found that there were no significant changes in the pedestrian crash numbers. Similarly in the USA, Campbell et al., (2004) suggest that for two-lane roads, the presence of a marked crosswalk was associated with no difference in pedestrian crash rates, compared to an unmarked crosswalk. However, in Sweden, Ekman, (1988) found that there is a doubling of risk of pedestrian injury when crossing on a zebra crossing compared to a crossing location without any signs or road markings, presupposing that all other conditions are equal. In New Zealand (NZ Transport Agency, 2009) the guidelines for pedestrian provisions suggest that, on average, installing a zebra crossing, without any traffic calming measures, will lead to a 28% increase in pedestrian crashes.

The findings from the various studies into pedestrian crashes at zebra and CSZ crossings suggest that there is a potential for increased pedestrian crashes following the introduction of CSZ crossings without traffic calming measures.

(ii) Safety of zebra and continental style zebra crossings in a low-speed environment

There is some evidence to suggest that there is a potential to reduce pedestrian casualties by installing zebra crossings in a low-speed environment. The UK pedestrian crossing guidelines (DfT, 2019) suggest that zebra crossings are more appropriate in a low-speed environment and where both pedestrian and traffic flows are low to moderate. In addition, the guidance recommends zebra crossings are not installed in environments where the 85th percentile speed exceeds 35mph, without speed reducing measures to slow traffic.

Most research into pedestrian accidents at crossings in a low-speed environment has involved installations with raised pavements to calm traffic. Dixon and Jacko, (1998) found that the presence of a speed hump at zebra crossings meant that drivers were more likely to yield to pedestrians. In New Zealand (NZ Transport Agency, 2009) it is suggested that that installing a zebra crossing on a raised platform, with parking prohibited on the approaches, will reduce pedestrian crashes by an average of 80%. This is based on a study conducted in Sydney, Australia involving the installation of 30 zebra crossing on a raised platform (Geoplan Urban Traffic Planning, 1993). Makwasha and Turner, (2017) also found significant casualty crash reduction of 63% for Australian ‘Wombat’ crossings (zebra crossings with raised platforms and ‘no stopping’ on the approaches). However, they noted that other international research suggested a more conservative estimate of 40% to 60% casualty crash reduction. The reduced casualty crashes reported at the low-speed sites might not solely be related to reduced speeds because the raised pavements would also improve pedestrian conspicuity for approaching drivers.

In recent years, there has been a growing prevalence of 20mph speed limits in Scotland. For example, Scottish Borders Council recently approved plans to permanently set 20mph speed limits across towns and villages, and City of Edinburgh Council have introduced a default 20mph network covering residential roads, shopping streets and the city centre. At a national level, there are plans to make 20mph the speed limit for all urban streets.

Also of relevance are recent changes to the Highway Code, which clarify that people waiting to cross at junctions have priority over traffic.

5.2. Legal Framework

5.2.1. Background

When considering signage, it was found that the existing prescribed signs were not appropriate for the new CSZ crossing type. Currently, drivers approaching existing UK pedestrian crossings facilities are familiar with the current signal controlled and zebra crossings layouts. Furthermore, on approaching such facilities, drivers are provided with visual clues to make them aware that they may be required to yield to pedestrians on a crossing. These include high visibility traffic signal heads and zig-zag markings at signal-controlled crossings, and flashing beacons and zig-zag markings at zebra crossings.

In the CSZ crossing installation, most drivers would be unfamiliar with continental style crossings and would not be provided with either signal heads, flashing beacons or zig-zags to warn them to prepare to stop. As a consequence, it would be important that drivers were made aware that they were required to yield to pedestrians at the new continental crossings and that they were provided with sufficient visual clues on the approaches to such facilities. This would require the use of non-prescribed signs.

5.2.2. Signage and layout

Development of two proposed CSZ crossing installations was undertaken, in consultation with Transport Scotland, which included establishing suitable layouts and necessary signage. The signage included the use of the following non-prescribed signs: continental style zebra crossing sign; non-standard priority plate and Special Sign (Diagram 7014). Detailed descriptions are provided in Table 5.1. A sketch of the proposed layout may be seen in Figure 5. 1.

Table 5. 1 Proposed non-prescribed signs for trial CSZ crossings in Scotland

Non-Prescribed Sign	Comments
<p>Swedish pedestrian crossing sign</p> 	<p>It is proposed that the current Swedish zebra crossing signs be installed adjacent to the zebra markings at the trial CSZ crossings. In the absence of either traffic signal heads, flashing beacons or zig-zag markings, such signs will provide visual clues to drivers on the immediate approach to a CSZ Crossing. In addition, the graphic of a pedestrian on a zebra crossing will warn drivers that pedestrians, on the crossing, have priority. It should be noted that this non-standard sign IS required at the crossing itself to provide the necessary visual clue. This is how they are utilised in Sweden.</p> <p>It should also be noted that it would be inappropriate to use the UK advance warning sign for pedestrian crossings (Diagram 544), in such circumstances, because such an advance warning sign could not be located at the crossing itself (drivers will be familiar with their use in advance of crossings and will not be expecting them at the crossing itself).</p>
<p>Non-standard priority plate (optional)</p> 	<p>It is proposed that a non-standard priority plate is combined with the non-standard Swedish pedestrian crossing sign.</p> <p>Drivers will not be familiar with CSZ crossings. In order to reinforce the requirement for drivers to give-way to pedestrians on the new crossing type, it is proposed that a non-standard regulatory sign, similar to 615.5, is mounted on the same post as the Swedish pedestrian crossing sign, indicating that drivers are required to give way to pedestrians on the crossing.</p>
<p>Special sign (diagram 7014)</p>  <p><small>17 Diagram 7014 Permanent change to road layout ahead</small></p>  <p><small>1. "NEW ROUNDABOUT" may be varied to: (a) "CHANGED PRIORITIES"; (b) "GAP CLOSED"; (c) "ONE-WAY SYSTEM"; (d) "NEW ROAD LAYOUT"; (e) "NEW TRAFFIC ISLANDS"; (f) "NEW TRAFFIC SIGNALS"; (g) "NEW ZEBRA CROSSING"; (h) "SIGNAL PRIORITIES".</small></p>	<p>Consideration should be given to warning drivers of the new layout ahead using Special Sign Diagram 7014 in accordance with TSM Chapter 4 Para 1.17 and the Traffic Signs Regulations and General Directions 2016 (TSRGD). The TSM and TSRGD refer to a sign with a legend warning 'New Zebra Crossing Ahead'. It is felt that this might mislead motorists because the crossing will have no zig-zag markings or flashing yellow globes. It is therefore proposed that a non-standard warning stating 'New Pedestrian Crossing Ahead' would be more appropriate.</p> <p>This proposal is for the trial. If CSZ crossing were to become widespread it is envisaged that the 'new crossing ahead' signs will</p>

Non-Prescribed Sign	Comments
	only be required, at each installation, until the public are familiar with this type of layout. Direction 37 indicates that a new crossing ahead signs should be restricted to a period no longer than 3 months.

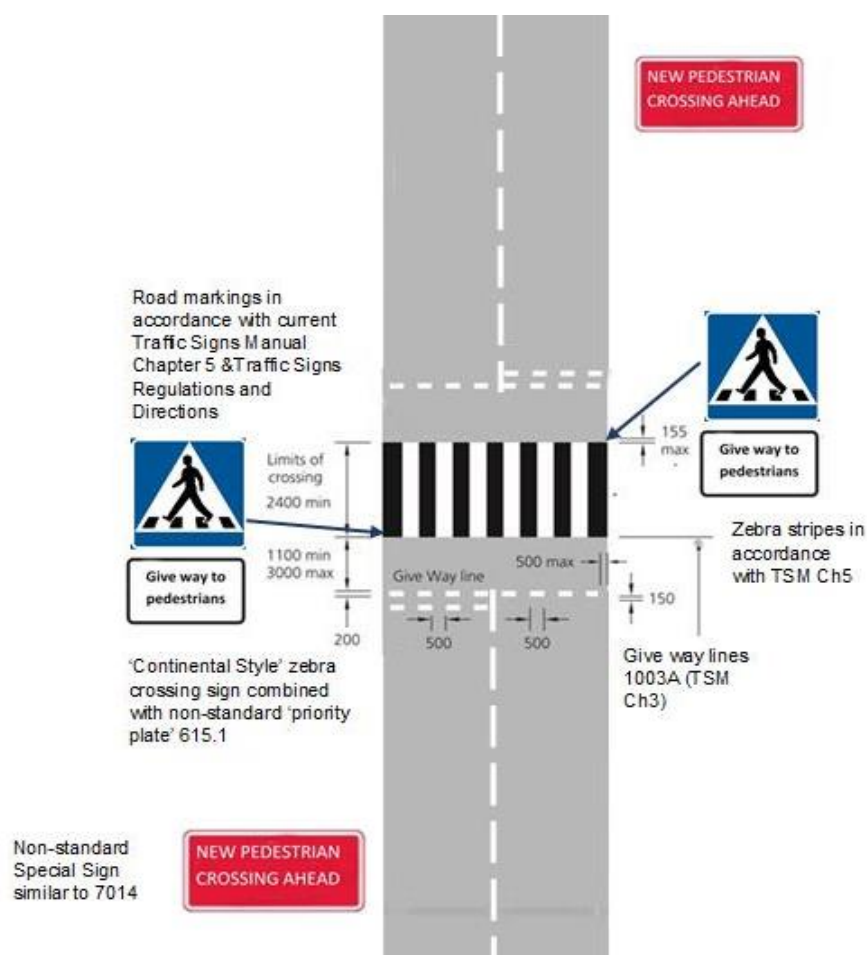


Figure 5. 1 Sketch plan and proposed layout for trial continental style zebra crossings

5.2.3. Non-prescribed signs and legal enforceability

Glasgow City Council made a formal application to Transport Scotland for ‘Authorisation of Non-Prescribed Traffic Signs’. However, on 4 October 2021 the application was refused due to concerns about legal enforceability and the extent of devolved powers in Scotland. No legal enforceability could be attached to the signs under the Road Traffic Regulations Act 1984 and pedestrians would not have legal priority over vehicles (as per traditional zebra crossings) at such installations.

Given these liability and safety concerns, the field trials proposed under Objective 6 were abandoned and consideration was given to the use of a driving simulator to assess potential driver behaviour at CSZ crossings.

It is recommended that the Scottish Government give further consideration to the legal issues surrounding trials of CSZ crossings in Scotland and explores whether there are legal solutions that would allow trials to proceed.

6. STAKEHOLDER CONSULTATIONS

6.1. Background

Pedestrian crossing design is a matter of interest to many organisations in Scotland and beyond. Stakeholders include local authorities, the Scottish Government, organisations working in active travel, groups representing disabled people, and motoring organisations (Table 6.1).

Table 6. 1 Stakeholder in zebra crossing design

Stakeholder group	Examples	Interest in pedestrian / zebra crossing design
Local government	All 32 local authorities in Scotland	<p>Responsibility for local roads and crossings.</p> <p>Keen to make roads safe and attractive for pedestrians, to increase walking and reduce cars. Targets to reduce car use e.g. 30% car km reduction target in Edinburgh and Glasgow. Plans to create ‘20 minute neighbourhoods’ where residents can meet their daily needs within 20 minutes of their homes by walking, using public transport, wheeling or cycling.</p> <p>Continental zebras may offer a lower-cost alternative to conventional crossings, potentially making it more affordable for local authorities to install more crossing points and encourage people to walk more.</p> <p>However, road safety is a key concern.</p>
Central government	Transport Scotland, Department for Transport	<p>Transport Scotland committed to making walking, wheeling and cycling the most popular mode of travel for short, everyday journeys. National 20% car km reduction target. Responsible for road signage and authorising non-prescribed traffic signs in Scotland.</p> <p>Traffic offences and Highway Code are reserved matters, not devolved to Scotland.</p>
Disability and access groups	RNIB, National Federation	Making streets safe and accessible for all.

	for the Blind, Mobility and Access Committee for Scotland, Disability Equality Scotland, Guide Dogs	
Active travel groups	Living Streets, Sustrans, Cycling Scotland, Cycling UK	Increasing rates of walking and cycling. Improving street design and infrastructure to make streets safe and accessible for people who walk, wheel or cycle.
Motoring organisations	AA, RAC	Road safety.
Law enforcement	Police Scotland	Keeping people safe, enforcing traffic law.

6.2. Stakeholder Engagement

For the current study, the focus of stakeholder consultation was on working with the local and central government bodies responsible for designing, authorising and implementing CSZ crossing design.

A key partner was Glasgow City Council, who were keen to explore whether CSZ crossings could be introduced in the city, to help to make Glasgow a more pedestrian-friendly place. In partnership with Glasgow City Council, two sites were identified in the city where CSZ crossings might be trialled and a crossing design was agreed with the Council.

At the start of the study, Aberdeenshire Council also expressed their support for the project and willingness to trial on a time limited experimental basis the installation of CSZ crossings at two locations on public roads in Aberdeenshire. The participation of Aberdeenshire in the project was subsequently cut short due to the impact of the covid pandemic:

changes to footway widths and road layout, together with changes in the number of pedestrians, meant that it was the wrong time to install a trial crossing that would be suitably used and provide meaningful feedback.

Throughout the study, meetings were held with officials at Transport Scotland in an attempt to establish an acceptable design for the trial CSZ crossing, and to explore whether there was a means to conduct the trials on the Scottish roads network under existing legislation.

Discussions were also held with representatives from Transport for Greater Manchester, who in 2021 published the findings from a research project in which CSZ crossings were trialled on side streets in Manchester. These discussions centred on the legal enforceability of the trial crossings in Manchester.

At the inception of the current study, the following groups were involved in discussion about key issues and scope: Cycling Scotland, East Lothian Council, Explore Dundee, Go Bike, Living Streets Scotland, Ramblers, Scottish Accessible Transport Alliance, Spokes and Sustrans Scotland.

6.3. Similar Initiatives Elsewhere

Scotland is not alone in its interest in CSZ crossings. Over the past few years, other places have also been investigating their feasibility.

In England, Transport for Greater Manchester recently trialled CSZ crossings on two side streets, the conclusion to a two-year study into side road zebras. Alongside national transport organisations, motoring bodies and charities, they have called upon the UK government to amend the regulations (Traffic Signs and Regulations Guidance Document) to allow large-scale, long-term trials.

In Wales, CSZ crossings are being trialled on side streets in Cardiff. If successful, these may be included in a Welsh amendment to the Traffic Signs Regulations and General Directions.

Also, in the Republic of Ireland, the Minister for Transport has recently announced a pilot scheme in which CSZ crossings will be trialled in eight locations over a nine month period.

7. DRIVER PERFORMANCE ON THE APPROACHES TO CONTINENTAL STYLE ZEBRA CROSSINGS

7.1. Introduction

An important aspect of the original research proposal was the undertaking of a full-scale field trial involving observations of the operation of two trial CSZ crossing installations in Glasgow and Aberdeenshire. These installations would have been within low-speed environment with adequate sight lines on the approaches and adequate street lighting to ensure that pedestrians were visible to approaching drivers during night-time conditions. As indicated earlier, in Section 5.2, it was not possible to gain approval for the proposed non-authorised signs, associated with the full-scale field trial, because of concerns about legal enforceability and the extent of devolved powers in Scotland. This meant that full scale road trials could not go ahead.

7.2. Use of a Driving Simulator to Measure Driver Performances on the Approach to Continental Style Zebra Crossings

As an alternative to undertaking a full-scale field trial, consideration was given to utilising a driving simulator to assess driver performances on the approach to a CSZ crossing. Driving simulators are often used for human factor research purposes to monitor driver behaviour, performance, and attention. Several studies have used them to investigate the behaviour of drivers towards pedestrians at crossing facilities (Bella and Silvestri, 2015; Fisher and Garay-Vega, 2012). The benefits of using a driving simulator in such circumstances, include the ability to measure the reactions of each driver, taking part, to exactly the same pedestrian event. As well as assessing driving performance and behaviour at the proposed CSZ crossings, it also allows comparisons with driver performance and behaviour at: mid-block location with no crossing facility; traditional mid-block zebra crossing (with Belisha Beacons and zigzags); and signalised mid-block crossing facility (Puffin and Pelican crossings).

7.2.1. Methodology

The simulator was set up so that there was access to driver reactions and performances on the approaches to pedestrian crossings. Undertaking the simulations involved recruiting volunteer drivers who were in possession of a full UK driver's license. For each test, participants were required to complete a 'pre-driving' questionnaire providing basic information such as age and driving experience. The volunteer drivers were also required to complete post-driving questionnaires so that any simulation issues could be identified (e.g., workload or difficulties).

Data collected from the driving simulator included driving performance (speed, acceleration and braking); the distance from the crosswalk at which the driver reacted to the presence of a pedestrian; the time taken to brake to a stop; driver yielding behaviour; and number of crashes/accidents for each crossing type. There was a mid-block location without pedestrian crossing facilities that featured a lone pedestrian that had already started crossing. This enabled a 'before' and 'after' comparison of a mid-block location without a crossing and the other crossing types. It was anticipated that such information would assist in determining the feasibility of introducing CSZ crossings in Scotland. Furthermore, it would also provide additional data to enable assessments of the relative performance of drivers at alternative pedestrian crossings such as zebras and signalised crossings.

Driving simulators for transportation research are widely used because of their advantages in terms of safety cost and programming convenience. The principal reason for this is that it is well established that simulation is both an effective method for training and also produces realistic responses by drivers to simulation scenarios. Simulators are available in varying levels of fidelity from moving base 360 projection systems with realistic controls to medium and low fidelity fixed base using simple 2D TV screens and off-the-shelf controls. It should be noted that a considerable proportion of research in Automotive User Interface or Human Machine Interface studies is done with low-fidelity simulators

and OTS such as that provided by the STISIM Drive package, as evidenced by the content of papers for the Automotive UI, ACM SIGCHI Conference on Automotive User Interfaces and Interactive Vehicular Applications. <https://www.auto-ui.org/18/>

7.3. Driving Simulator Experiment

The aim of the driving simulator experiment was to enhance the overall study, in the absence of a street experiment, with a measured response of drivers' to simulated road and crossing environments. To do this the STSIM simulator was coded with a simulation drive where scenery, road paint and surroundings were a rough approximation of Scottish city streets. Driving signs and road markings were as UK standard, apart from speed limit signs that were given in KM/Hr. This was necessary as the vehicle cluster instruments showed speed in KM/Hr and thus facilitated comparison with the numbers on the signs. Speed limits used in the simulation were 70km/hr in non-built up areas and 50 km/hr in urban areas with crossings. The vehicle dashboard and instrument cluster corresponded to that of a conventional vehicle and a simulator rear-view mirror and wing mirrors showed the scene behind the car. The STISIM version was "STISIM Drive Simulation Kernel Build: Build 3.21.02".

The participant sat in a frame buck with automotive seat, steering wheel and indicator paddles. There was a conventional 3 pedal arrangement, however the car behaved as an automatic with the right pedal acting as an accelerator and the middle as brake. Immediately in front of the driver was a large display screen (60 inch) displaying the whole simulation (See Figs: 7.1, 7.2).



Figure 7. 1 The driving simulator set-up

The room was indirectly lit and acoustically separated from nearby areas. High level windows ensured adequate ventilation. There were three routes each with a differing ordering of crossings in order to counterbalance learning and order effects. For each participant's driving session (and counterbalance level), the route and scenery was identical, in timing, positions and presence of vehicles, pedestrians movements and crossing behaviour. The conditions were set at UK average of a bright day with good ambient lighting and a slight haze at a horizon of around 1km. The vehicle dynamics were as for a standard coupe.

The primary research question, to be addressed, was whether or not it was possible to attribute any potential significant differences in mean braking time responses of driver to pedestrians crossing a road in the following situations:

- A conventional zebra crossing with both Belisha Beacons and standard road markings including zig-zags;
- A CSZ crossing configured in accordance with proposed full scale field trial (advance warning sign and painted crosswalk (see Figure 7.2);
- An individual pedestrian suddenly crossing the road on a straight stretch, away from a formal crossing, with clear visibility for over 100 metres; and
- A signal controlled crossing, with vehicle signal heads corresponding to UK standard (red/amber/green) and with pedestrian control lights (red/green/blank) facing pedestrians.



Figure 7. 2 The continental style zebra (TL,TR) and the Belisha crossing BL,BR) – drivers views

7.4. Experimental Procedure

The experimental procedure is also given in the briefing document that was read to the participant at the start of the study (see Appendix D). After welcome and consent form completion, participants were invited to make themselves comfortable in the driving buck and the operation of the controls explained to them. Each participant was initially required to drive along an identical standard training route, within the simulator, which required a moderate level of steering, braking, speed limit adherence, and response to pedestrian and other hazards. The training route also included a pedestrian crossing before the experimental run. Any crashes during this stage resulted in a reset and continuation from the point of collision. If participants required any explanation or queried the procedure, this was managed during the training run.

After a short break the experimental run commenced. This was a completely different route to that originally driven in the initial simulation training. The participants were briefed to drive according to the UK road signs and regulations, not to break speed limits (warnings provided) and to respond appropriately to any hazards they encountered. The researcher did not comment during the trial run and was seated at the control console.

The Simulator was configured to automatically collect data of the vehicle controls at a frequency of multiple times per second. Data collected included: velocity (speed); distance on route; time on route; lateral accelerations, longitudinal acceleration; braking actions; steering deviations from centre-line, and no/type of crashes.

Data was collected within blocks whose start and finish bracketed the different crossing types at each of three locations. The pedestrian crossing was always within the same location block in a straight section clear of visual obstructions or distractions.

For the signal controlled crossing, the initial amber followed by red display commenced when the driver was 80m in advance of the crossing. For the zebra and CSZ crossings, pedestrians moved to the kerbside waiting to cross, when the driver was 80m in advance of the crossing location. When simulating pedestrians, crossing away from a formal crossing, the simulation was set up so that they just stepped out onto the road when a driver was 80m in advance of the location. This avoided any ambiguity regarding whether or not a crossing had been initiated. Following the experimental run, participants were offered refreshments, asked to complete questionnaires and debriefed.

7.5. Analysis of Data

The data was anonymised and decoded from counter-balancing. A visible crossing distance calculation was made from the data according to the following protocol.

From the route coding it was possible to identify the time when a driver was able either to see a pedestrian preparing to cross or see an amber display followed by red display at a signalised crossing. This was always 80m in advance. The data analysis commenced at this time. It was possible to establish how long it took for a driver to brake using the velocity, distance on route, braking force and accelerator force. For example, when the speed (km/h) reaches zero (0) (Figure 7.3), the time was recorded as 108.832 seconds. The pedestrian started to cross at 103.732 seconds. Therefore, the braking time for this crossing was $108.832 - 103.732 = 5.1$ seconds.

TIME	DISTANCE	DEVIATION	SPEED		ACCELERATOR	BRAKE			
108.499	1651.44	-1.60	4.85	0	0.000	0.508	1.00	0.00	0.00
108.532	1651.48	-1.60	4.34	0	0.000	0.508	1.00	0.00	0.00
108.565	1651.51	-1.61	3.83	0	0.000	0.512	1.00	0.00	0.00
108.599	1651.54	-1.61	3.32	0	0.000	0.516	1.00	0.00	0.00
108.632	1651.56	-1.61	2.80	0	0.000	0.516	1.00	0.00	0.00
108.665	1651.58	-1.61	2.29	0	0.000	0.520	1.00	0.00	0.00
108.699	1651.59	-1.61	1.76	0	0.000	0.528	1.00	0.00	0.00
108.732	1651.60	-1.61	1.24	0	0.000	0.528	1.00	0.00	0.00
108.765	1651.61	-1.61	0.72	0	0.000	0.528	1.00	0.00	0.00
108.799	1651.61	-1.61	0.19	0	0.000	0.532	1.00	0.00	0.00
108.832	1651.61	-1.61	0.00	0	0.000	0.532	1.00	0.00	0.00
108.865	1651.61	-1.61	0.00	0	0.000	0.532	1.00	0.00	0.00
108.899	1651.61	-1.61	0.00	0	0.000	0.532	1.00	0.00	0.00
108.932	1651.61	-1.61	0.00	0	0.000	0.532	1.00	0.00	0.00
108.965	1651.61	-1.61	0.00	0	0.000	0.532	1.00	0.00	0.00

Figure 7. 3 Data table from a participant slowing to a stop

In some cases the participant will not brake to 0 km/h, continuing to move at low speed on the approach to the crossing location. The method followed to calculate this case was to locate the point at which the minimum speed is reached. At this point, the time value recorded was taken when the participant finally released the brake pedal with the minimum speed constant (shown as 0 brake force).

The counterbalanced order of crossings is shown in Table 7.1.

Table 7. 1 Arrangement of crossings in each simulation

	1st	2nd	3rd	4th
CASE A	Continental sign	Belisha crossing	Pedestrian only	Traffic light
CASE B	Belisha crossing	Traffic light	Pedestrian only	Continental
CASE C	Traffic light	Continental sign	Pedestrian only	Belisha crossing

The results for the braking time are presented in Figure 7.4, in a box and whisker plot showing the mean time values, interquartile range and total range, with outliers highlighted. It was notable that although there were observable differences in mean values, the distributions were large, ranging between 4 and 12 seconds, with some extreme outliers evident.

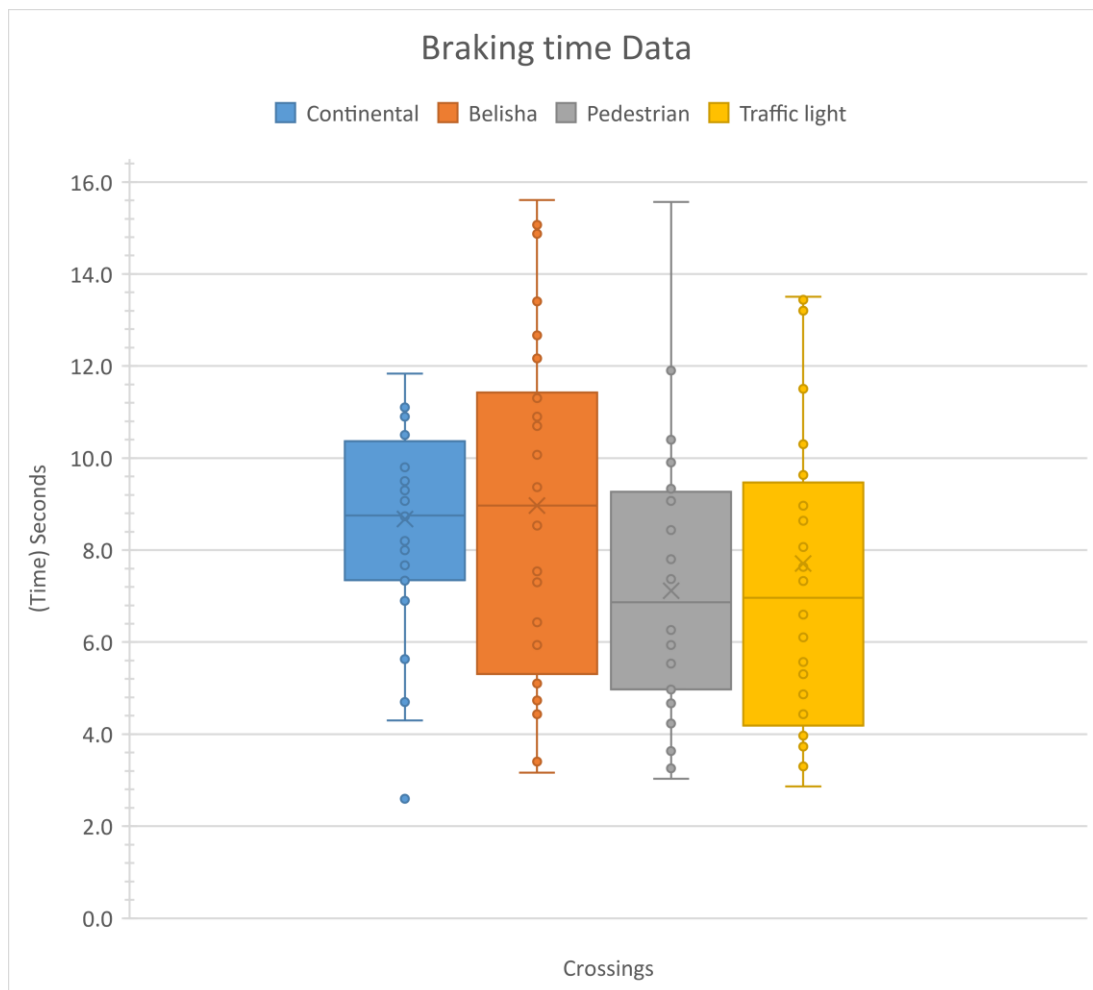


Figure 7.1 The means, ranges, and interquartile ranges, plus outliers, of the braking time data

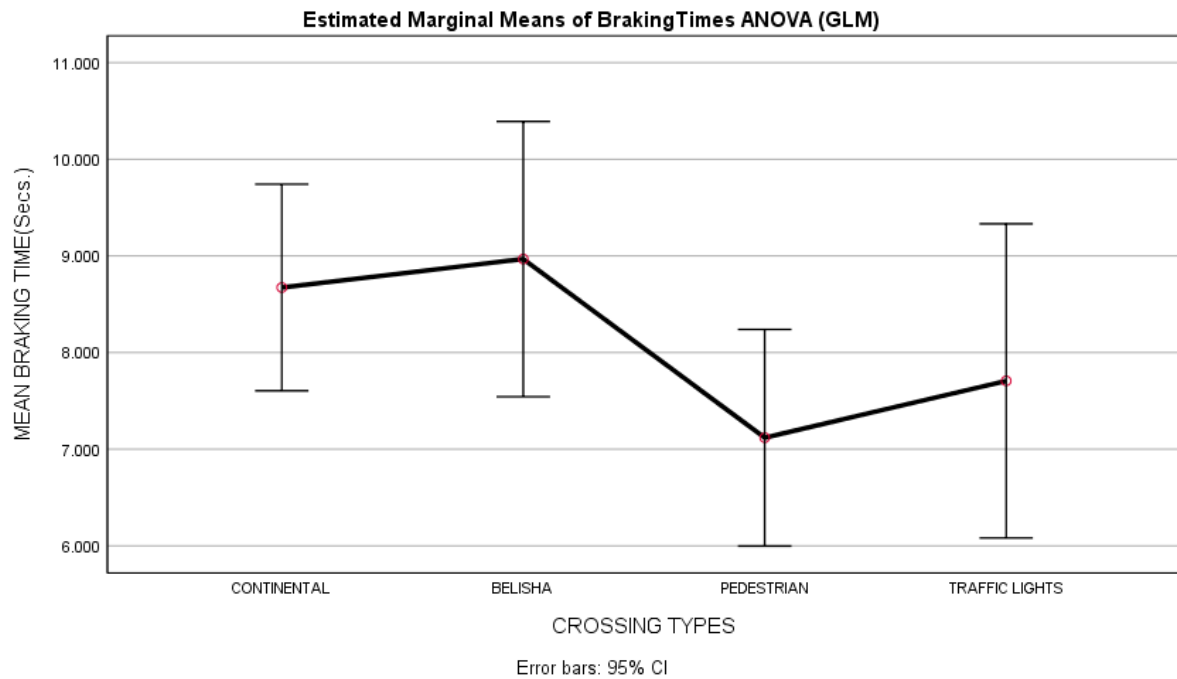
7.5.1. Inferential test for statistical significance

The analysis used an inferential test of differences between mean values in a repeated measure (1 Factor Repeated measures analysis of variance (ANOVA). This was calculated using a test for differences between means in general linear model using SPSS 20.

The null hypothesis was that there would be no significant differences between the means of the four conditions other than that may have occurred by chance.

The experimental hypothesis was that there was a significant difference between the conditions.

The means diagram (Figure 7.4) shows means and confidence intervals for each condition.



This Interaction diagram represents the Mean braking times for each crossing type after counterbalancing.

Figure 7. 4 The ANOVA interaction diagram showing the condition means and 95% confidence intervals for braking times at different crossing types

The test for a significant difference between crossing types and within subjects was significant ($n = 29$, $df=3$, $F= 2.790$, $P < 0.46$) (Sphericity assumed, Mauchly, $P = 0.698$ n.s)

Table 7. 2 ANOVA test results

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
CROSSINGS	Sphericity Assumed	61.532	3	20.511	2.790	.046

To establish which crossings differed significantly with which, a pairwise comparisons test was carried out with Bonferroni adjustments for multiple comparisons.

Table 7. 3 ANOVA post-hoc comparison results

Pairwise Comparisons

Measure: BrakingTimes

(I) CROSSINGS		(J) CROSSINGS		Mean Difference (I-J)	Std. Error	Sig. ^b	95% Confidence Interval for Difference ^b	
							Lower Bound	Upper Bound
1		2		-.294	.788	1.000	-2.537	1.948
		3		1.554	.707	.220	-.459	3.568
		4		.966	.807	1.000	-1.332	3.264
2		1		.294	.788	1.000	-1.948	2.537
		3		1.849 [*]	.620	.036	.082	3.615

	4	1.261	.674	.435	-.659	3.181
3	1	-1.554	.707	.220	-3.568	.459
	2	-1.849*	.620	.036	-3.615	-.082
	4	-.588	.734	1.000	-2.678	1.501
4	1	-.966	.807	1.000	-3.264	1.332
	2	-1.261	.674	.435	-3.181	.659
	3	.588	.734	1.000	-1.501	2.678

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

b. Adjustment for multiple comparisons: Bonferroni.

Crossing 2 (Belishas) was found to be significantly different from Crossing 3 (Pedestrian) in its effect on braking times at ($n=29$, $p=0.036$, $P < 0.05$) in post-hoc comparison with Bonferroni adjustment.

7.5.2. Interpretation and results

It can be concluded that there were significant differences between means of all the four situations, therefore the results did not occur by chance. Post-hoc comparisons suggested that the braking on the approach to the CSZ crossing was less severe and that braking on the approach to a location, where a pedestrian crossed a road some distance from a formal crossing was more severe.

It would appear that the visual stimuli associated with the road markings, advance warning signs and pedestrians waiting to cross at a CSZ crossing resulted in a similar severity of braking on the approach to that of conventional zebra crossings with flashing Belisha Beacons and zig-zag markings. The only visual stimulus to drivers approaching a pedestrian who was crossing at a location some distance from a formal crossing would be the actual pedestrian. This might explain why a driver's braking on the approach to such a pedestrian, crossing the road, was more severe.

7.5.3. Signal controlled crossing

We would expect that the very strong visual clue of amber followed by red signal display would assist in producing much less severe braking on the approach. Drivers are conditioned to respond to amber followed by red light stimulus. Research backs this up in terms of fewer accidents. However, in this study; as a result of software limitations, the implementation of the signal controlled crossing was incorrect, judged unconvincing, and was inaccurate according to UK practice; although the braking results fell in the range between the Belisha, and the single pedestrian. For these reasons, the data from the signal-controlled crossing was considered unreliable, particularly as statistical post hoc comparisons did not reveal significant differences from the other crossings and the result may therefore have been due to chance.

7.5.4. General observations

Further, some general observations suggest that the outliers and distributions (95% confidence intervals) were broad. This reveals a wide variance and lack of homogeneity in the braking times. To some extent this may be explained by differences in braking style (strong – late braking, versus hesitant intermittent braking) and this is also supported by the fact that some drivers never braked to a standstill, simply slowing and allowing the pedestrians to cross, rolling on thereafter. This may reflect differences in levels of experience or driving style. All the participants had held a license for at least 10 years and there was insufficient data to check frequency of collisions.

It should be noted that the CSZ crossings included in the simulation, attempted to replicate the layout proposed for the original field trials. As indicated earlier, the results suggest that braking characteristics in the approach to the CSZ crossing layout proposed in the trial would be similar to that on the approach to a conventional zebra crossing. However, the proposed field trial layout included a large advance warning sign, which would normally be set up at any such new installation. This would normally be removed several months afterwards. On its removal, the visual stimulation on the approach to the crossing would be reduced and this may result in different braking performances on the approach. Although the results suggested that it would be safe to go ahead with the field trial undertaking further simulations, without advance warning signs on the approaches to CSZ crossings would be desirable as future work.

8. CONCLUSIONS AND RECOMENDATIONS

8.1. Background

There are social and environmental benefits associated with walking, including reductions in traffic congestion and pollution and improved health and wellbeing. As indicated earlier, in Scotland, measures that encourage walking have been the focus of a number of recent policies and guidelines. The introduction of additional formal low-cost crossing facilities such as continental style pedestrian crossings may help address this issue. As a consequence, an investigation to explore the feasibility to introduce such a measure is timely.

8.2. Potential Benefits

As well as the potential to encourage walking, CSZ crossings are quicker, easier and cheaper to install than traditional zebra and signalized crossings and would allow road authorities to provide additional formal crossings on the urban road network. This would reduce the journey times required by pedestrians to reach formal crossing points. The results from the attitudinal survey identified a clear need for more crossing facilities at mid-block locations; 55% of respondents agreed that there were insufficient formal pedestrian crossings and 62% indicated that they crossed roads away from formal crossing under light traffic conditions. The results also showed that 48% of those surveyed perceived that they waited more than 30 seconds to cross and 19% perceived they waited more than 60

seconds. There is evidence to suggest that longer waiting times to cross result in more risky pedestrian behaviour (Almodfer et al., 2015; Hamed, 2001). Increasing the number of formal crossings by introducing CSZ crossings therefore has the potential to reduce the overall number pedestrian casualties on the network.

8.3. Safety Issues

As indicated earlier, current guidelines (DfT, 2019) suggest that the three main objectives of any proposed pedestrian crossing installation should be safety, convenience and accessibility. Although there is a requirement to provide adequate sight lines for drivers approaching a crossing and to provide adequate street lighting to ensure pedestrians are visible at night, there is no indication regarding how to assess whether or not the introduction of new crossing facility would increase safety.

The literature, covering the safety of zebra and CSZ crossings, suggest that generally there is a potential for an average increase of 28% in pedestrian crashes, following the introduction of such crossings, if there are no associated traffic calming measures. However, if such crossings are introduced, with traffic calming measures, there is the potential for pedestrian crashes to be reduced by between 40% and 80% compared to if there was no crossing at all. A major consideration, in the introduction of CSZ crossings in Scotland, is that they should be low-cost. However, if additional traffic calming measures are required at the same time, they may no longer be low-cost. Blanket 20mph zones are rapidly being introduced in Scotland and it is possible that in these low-speed environments there may be the potential for reduced pedestrian crashes following the introduction of CSZ crossings. This is worthy of further investigation.

UK design guidance (DfT, 2019) requires that a minimum sight distance, for drivers is provided on both approaches, to any proposed crossing, based on 85 Percentile approach speeds. In order to maintain these sight lines, it is important to prohibit parking on the approaches. This is supported by the literature. For night-time operation it is important that a pedestrian can be readily seen against the background of other lights and signs. In the UK, this means that designers must ensure adequate street lighting is provided in accordance with BS 5489. This has implications for the introduction of CSZ crossings. Their introduction would have to be limited to locations where parking is prohibited on the approaches and where street lighting is sufficient to satisfactorily illuminate pedestrians. If additional lighting is required, this may mean that CSZ crossings are no longer low-cost.

8.4. The Introduction of Continental Style Zebra Crossings in Scotland

8.4.1. Attitudinal issues

CSZ crossings operate in a similar way to pedestrian crossings. With reference to zebra crossings, as reported earlier, 55% of respondents, in the attitudinal survey, indicated that did not know that drivers approaching a zebra crossing legally do not have to stop for pedestrian who are waiting to cross but have not set foot on the crosswalk itself. This is reflected in the 79% of respondents who also indicated

that they would either ‘always’ or ‘often’ wait until a driver stopped before stepping on to the crosswalk. In terms of pedestrian behaviour, 11% of respondents admitted that they crossed the road close but not on the crosswalk of pedestrian crossings. Downey et al., (2018) have reported that 89% of the contributing factors for pedestrian crashes occurring in the vicinity of a pedestrian crossing were assigned to pedestrians and 11% to drivers. Typical factors for pedestrians were ‘failed to look’, and ‘careless, reckless or in a hurry’. The introduction of the new crossing type may provide an opportunity make pedestrians more aware of their priority at zebra and CSZ crossings and the dangers of crossing in the vicinity of such crossings.

Currently, only 54% of respondents in the attitudinal study felt safe when using existing zebra crossings and only 46% felt safe when using existing CSZ type crossings in such locations as supermarkets and retail parks. Furthermore, 57% of respondents were against the introduction of CSZ crossings in Scotland. This suggests that there may be significant opposition to the introduction of CSZ crossings on the Scottish urban road network

8.4.2. Potential operational characteristics of continental style zebra crossings in Scotland

As reported earlier, there were similarities in driver yielding behaviour at CSZ crossings located on private roads in Scottish shopping centres and retail parks in Scotland and at a CSZ crossing within a low-speed environment in Spain. There were no significant differences in the percentages of drivers either stopping (63%) or slowing down (30%) on the approaches to four of the Scottish CSZ crossings and the Spanish continental crossing (61% and 33% respectively) when pedestrians were either on the crosswalk or approaching the crosswalk. There was also no significant difference in the percentages of pedestrians waiting on arrival at the crosswalk (both 33%). These findings provide an indicator that CSZ crossings introduced on public roads in Scotland may operate in a similar way to those in Spain.

8.4.3. Scottish trials of continental style zebra crossings and driving simulation initiative

The original proposal, for this study involved observations of trial CSCZ crossings at low-speed public roads in Glasgow and Aberdeenshire. The fact that the operational characteristics of the Scottish CSZ crossings operating on private roads at shopping centres and retail parks were similar to those found at the Spanish site was encouraging. However legal issues, with signage, meant that it was not legally possible to assign priority to pedestrians on CSZ crossings. This meant that it was not possible to go ahead with the field trial. As a consequence, in order to gain an understanding of the potential operational characteristics of CSZ crossings on public roads in Scotland, volunteers were recruited to take part in a driving simulation exercise. The results suggested Scottish driver behaviour on the approach to a CSZ crossing would be similar to behaviour on the approach to a conventional zebra crossing.

8.5. Recommendations

There is a requirement that all crossings should operate in a safe manner in Scotland. International experience suggests that CSZ style crossings installations would increase pedestrian crashes by 28% if no traffic calming measures are in place. However, introducing traffic calming measures at the same time might reduce pedestrian crashes by between 40% and 80% compared to having no crossing at all. Scotland is rapidly introducing blanket 20mph zones. Overall speed reductions within these 20mph zones could mean that there would be a reduction in pedestrian crashes at CSZ crossings installed without traffic calming. This is worthy of further investigation.

The study also found that the introduction of low cost-CSZ crossing would have to be restricted to sites where there was adequate visibility. This would involve prohibiting vehicles stopping on the approaches. Adequate street lighting would also be required.

The attitudinal survey confirmed that only 44% of pedestrians felt safe at CSZ crossings on private roads and 57% were against their introduction on public roads. This suggests that there may be considerable public resistance to any such crossings which would have to be addressed before any attempt to introduce such crossings on public roads in Scotland.

The fact that there were similarities between the operation of CSZ crossings on private roads in Scotland and at a CSZ crossing in a low-speed environment in Spain is encouraging with regard to carrying out a field trial of CSZ crossings on public roads in Scotland.

The simulation findings, which suggest that driver behaviour on the approach to CSZ crossings is similar to that on the approach to a conventional zebra crossing also supports the case for field trials of CSZ crossings in Scotland.

The 'new pedestrian crossing ahead' sign used in the simulation could increase the braking time by giving the driver advanced warning and could account for the result that there is no difference in braking time between the traditional and CSZ crossing. The sign would be appropriate for a trial installation, but it would be anticipated that this would be removed after 3 to 6 months. Future driving simulator experiments should remove this sign.

The above findings suggest that, if the legal hurdles can be overcome, the undertaking of full-scale road trials of CSZ crossings in a low-speed environment in Scotland would be desirable.

As part of a study involving full-scale road trials, discussions should be held with local authorities across Scotland. Issues for consideration include: the level of demand for pedestrian crossing points; the interplay between crossing design and local plans for active and sustainable travel; an understanding of the costs for new crossings and budgetary constraints; the pros and cons for local authorities of different crossing types; and potential locations for on-street trials of CSZ crossings.

Further engagement with Transport Scotland is required to reach a solution for how to legally conduct on-road trials of CSZ crossings on public roads in Scotland.

Furthermore, it will be vital to talk to other stakeholders, including disability and access groups, to get a deep understanding of the broad range of views on this topic, particularly around issues of safety and accessibility.

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