Barbara Rymsza
prof. IBDiM dr hab. inż.
Instytut Badawczy Dróg i Mostów w Warszawie
brymsza@ibdim.edu.pl

Krzysztof Kaperczak
dr inż.
Instytut Badawczy Dróg i Mostów w Warszawie
kkaperczak@wp.pl

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Pedestrian crossings for the visually impaired people

Abstract: The article discusses the topic of visually impaired pedestrians (with no or low vision) moving along the street crossing. Ways of their moving across the street were presented as well as the negative impact of the crossing geometry on the safety. Then means to improve the safety on the crossing applied in other European countries were described. The authors suggest introducing those improvements in Poland taking into consideration Polish specific conditions.

Keywords: roads, pedestrian crossings, people with the visually impaired

Introduction

Sight is the basic human sense. Thanks to sight, a person receives as much as 80% of the information coming from the environment [1], which allows you to determine your own location, notice obstacles, and recognize subsequent elements of the landscape.

It is different for visually impaired and blind people. They cannot see landscape elements and obstacles from a distance; they must first touch them with their hand or foot. Only some of them can smell, for example, the specific smell of baked bread in a bakery, hear, for example, the sound of air pushed by passing cars or the rumble of tram wheels on rails - which allows you to determine where you are or how close to an obstacle. Blind and visually impaired people can also remember the location of individual elements of space in the sequence of combinations of time and the characteristics of the access road, e.g., to reach a pedestrian crossing, walk along the pavement to the lamp post, then turn at a slight angle and walk a dozen more steps.

Based on this knowledge, a specific model of how these people move was developed, called "spatial orientation."

Spatial orientation is the ability that each person develops individually to orient himself and move around in both closed space (inside the building) and open space (on pavements, at pedestrian crossings, and at public transportation stops). Individually developed methods of recognizing characteristic and repetitive ways of arranging space and its individual elements, primarily through the touch of a white cane or feet, and occasionally through the senses of hearing, smell, and "remnants" of sight. The skill of spatial orientation can be mastered while teaching in schools or in various types of training courses.

A significant role in mastering the issues of spatial orientation is played by the period of vision loss. People who lost their sight before the age of five have far fewer memories containing images of space and its elements. So, a weaker ability to assign a given element after prior recognition of shapes with a hand, a cane, a foot, the rest of the sight to the remembered element - seen before losing sight.

Tactile surfaces specially laid in pavements for blind and visually impaired people are increasingly used in learning spatial orientation. These are properly made combinations of concrete or stone slabs with the texture of the upper surface (with a grooved surface) clearly different from the standard pavement surface.

When properly arranged, they are easily recognized with a white cane, foot (even with shoes), and sight (thanks to the contrasting colors in relation to the rest of the pavement surface).

Where visually impaired people have problems keeping their direction, i.e., on a wide pavement or square, the so-called guide and information strips are helpful. However, where there are dangerous places, e.g. at the exits from the pavement to the road at pedestrian crossings, in front of the stairs at collision-free pedestrian crossings, along the edge of platforms of public transport stops, the so-called warning stripes.

The detailed characteristics of texture parameters (guiding, information, and warning lanes) are currently quite well codified, while the method of arranging the lanes, due to the variety of ways of building and space arrangement, is only partially codified. This applies to both the norms in individual European countries and Polish regulations (including acts of local law in individual cities). All of them differ from each other, and most of them agree only on one issue: their area scope covers only the zone belonging to pedestrians—paved surfaces and pedestrian infrastructure facilities. At pedestrian crossings across the road or track at ground level, the limit of their use is the edge (curb) of the road or track and islands—the so-called asylum. On the other hand, in the common part of the crossing, where vehicles and pedestrians move, only a few studies address this issue.

Blind and visually impaired pedestrians on a pedestrian crossing

When crossing a road or a tram track, blind or visually impaired people should first choose a crossing they are familiar with. They feel more confident because they remember:

- direction of passage, e.g. perpendicular to the axis of the road, i.e. the direction of movement of vehicles, and to the curb at the crossing,
- marking, i.e., the passage is marked with horizontal P-10 stripes. The stripes are recognizable by visually impaired people, which facilitates orientation and maintaining the correct direction of movement,
- arrangement, e.g. the width of the roadway (length of the crossing path), whether there is a lawn next to the crossing or fencing or bollards preventing parking cars,
- equipment, e.g. whether there are traffic lights and sound signals, the duration of the green light for pedestrians (long or short),
- other features facilitating the identification of the passage and orientation on it, e.g. damage to the surface, including defects or undulations that "prompt" to maintain the correct direction of movement.

If visually impaired pedestrians have a choice between a crossing with and without traffic lights, they choose a crossing with signaling, especially the one with sound. Then they can be sure that, in a certain period of time (when the light is green), cars will not pass—the certainty of a safe passage is guaranteed. In addition, with sound signaling, a person who loses the direction of movement on the roadway (gets lost) can always "rescue" direct to the source of the sound signal emission, i.e. the signaling pole on which the loudspeaker emitting the sound signal is mounted, which is always outside the roadway (on sidewalk or island). The evacuation is facilitated by the provision in [2] that at crossings, the sound signal from one emission source (pole) should be audible up to approx. audible closer.

At crossings without signals, the crossing is much more difficult. It takes place under stress related to the risk of contact with the vehicle and an accident. At such crossings, crossing the road of visually impaired people requires, first of all, the ability to see an

approaching car from a distance, assess its speed of approach and compare it with the width of the crossing road and your own speed of movement, so as to be able to pass in front of the vehicle. In the case of a dual carriageway with a median and an asylum, it is easier because the decision to enter the carriageway and cross is made on the basis of the observation of several lanes but of vehicles approaching from only one direction. On a single-carriageway, two-way, and no asylum, decision-making requires observation and analysis of two directions at once, i.e. turning the head and thus extending the observation time and making it more difficult to assess.

Blind people entering the crossing without traffic lights can count on their own hearing (capturing the noise of the approaching vehicle) and "hope" that the driver will notice them (in time) and manage to stop the vehicle, allowing them to pass. Of course, a white cane is a signal for drivers about the sensory limitation of a person at the crosswalk and the need to give way to them, but there is no certainty that the driver will notice them and react in this way. However, the risk to the pedestrian, if an error occurs, is huge.

Blind and visually impaired people often use auditory observation of the movement of other (sighted) people when crossing, i.e. they enter and cross the road only when they hear or see that other passers-by are doing it or ask them to do so.

Maintaining the direction of crossing the road part of each pedestrian crossing by visually impaired people is usually relatively simple if the crossing is marked with road markings (P-10 - so-called "zebra" according to [2]). Visually impaired people are able to maintain the direction by recognizing the contrast created by painted white stripes against a dark road background (usually black asphalt), or they can also use other markings, e.g. a stop line for vehicles before crossing (P-14 according to [2]).

For the blind, recognition of the direction of crossing the road at an unknown or unremembered crossing is based on the assumption that the starting direction is an angle of 90° in relation to the line created by the curb at the crossing. They use a cane and their feet to check it. Furthermore, once on the crossing road, they only remember the direction of the crossing because there are no elements on the road to mark it. On wider roads, these people can lose their way. They turn in one direction, not hitting the entrance or the asylum on the other side of the passage, but the lawn, the fence, and even the carriageway of the cross street. On the basis of conversations conducted by the authors with blind people, it was estimated that the approximate width of the roadway, beyond which it is difficult to maintain a rectilinear direction of movement, is about 10.0 m.

A similar problem exists at crossings marked at an angle other than 90° to the direction of travel of cars and where the curb line is not perpendicular to the direction of pedestrian movement on the crossing (e.g. a road in a horizontal curve or a crossing marked on a curve connecting two roads - the so-called inner edge of the "right turn"). Then, moving on the roadway at the crossing on the basis of checking the arrangement of the curb is wrong from the beginning and does not provide entry on the other side of the road to the sidewalk at the crossing.

The problem of the movement of blind people on the road (and track) of pedestrian crossings is certainly observed by everyone, but only some countries and cities have decided to solve it.

Austria - Vienna

In Vienna, on the roadways of the streets with pedestrian crossings, you can see the surfaces of the leading lanes made of three types of material:

- in the form of a strip of split stone cubes (Fig. **1** and Fig. **2**), the advantage is high recognition with the foot and a white cane (the contrast between the surfaces - uneven

stone cubes and smooth asphalt), the disadvantage is the violation of material continuity (tightness) of the asphalt surface,

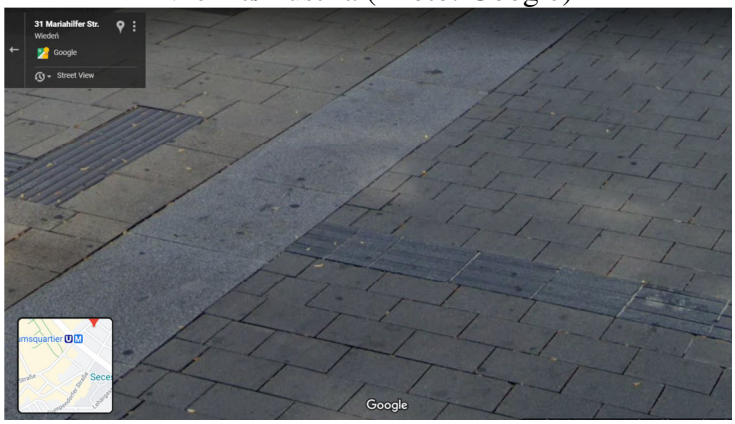
- in the form of a strip of corrugated stone slabs (Fig. **3** and Fig. **4**), the advantage is the uniformity of the road surface, the disadvantage is laying only on roadways with moderately heavy traffic (passenger cars, delivery vans, and light trucks),
- made of chemically hardened masses (Fig. **5** and Fig. **6**), the advantage is the ease of execution without interfering with the surface, and color contrast, the disadvantage is less textural contrast with the road surface.

1. Leading lane made of split stone cubes - general view, Vienna/Austria (Photo: Google)

2. A leading lane made of split stone cubes - close-up, Vienna/Austria (Photo: Google)

3. Leading lane made of milled stone slabs - general view,

Vienna/Austria (Photo: Google)



4. Leading lane made of milled stone slabs - close-up, Vienna/Austria (Photo: Google)

5. Leading lane made of chemically hardened masses - general view, Vienna/Austria (Photo: Google)

6. Leading lane made of chemically hardened masses - close-up, Vienna/Austria (Photo: Google)

According to the explanations obtained from the City of Vienna after experiments with different types of materials, currently, strips with stone pavements are only made as grooved pavements. And their use is limited only to pedestrian and pedestrian-vehicle zones and pedestrian crossings, where the street surface is made of stone (e.g., in the historic part of the city). On the other hand, at pedestrian crossings, where the top layer of the road surface is

asphalt concrete (asphalt), the leading lanes are made only of thick-layer chemically hardened masses.

The lane made on asphalt roadways called the "crossing aid line" (from German: querungshilfslinie) is made on the basis of the provisions in [3].

According to this document, the parameter determining the execution of the lane is only the minimum width of the roadway (meaning the length of the pedestrian crossing path from the curb to the curb), which is 6.00 m. This width (length of the pedestrian crossing path) is affected by the cross-section of the street and possibly an asylum for pedestrians.

Depending on its width (calculated between the edges of the roadway), the total length of the crossing path:

- for an asylum with a width of s ≥ 2.5 m (which allows you to safely wait for vehicles to pass) is calculated separately for each direction of traffic,
- for an asylum with a width of s < 2.5 m (which does not allow you to safely wait for the passage) it is calculated jointly, therefore the width of the carriageway in both directions of traffic adds up.

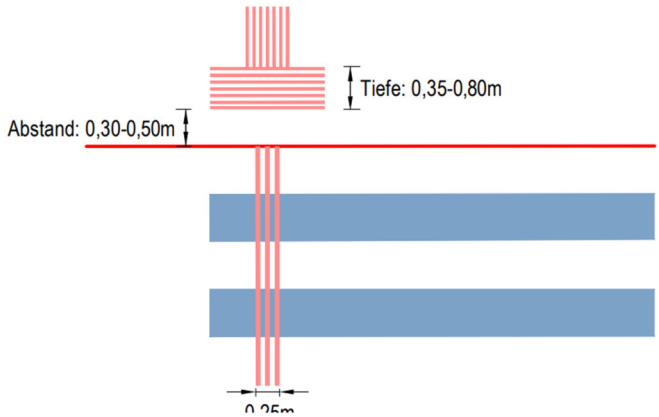
In the narrow asylum, there is no possibility of waiting for a safe passage; there are no curbs and no warning or information stripes that signal the end of one carriageway and the beginning of the next. In the center of the asylum, a single strip is made slightly wider than the typical warning against pedestrian crossings, which signals the blind and visually impaired pedestrians the center of the asylum - the place of optimal (but not safe) stopping and waiting for further crossing, and at the same time changing the direction of traffic on the road.

The "leading lane" or "line helping to cross" the roadway consists of a set of "bars," specially made of chemically hardened masses, placed on the upper surface of the roadway. The total width of the lane (s = 25 cm) consists of the width of 3 bars and 2 spaces between them, each 5 cm wide (Fig. **7** according to [3]). The height of each bar is 5 mm [4].

The location of the lane in the width of the passage depends on whether the passage is equipped with traffic lights, then the lane is placed:

- for a crossing without traffic lights: in the middle of the crossing,
- for a crossing with traffic lights: on the side of the crossing [3]. (because the leading lane on the sidewalk leads to the signaling pole placed on the side of the crossing)

Using the button located on the signaling device's pole, you can call the green light (the button also has a description of the topography of the passage along with the direction of the passage).



7. "Line helping to cross" the asphalt road according to [3]

Germany - Dresden

The authors encountered only one case of a lane running through a tram track. It is made (based on the explanations of the Dresden City Hall) on the basis of the no longer functioning standard allowing the use of split stone cubes (Fig. **8** and Fig. **9**), the arrangement of which in the asphalt ensures high recognition (contrast of recognition with a foot and a white cane).

8. Stone paving lane - general view,
Dresden/Germany (Photo K. Kaperczak)

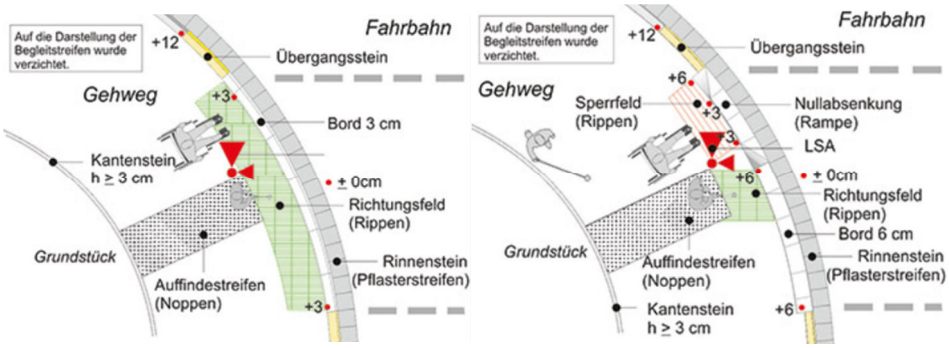
9. Stone cobblestone leading lane - close-up,
Dresden/Germany (Photo K. Kaperczak)

The justification for making the lane in this place was to design the passage as a labyrinth for safety reasons, forcing pedestrians to face the direction of travel of the tram along the nearest track. This, in turn, forces crossing the track at an angle different from 90°, which is troublesome and even dangerous for a blind or visually impaired person.

The tightness (uniformity) of the asphalt surface is not important in this case, because the hardening was made only to increase the comfort of pedestrian movement and to provide the leading strip with a high-contrast background.

In the current standard [5], the direction of movement on the roadway or trackway is signaled by the direction of placing warning boards in front of the curb of the crossing, the

ribs of which indicate the direction of crossing the roadway or trackway. The method of laying the slabs on the passage - along the entire width of the passage or only on a fragment, which then constitutes an extension of the guide and information strip leading to the passage (Fig. **10a** and Fig. **10b**) depends on the height of the curb on the passage.



10a and **10b** Examples of the execution of warning lanes (green), the ribs of which also indicate the direction of movement on the carriageway of a road or track: a) the height of the curb is 3 cm and b) the height of the curb is 6 cm according to [5]

Czech Republic

The movement of the blind on the crossing road is supported by a lane called "vodící pás přechodu" (literally translated as "the leading passageway"). It can be found in the Czech Republic on many pedestrian crossings. It is made on the basis of the standard [6] and, as in Vienna, made in the technology of applying a thick-layer chemically hardening mass.

The lane can be an integral part of the horizontal painting (the "zebra"; Fig. **11**) or an independent stripe (Fig. **12**). According to [6], the justification for making a lane on a pedestrian crossing is the occurrence of one of the following conditions:

- width of the carriageway (understood as the length of the pedestrian path between curbs): greater than 8m,
- radius of the road curve (in relation to the curb curve): less than 12m.

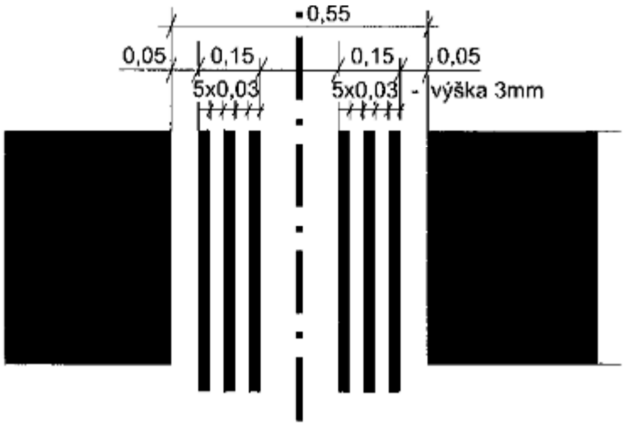
11. A leading lane made of chemically hardened masses in the "zebra" structure, Harrahov/Czech Republic (Photo K. Kaperczak)

12. Independent leading lane made of chemically hardened masses, Piosek/Czech Republic - Zaolzie (Photo K. Kaperczak)

In practice, the interpretation of the need for a lane depends on the local road authority. For example, in the city of Trutnov, the lanes are made successively at all pedestrian crossings, regardless of the width of the road or the size of the curves.

As in Vienna, the Czech normative execution of the asylum results in the shortening of the actual access route - meeting the condition of limiting the width of each roadway to 8 m.

According to the standard [6], the general width of the leading lane is 55 cm. It consists of the width of the "bars" and the width of the spaces between them. The lane can be made in two variants: 2 x 2 and 2 x 3 bars; however, in practice, the 2 x 3 variant prevails (the authors have not encountered the 2 x 2 variant anywhere). The width of the bar and the gap between the bars is 3 cm, the width of the gap between groups of bars is 15 cm, and the width of the gap between groups of bars is 5 cm (Fig. **13**). The height of the bars above the road surface is 3 mm [6], but it is approximate, as the permissible range is 2÷4 mm [7]. The lanes on the roadway must be an extension (continuation) of the guide and information lanes placed in the pavement before the crossing curb [7].



13. Detailed parameters of the lanes (drawing in the negative version) according to [7]

As for the need to use leading lanes and their usefulness in facilitating the movement of blind and visually impaired people, the Czech road authorities (Czeski Cieszyn, Trzyniec, Piosek) had no information. On the other hand, the Czech organization of the blind and visually impaired (Sjednocená organizace nevidomých a slabozrakých ČR, z.s. – SONS ČR),

when asked by the authors, confirmed their usefulness and the use of the lanes by people with visual impairments.

Leading lanes similar to those in the Czech Republic can also be found on the streets of Slovak cities, e.g. Čadca (Fig. **14**)

14. Example of Slovak lanes,
Czadca/Slovakia (Photo by I. Pawliczak)

Poland - Cieszyn

The construction of the lanes at the Księstwa cieszyńskiego Roundabout in Cieszyn was inspired by the use of lanes in the neighboring Czech Cieszyn, according to information obtained from the Municipal Road Administration in Cieszyn. However, during the final execution, modifications were made, and instead of two groups of lanes (2 x 3), one, but wider, was made. Because the roundabout was built in stages, there are two types of lanes at the intersection.

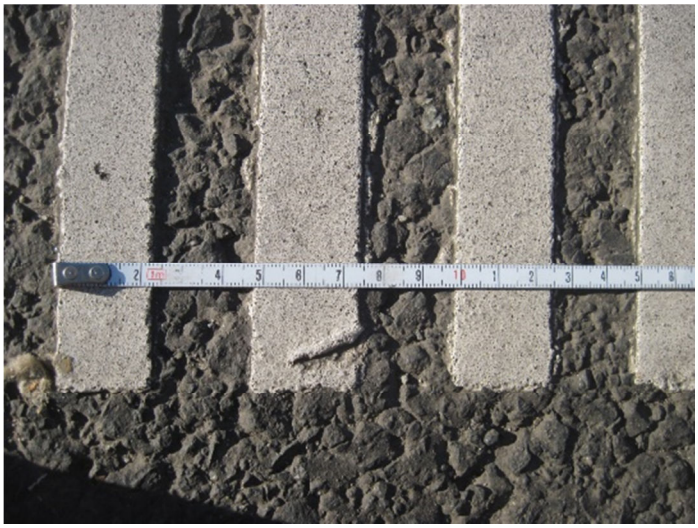
Lanes made earlier - the older ones are located on two inlets, and consist of 7 bars (Fig. **15a** and Fig. **15b**) and this is probably a solution modeled on the lanes laid in the Warsaw subway. The width of the bars and the spacing between them is 2÷3 cm, and the total width of the lane is approx. 31÷34 cm (it varies depending on the accuracy of the workmanship; in the Warsaw metro the width of the bars is 2 cm and the gap is 2.5 cm wide [8]).

15a and **15b** Modified leading lanes (older lanes) with length to curbs, Rondo Księstwa Cieszyńskiego, Cieszyn (Poland) (Photo by K. Kaperczak)

Lanes made later and newer have fewer bars - 6 (Fig. **16**), and their width and spacing are 2÷2.5 cm (Fig. **17**), the total width of the lanes is 27.5 cm and 28 cm (inaccuracy of workmanship). The difference in the length of the lanes is noticeable - the older ones reach the curbs, the newer ones only the transverse passage lanes.

The height of the bar above the asphalt surface is identical to that of the crossing lanes (markings P-10), i.e., about 2÷3 mm.

16. Modified leading lanes (newer lanes) with reduced length (only for longitudinal lanes), Rondo Księstwa Cieszyńskiego, Cieszyn/Poland (Photo by K. Kaperczak)

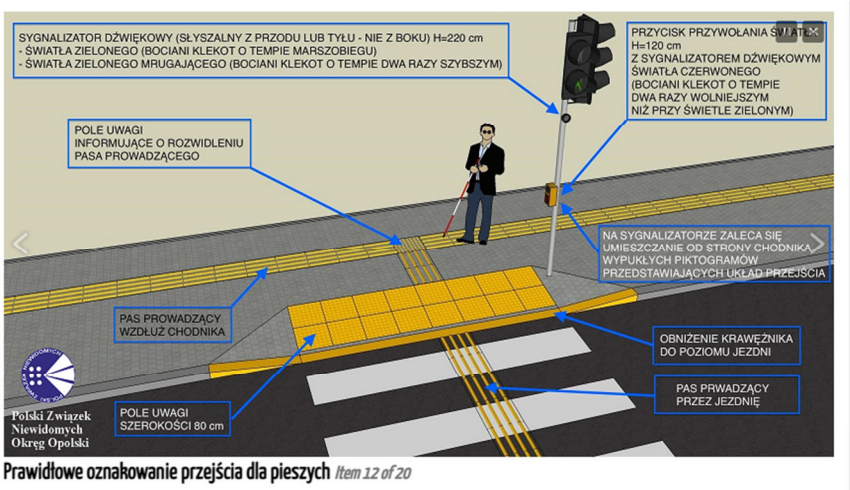


17. Distance parameters of the elements of the (new) leading lane fragment – own measurement, Rondo Księstwa Cieszyńskiego, Cieszyn/ Poland (Photo by A. Piętka)

Information from users (Polish Association of the Blind, Koło Terenowe Cieszyn) shows that they are useful in the movement of visually impaired and blind people - they are felt with feet and white canes. However, this opinion was formulated on the basis of individual tests performed by blind and visually impaired people in the summer, in conditions of no snow and sand contamination, and in shoes with thin soles.

Poland - Opole

The Polish Association of the Blind, Opole District, has prepared a study in which the drawings present a number of solutions for the arrangement of public space, facilitating the movement of visually impaired people in this space. Among them was a solution with lanes leading through the road, similar to the Cieszyn solution (Fig. **18**). [9] Unfortunately, so far, the above proposal has not gone beyond the drawing stage and has not been implemented at any of the pedestrian crossings in the city of Opole or the Opolskie Voivodeship.



18. Proposal of a pedestrian crossing taking into account the needs of the blind and visually impaired according to [8]

Summary

It seems that lanes facilitating crossing the road could be made at Polish crossings more often (not only at one crossroads in Cieszyn). However, this requires research and analysis, including the production of test lanes, which would confirm their usefulness. The test lanes could be made based on the solutions presented above and Polish regulations regarding the execution of road markings.

The following conditions can then be adopted:

• location (if at least one of the following factors is present):
  – the width of the roadway is greater than 10.0 m, and in the case of asylum, the length of the passage is included:

✓ width of both carriageways and the width of the asylum when the width of the asylum is s <2 ,00 m

✓ width of the roadway is assumed separately for each direction of vehicle traffic when the width of the asylum $s \geq 2{,}00$ m [3]

  – on sections where the curbs of passages form an arc with a radius of less than 12 m [6],
  – on sections where the direction of pedestrian crossing (in the meaning of the crossing axis) is not perpendicular (a difference of more than ±10°) to the direction of traffic (in the meaning of the road axis);

• location along the width of the passage: as an extension (continuation) of the guide and information strips laid on the sidewalk in front of the passage (preferring in the middle of the width of the passage);
• material: thick-layer chemically hardening or thermoplastic mass;
• specific conditions:

- execution technology:
  - when painting with a thin layer, the lanes can be made directly on the "zebra" stripes,
  - when painting with a thick layer, the "zebra" stripes must be cut (free space in the "zebra" lanes left),
- width of the "bars" and the gap between the "bars": 3.0 cm,
- height of bars: min. 3.5 mm - the maximum that a horizontal marking can have according to [2] (a change about the Czech standard - 3 mm [6]) is justified by heavier weather conditions in Poland - resulting in wearing shoes with thicker soles), optimal due to on the above weather conditions, the height would be 5 mm (as for profiled or structural markings approved by GDDKIA [10]).

Wider use of such a crossing lane necessitates at least preliminary testing of its usefulness by both users – blind and visually impaired people – and the road administrator. For this purpose, it is necessary to make a test strip at a selected crossing or a set of crossings (multi-inlet intersection). The choice of the passage(s) should be justified by the movement of a significant number of blind and visually impaired people on it, who will check their usefulness for themselves as widely as possible, and the administrator of their impact on the safety of vehicle traffic and implementation and operation difficulties.

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