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Pedestrian Safety in Road Traffic in Poland

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Abstract. Every third road accident in Poland involves a pedestrian as a participant or, most of the time, a casualty. Pedestrian accidents are usually the result of complex situations and the outcome of a number of factors related to driver and pedestrian behaviour and road infrastructure. Safety depends largely on how well the traffic condition is perceived and on visibility in traffic. The paper presents the results of analyses of methodologies for systematic studies of pedestrian behaviour and pedestrian-driver relations. The effects of the location of the site, type of cross-section and other selected parameters on pedestrian and driver behaviour are demonstrated. The analyses showed that pedestrians are most often put at risk by too long pedestrian crossings, vehicles going too fast around pedestrian crossings, lack of proper sight distance and poorly lit or unlit pedestrian crossings. The reason for such defective infrastructure is that planners, designers, contractors and maintenance services are not receiving any support from design, marking and maintenance regulations for pedestrian traffic. In addition, the Road Traffic Law is not restrictive enough when it comes to drivers' obligations towards pedestrian safety. Polish design regulations allow long pedestrian crossings up to four lanes in one direction or three lanes in two directions irrespective of traffic control and speed limits. Pedestrian crossings should be kept at a maximum of three lanes. There is nothing in the design regulations about the required driver-pedestrian sight distance. Neither does the Road Traffic Law help engineers with that. It is legal to park vehicles within 10 m of a pedestrian crossing which does not guarantee the necessary sight distance. Drivers must be able to see a pedestrian waiting or stepping onto the crossing from a distance that will help them come to a stop safely. It is safer to follow the principle of providing adequate pedestrian sight distance. Recommendations for pedestrian crossing design are also provided.

1. Introduction

The distance to be covered by a road user is the decisive factor when road users choose how they will travel. More than 75% of walks are under 1 km with only 5% of the trips above 2 km. Transport behaviour studies in Poland show [1] that walking represents 20–25% of all trips in cities. To compare, in Paris the share of walking is app. 36% and 32% in London [2]. People walk primarily for shopping, public transport stops, school or workplace, for recreation and tourism, public utility places, etc.

With no clear and understandable rules for pedestrian priority, drivers' behaviour may pose a risk to pedestrians. This includes drivers driving carelessly across pedestrian crossings and pedestrians carelessly stepping onto the road, crossing the road where it is not allowed, etc. Lack of adequate pedestrian infra-structure on the road (refuge islands, signage) and along the road (pavements) is another problem. This is particularly true for city outskirts, sections of transit roads and sections of roads outside built-up areas where pedestrian traffic may be quite intense. In addition, some of the existing pedestrian facilities do not meet the standards of traffic and safety (e.g. technical condition, location of pedestrian crossings related to sight distance, public transport stops, and deficient pedestrian areas).

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2. Pedestrian hazard in Poland

In 2014 there were 1,116 pedestrian road deaths on Polish roads (34% of all fatalities), 8,397 pedestrians were injured, of which 3,009 were serious injuries. While the trend in pedestrian casualties in Poland is successively decreasing (figure 1), the percentage share of pedestrian deaths in all road deaths remains high which in 2014 was 34%. The demographic fatality rate continues to be very high for pedestrian fatality accidents. Last year it was 29 people per 1 million populations.

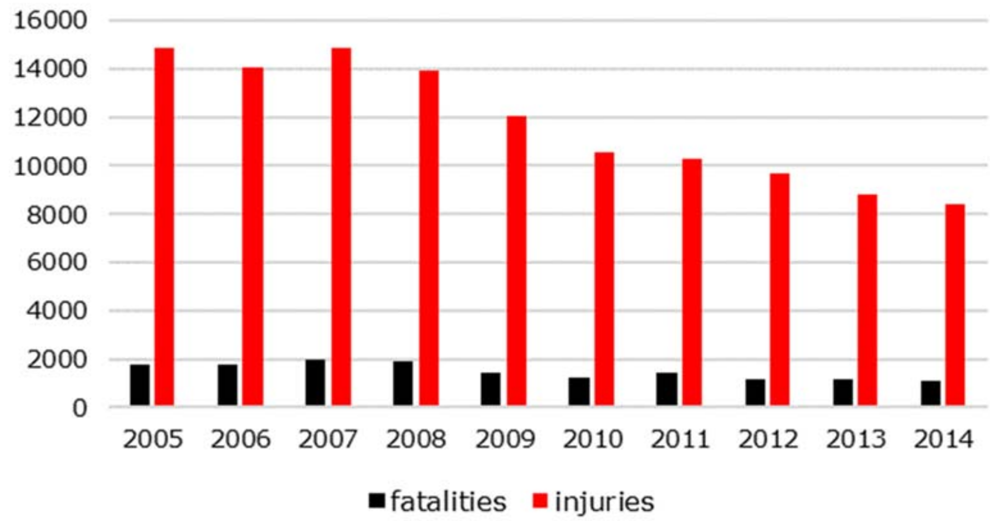


Figure 1 Distribution of pedestrian injury and fatality in Poland between 2005-20014

The standard of Poland's road network differs from region to region. As a result, the safety of road users differs as well. The risk of being involved in an accident is particularly high for pedestrians. The degree of the risk can be measured using the demographic rate of serious pedestrian accidents (pedestrian fatality and serious injury per 100,000 population). The analysis was applied to the regions and showed that (figure 2):

- the highest risk of serious pedestrian accidents was in the regions of Malopolskie and Lodzkie,
- the lowest risk was in the regions of Opolskie and Pomorskie.

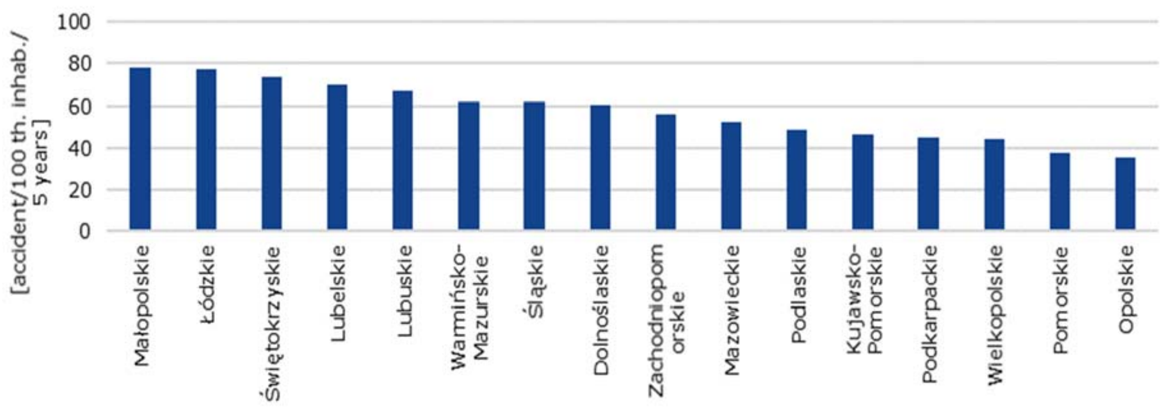


Figure 2 Ranking of societal risk measured with the demographic indicator of serious pedestrian road accidents

3. Experience of pedestrian behaviour and pedestrian-driver relation

3.1. Polish experience

Polish studies have focussed on studying pedestrian behaviour by analysing digital footage from test cameras. This method is used in the MOBIS programme, for example, whose main objective is to develop a method for assessing pedestrian safety using video footage [3]. Polish studies have also examined luminance on pedestrian crossings at night time depending on road lighting. Pedestrian visibility on a pedestrian crossing was found to be the decisive factor of their safety. This suggest the need for properly selecting and designing lighting [4]. Pedestrian safety on pedestrian crossings was also studied by observing driver reactions to a pedestrian stepping from the right side in a driving simulator. The test was con-ducted in a simulated hazard, i.e. a pedestrian suddenly stepping onto the road while a car is moving. [5]. Work on the textbook "Pedestrian Safety" [6] included pilot in-the-field tests to collect more reliable data. The tests included observations of conflicts and dangerous situations. Another approach to studying pedestrian-driver behaviour was applied in Warsaw for assessing the city's pedestrian transport system. Pedestrians were surveyed to understand: road safety, technical condition of pavements, ease of access to public transport stops, ease of movement (such as lack of obstacles, i.e. cars parked on pavements) [7].

3.2. International experience

In the United States pedestrian traffic is usually studied using surveys. US scientists have developed several types of surveys with the most popular ones being: a walkability checklist and principles of pedestrian design. When the check-list is used, pedestrians are handed a base list with pre-defined problems and the answers are on a scale from 1 to 6 [8]. A pedestrian-driver survey was conducted in Maine using cameras to record the survey. The analysis looked at the probability of an accident on pedestrian crossings for different parameters such as driver speed, width, a marked or unmarked pedestrian crossing, signalised or unsignalised crossing, with barriers or without them [9, 10].

In Australia a survey was conducted to establish how familiar road users are with traffic regulations on the priority of road users in different situations [11]. Another research method applied in Australia looked at the behaviour of children on main and local roads. The study focussed in particular on where they stop, whether they look around, analyse how vehicles move and how children cross the street [12]. In another study surveys were used to collect the basic parameters such as the respondent's age, gender and education. The analysis also looked at the destination and knowledge of the regulations by asking questions about road users' priorities in different situations [13]. A study in New Zealand was de-signed to analyse time lost by pedestrians on crossings with traffic lights. This was measured by observers who would randomly choose a pedestrian approaching a crossing and record the time when they stopped and crossed the street [14].

A study in France aimed to analyse the behaviour and mutual pedestrian-driver relations. When the results were analysed it was found that when a pedestrian looks at an approaching vehicle, the vehicle is more likely to stop by more than 10% [15]. A survey in the United Kingdom checked three potentially dangerous behaviours: crossing a dual carriageway, crossing on red on a Pelican light controlled crossing and crossing a very busy road between parked cars [16]. The method used in Spain involved automatic pedestrian detection on crossings using cameras. The parameters measured included: waiting time, pedestrian and vehicle speed, vehicle type and pedestrian gap acceptance. In addition, manual checks were made of gender, age, number of people or pedestrian baggage [17]. In Germany behaviour in road traffic at signalised junctions was studied recording the duration of signal phases, time for a pedestrian to cross the whole crossing or part of it (when the road was divided by a dividing lane or refuge), waiting time, pedestrian speed, "type of pedestrian behaviour" and driver-pedestrian conflicts [18]. In the Netherlands studies showed that excessive vehicle speed is the big-gest problem for pedestrians, especially for people aged >65. This is due to difficulty in assessing the speed of oncoming vehicles. It was also established that young people frequently cross on red [19]. In Sweden road user behaviour was recorded with cameras [20, 21]. In Belgium a study was made of whether pedestrians respect the red light on signalised crossings [22]: 21% of the pedestrians did not comply. In Finland cameras were used to study vehicle and pedestrian speed, traffic volume and driver behaviour. Based on this an estimate was made of the number of drivers who stop before the crossing, slow down or do not change the speed [23]. Austria's method was divided into four stages: surveys by telephone and on test sites. Drivers were surveyed on test sites and asked to identify dangerous or non-compliant situations [24].

The SARTRE 4 project is an element of the European Road Safety Observatory (ERSO). In the first three editions of the project only drivers were surveyed; in the fourth edition the target group was extended to include motorcyclists, cyclists, pedestrians and public transport passengers. Thirty three questions asked about the behaviour and sense of road safety. The answers in Poland showed that 22% of respondents felt very safe on the roads, 46% felt partially safe, 32% thought the roads were dangerous [25].

As we can see from Polish and international research, there is a need for site tests to observe pedestrian and driver behaviour within pedestrian crossings. Equally, surveys are important to understand road users' impressions and attitudes to specific solutions and regulations and to learn what problems they have observed. There is a need for studying real situations on pedestrian crossings, depending on where they are located and arranged, pedestrian volumes and pedestrian profiles. In the case of drivers, it is important to observe how drivers react depending on pedestrian behaviour. This helps with assessing the effective-ness of the solutions and improving pedestrian safety where it is particularly dangerous, i.e. on pedestrian crossings. The majority of the countries known to study pedestrian behaviour and driver-pedestrian relations, do not conduct regular studies and only focus on selected aspects. Systematic research in Poland is needed especially due to the very high risk for pedestrians.

4. Pilot tests in Poland

The scope of the pilot projects was limited to two regions: Pomorskie - it has an average level of pedestrian risk (the second region with the lowest societal risk in relation to the number of fatal and serious injury accidents vs. the population), Malopolskie - it has a very high level of pedestrian risk (the worst region for societal risk in relation to the number of fatal and serious injury accidents vs. the population). The areas vary in terms of the development, road cross-section and location of pedestrian crossings (figure 3).

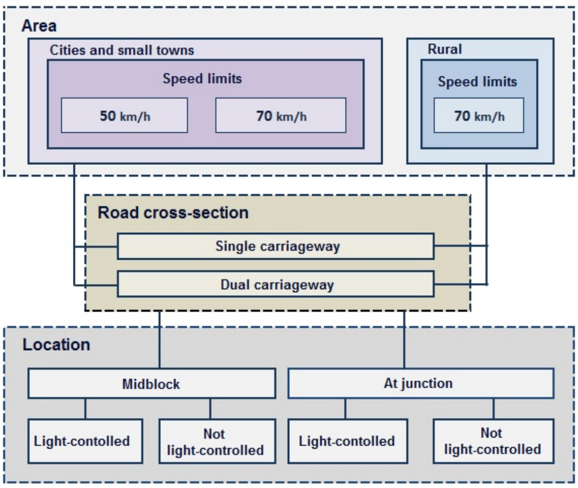


Figure 3. Diagram of test points selection [26]

Speed was measured for free-flow vehicles only, i.e. they were not affected by other cars. Within this group the analysis looked at those cars which moved freely along a section of 100 m before the crossing. The following situations were identified for analysing vehicle speeds on pedestrian crossings:

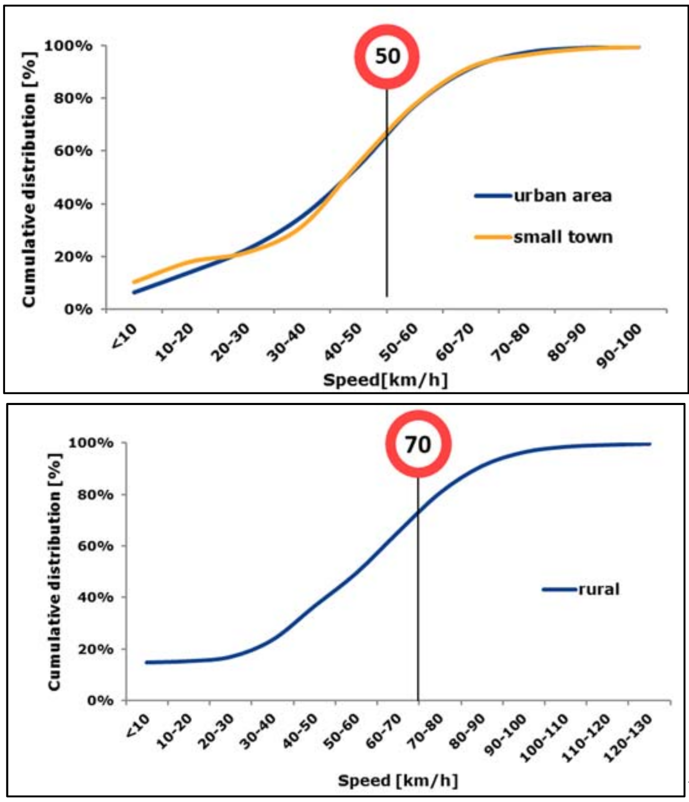
- no pedestrian,
- a pedestrian waiting before the crossing,
- a pedestrian on the pedestrian crossing.

Pedestrian behaviour was studied looking at the following characteristics: distance between the pedestrian and road while waiting to cross, whether the pedestrian looked at the traffic before and during crossing, pedestrian age structure and gender. In addition, pedestrians were surveyed after they had crossed the road as well as drivers who parked near selected test points.

In both regions 69 test points were designated, 1,890 surveys were conducted with pedestrians, which is on average 30 surveys per one test point. There were also 543 surveys with drivers.
The problems which emerged in the pilot and which need to be addressed in national tests is that some pedestrian crossings were used by a very small number of pedestrians throughout the day (less than 20) which is particularly frequent in places outside built-up areas and in small towns.

5. Study results

The data collected (video footage) were used to analyse driver behaviour. It was found that when traffic is light-controlled, 3% of drivers do not stop for the red light as required. In 50 km/h areas (test points in towns and villages) app. 40% of drivers exceed the speed limit (figure 4a) and in non-built-up areas with a speed limit of 70 km/h, app. 30% of drivers go over the prescribed speed limit (figure 4b), a clear indication of the need to apply speed management solutions and enforcement.



a)

b)

Figure 4 Cumulative distribution of speed 10 m before the pedestrian crossing a) in towns and villages – V = 50km/h, b) non-urban areas – V=70 km/h [26]

In towns and villages for all types of cross-sections, vehicle speeds are lower if pedestrians are waiting to cross as opposed to where there are none (by 16 km/h for 1x2 cross-section, by 16 km/h for 1x4, by 2 km/h for 2x2 and 2x3). The lowest speed on approaching a crossing with no pedestrians waiting, at 10 m from the crossing was recorded for the 1x2 cross-section with a refuge island (30 km/h less than for 1x4, 23 km/h less than for dual carriageways (figure 5). The lowest speed on approaching a crossing with pedestrians waiting was recoded for 1x2 cross-section with no refuge (16 km/h less than for 1x4, 22 km/h less than for dual carriageways). The lowest speed on approaching a crossing being crossed by a pedestrian was recorded for 1x2 with a refuge but the differences between the cross-sections are quite small.

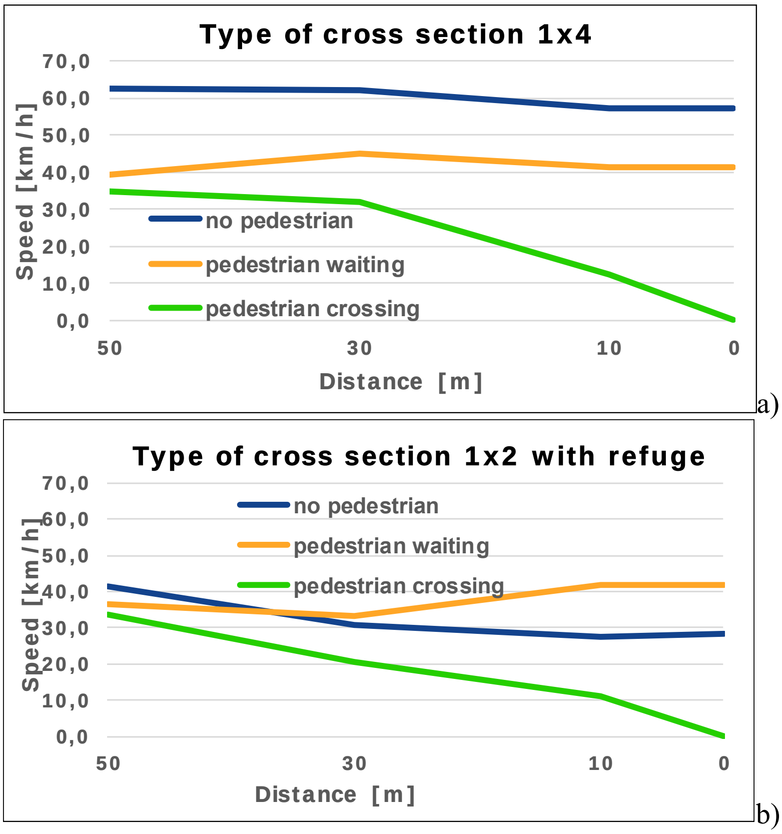


Figure 5 Characteristics of vehicle speeds on approaching pedestrian crossings for selected cross-sections [26]

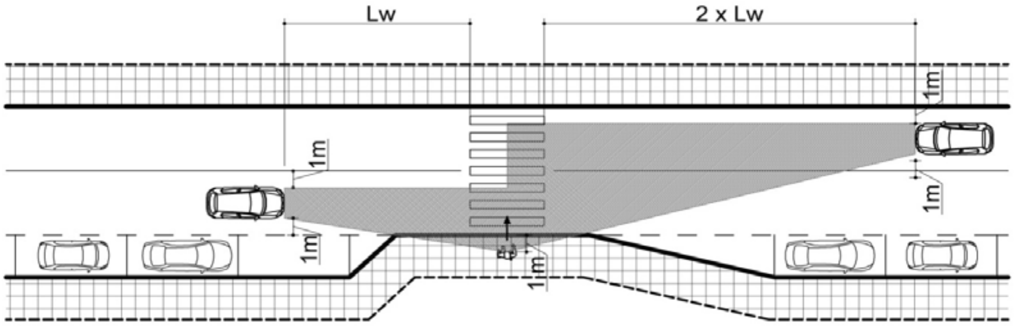
6. Selected recommendations for improving pedestrian safety

The analyses showed that pedestrians are most often put at risk by too long pedestrian crossings, vehicles going too fast around pedestrian crossings, lack of proper sight distance and poorly lit or unlit pedestrian crossings. The reason for such defective infrastructure is that planners, designers, contractors and maintenance services are not receiving any support from design, marking and maintenance regulations for pedestrian traffic. In addition, the Road Traffic Law is not restrictive enough when it comes to drivers' obligations towards pedestrian safety.

First, a method must be introduced to ensure a match between type of pedestrian crossing and speed limit. Because speed limits are generally exceeded everywhere in the country, it is recommended to use the 85th percentile V85 of measured speed. A stock-taking of the infrastructure showed that many pedestrian crossings have 50, 60, 70 km/h speed limits and as much as 90 km/h in non-built-up areas. This applies to crossings that stretch over two lanes and more. The Pedestrian Safety Handbook [6] points out that a safe speed is 30 km/h. Speeds between 30 to 50 km/h are moderately safe. The relation between the probability of a vehicle hitting a pedestrian and the probability of pedestrian death shows a 50% chance of survival when the pedestrian is hit by a vehicle going at about 50 km/h. Thus, anything above 50 km/h is considered dangerous and speeds above 70 km/h are considered critical. This should be the basis for planning types of pedestrian crossings.

Polish design regulations allow long pedestrian crossings up to four lanes in one direction or three lanes in two directions irrespective of traffic control and speed limits. Pedestrian crossings should be kept at a maximum of three lanes. There is nothing in the design regulations about the required driver-pedestrian sight distance. Neither does the Road Traffic Law (art. 49.1.2) help engineers with that. It is legal to park vehicles within 10 m of a pedestrian crossing which does not guarantee the necessary sight distance. Drivers must be able to see a pedestrian waiting or stepping onto the crossing from a distance that will help them come to a stop safely. It is safer to follow the principle of providing adequate pedestrian sight distance. A pedestrian crossing the road should be able to judge thanks to the sight distance that there is a safe time gap to allow them to cross safely (figure 6).

a) pedestrian sight distance



b) driver sight distance

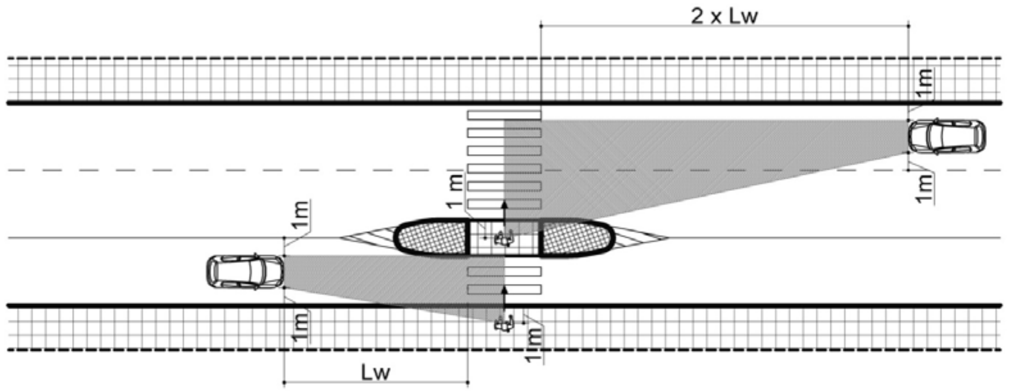


Figure 6 Proposed principles for determining sight distance on pedestrian crossings, [6]

Good sight distance Lw of a vehicle coming from the right or left side of a pedestrian is determined depending on: 85th speed percentile V85 measured within the area of the pedestrian crossing, width of the pedestrian crossing (number of lanes to be covered by the pedestrian) and pedestrian speed Vp. Initial tests have shown that optimal vehicle sight distance for 85th percentile V85 is 45 m.

To improve pedestrian safety on crossings, long crossings must be related to the volume of motorised traffic, pedestrian traffic and the actual speed of vehicles and sight distances. Safe speed cannot be higher than 50 km/h. In addition, clearance for parking must be checked in relation to the speed limit to ensure proper sight distance. Road safety management must be implemented to provide pedestrian safety when designing and using road infrastructure.

7. Conclusion

Walking plays a crucial role in the transport system. This is true of small towns and villages with very little public transport and of big cities where walking is often used to move around the city. Walking is also part of many people's everyday lives (especially children, school youth, older people, people who do not have a car). Having said this, pedestrians are the most vulnerable road users and most at risk of death in road accidents, representing more than 30% of all road accident fatalities in Poland.

The relations between walking and driving and the hazards generated should be further researched to ensure that pedestrians can use roads safely. The pedestrian-driver relation and the behaviour must be monitored on an on-going basis and pedestrian crossings must be inspected for safety. This will help improve pedestrian safety effectively.

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