Application of Active Crossing for Pedestrians as a Way to Improve their Safety

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Abstract. Pedestrians, as a group of road users, are directly and the most exposed to contact with vehicles. 50% of accidents involving pedestrians in every EU country is mostly caused by the wrong behaviour of the driver towards the pedestrian. 70% of these accidents occur directly on the crosswalk resulting in more than 200 fatal victims every year. Each local government strives to eliminate the fatal victims within the area of its voivodship, municipality or community. For years the pedestrians have been main victims of the road traffic and most of them losing their lives on the crosswalks, which are supposed to be the safest location to cross the flow of vehicular traffic. According to the most recent calculations, the unit cost of fatalities is about EUR 8,500,000, the unit cost of a seriously injured person is EUR 9,700,000 and the unit cost of a slightly injured in an accident is EUR 113,000. The figures above show that the cost of construction of even 30 most innovative crosswalks that will contribute to save at least one pedestrian is a very good investment in terms of costs (if one can translate safety into money). The article aims to analyse the impact of using active crosswalks for pedestrians as an improvement of pedestrian safety. The article includes examples of design solutions from a technical point of view, as well as design guidelines for the locations of crosswalks.

1. Introduction
Every year, more than 220 pedestrians are killed on our roads, and almost 1/3 of them directly on crosswalks [5].

Pedestrians are the most endangered group of people on the roads directly exposed to vehicles. In recent years, there have been nearly 8,400 accidents involving pedestrians per year, resulting in nearly 1,000 deaths per year. These events are the cause of many factors directly affecting pedestrian safety, such as poorly located crosswalks, poor road construction, poor behaviour of pedestrians and drivers, or poorly lit and marked crosswalks.

Of more than 8,400 accidents, over 4,300 were due to poor pedestrian behaviour, 3,500 of which occurred directly on the crosswalk, killing more than 220 people.

According to the latest calculations, the unit cost of a fatal victim is PLN 2,052,518, the unit cost of a severely injured victim is PLN 2,323,299, and the unit cost of a lightly injured victim is PLN 26,860 [3].

Statistics and research have been carried out for years to eliminate fatal accidents. "Vision Zero" is an international programme carried out in almost every country to eliminate fatalities. The program aims to bring about the situation on the roads, where not a single person dies in the course of the year. The only major city in our country that has managed to introduce "Vision Zero" was Jaworzno, where not a single person has died on the roads for the last few years. This was possible through investments in road and transport infrastructure and the main objective is to move traffic out of the city and slow down car traffic in the city.
Each local government aims to eliminate fatalities in its own voivodship, district, city or community. Pedestrians have been the main victims of road traffic for years, and they are killed on crosswalks, which they should consider the safest places to cross the road.

Pedestrians are killed as the result of:
- Failure by the driver to act with due care at the place designated for pedestrians
- Overtaking at a pedestrian crossing
- Stopping too late, often resulting from too high speed, but also from poorly lit crosswalks or poor location of the crosswalk, e.g. directly behind a road curve
- Driving under influence

Unfortunately, pedestrians are also to blame when:
- Running onto the roadway
- Crossing at the red light
- Moving in darkness in dark clothes without reflective features. Such a pedestrian is often not even visible at the crosswalk.

2. Dangerous pedestrian crossing across the road and at crosswalks

Pedestrian crossing across the road is one of the riskiest behaviour of road users. Accidents with pedestrians most often occur on the road (60% of accidents with pedestrians). Other dangerous locations are crosswalks — 30%, and sidewalks — 4%. The share of injured victims on these road elements is similar to that for accidents. In the case of fatalities, however, the distribution is different, with 79% of the total number of pedestrians killed on the roads, 17% on crosswalks and 1% on roadsides.

However, these statistics are not exhaustive. Detailed analyses conducted by the authors of this study show that almost 50% of participants of road accidents with pedestrians on a straight section of the road wanted to cross the road, while this share is as high as 75% in the streets. Hence, the conclusion is that pedestrians crossing the road may account for a significant proportion of all pedestrian fatalities, amounting to:
- 50% on non-urban roads
- 75% in cities

Therefore, in Polish circumstances, an attempt to cross the road is a very risky behaviour. Important safety problems for pedestrians crossing the road are:
- Lack of pedestrian protection at crosswalks (no refuge islands protected by curbs, ineffective protection through painted refuge islands, no crossings for cyclists, etc.)
- Excessively long crosswalks, in particular very dangerous crosswalks in four- or six-lane streets without a median strip, and sometimes with tramway tracks in the middle
- Lack of pedestrian facilities (such as pedestrian-switched traffic lights, footbridges)
- Exposing drivers driving with a high speed to the risk of pedestrians being hit (designated crosswalks with no pedestrian visibility or no speed limits or a capability to enforce it)
- Lack of pedestrian-driver visual contact (lack of visibility of the crosswalk, cars approaching a crosswalk in the shade of other vehicles, poorly organized shifted crosswalk) [2, 7].

3. The System of Tactile Walking Surface Indicators – TWSI and LUMIFON system

The System of Tactile Walking Surface Indicators – TWSI based on the ISO standard 21542:2011 [1]. The LUMIFON system was introduced to carry out the tasks of the System of Tactile Walking Surface Indicators – TWSI. LUMIFON enables the identification of the location thanks to the use of a constant combination of colours and textures of tactile elements. The purpose of tactile indicators is to increase the spatial orientation of visually impaired people [4].

The system consists of the following types of textures:
- Type A – directional texture
Directional path tiles of dimensions 30x30cm, 30x60cm and 30x90cm, with the texture of elevated horizontal blocks, characterized by colour contrast of at least 50%.

- type B – warning (safety) texture
  Warning field tiles of dimensions 30x30cm, 40x40cm, with truncated domes in slanted arrangement on their surface.
  They have a colour contrast of at least 70%.

Type C – caution (information) texture
Caution field tiles of dimensions 40x40cm, with truncated domes in a rectangular arrangement on their surface. They have a colour contrast of at least 30%.

In accordance with the guidelines of the Polish Association of the Blind (PZN) [6], in the chapter titled: “Principles of placing contrast and tactile indicators in public space” defines what indicators should look like for the blind and partially sighted people at crosswalks, as follows:

- Warning strips shall signal when approaching a dangerous location and warn against imminent danger.
- A guidance path consisting of a sequence of directional tiles comprising a sequence of elements enables a blind or partially sighted person to maintain an adequate direction of movement.
- Caution fields inform of a crossing or branching of guide strips of the tactile path or the change of the direction of movement.

Introduction of a unified warning system for disabled people based on the system of composite surface tiles developed by LUMI brand in accordance with the latest DIN standards. The company introduces products offered under the “LUMI” brand, which meet the highest expectations of disabled people and significantly improve their safety in public spaces through the use of contrasting colours and physical properties. The bright colours used make the elements of indicators visible to those visually impaired, but they also attract the attention of other traffic participants, who pay more attention to the sensitive places where the system is used. The physical structure of the tiles allows the blind people to
feel the material difference on the surface, which makes it possible to more accurately determine their location.

An additional advantage of the “LUMI” system is the ease of installation, which allows the use of the tiles both on the newly designed surfaces of concrete slabs and cobblestones and on asphalt surfaces, as well as on the existing surfaces without the need of disassembling the substrate. The system of composite surface tiles, consisting of “LUMI PO” warning tiles, “LUMI PP” directional guidance tiles, “LUMI PW” choice tiles, and “LUMI PA” anti-slip tiles, fully solves the disparate ways of marking of warning places for the blind and partially sighted people in our country [4].

4. Examples of placing contrast and tactile indicators on crosswalks
Below are examples of crosswalk indicators according to the guidelines for blind and partially sighted people using the LUMI FON system (Figure 5, 6, 7):

Figure 5. Indicators of a crosswalk with refuge island according to the guidelines for blind and partially sighted people using the LUMI FON system. (bright yellow) [author’s own elaboration]

Figure 6. Indicators of a crosswalk with refuge island according to the guidelines for blind and partially sighted people using the LUMI FON system. (bright yellow) [author’s own elaboration] [5]
Figure 7. The model of crosswalk indicators according to the guidelines for blind and partially sighted people using the LUMI FON system. (bright yellow) [author’s own elaboration]

Below is an example of crosswalk indicators against the guidelines for blind and partially sighted people (Figure 8):
Due to the lack of a uniform system of tactile marking throughout the country, each of the cities and public transport administrations develops its own marking standards, which makes it difficult for a person with disabilities to properly identify the place in different cities.
Disparate marking systems are used — products made to different technical standards from various countries, so that different products which often do not meet their characteristics are used the market. It is not possible to distinguish any concrete tiles used from the ground by their contrast. The products have different colours, spacing and dimensions.

5. Conclusion
Disparate marking systems are used in Poland — products made to different technical standards from various countries, so that different products which often do not meet their characteristics are used the market. The authors suggest the use of products offered under the “LUMI” brand. The aim is to improve pedestrian safety at crosswalks. LUMI system meets the highest expectations of disabled people and significantly improves their safety in public spaces through the use of contrasting colours and physical properties.

The bright colours used make the elements of indicators visible to those visually impaired, but they also attract the attention of other traffic participants, who pay more attention to the sensitive places where the system is used, especially at crosswalks. The physical structure of the tiles allows the blind people to feel the material difference on the surface, which makes it possible to more accurately determine their location even in dangerous places, such as nearby roads with high volume of traffic.

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