SAVE GUIDING OF VISUALLY IMPAIRED PEOPLE - ARTIFICIAL GUIDING LINES ARRANGEMENTS IN THE INFRASTRUCTURE

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Abstract: The paper presents arrangements that ensure safe mobility of visually impaired people in public places and sites intended for transport. An analysis of the current situation points to the fact that there is a real problem in using artificial guiding lines as for their parameter differentiation in interior and exterior. Some countries do not use artificial guiding lines at all while others overuse them; moreover, they use different parameters and surface. The article shows how logic is applied in the creation of barrier free environment, where artificial guiding lines are an integral part. Further, the article defines fundamental features and parameters of the artificial guiding lines in the Czech Republic. The aim of the paper is to propose a gradual convergence of tactile arrangement systems, especially for the guiding lines, which are one of the most fundamental requirements for safe mobility of visually impaired people.
Keywords: accessibility, barrier free environment, Design for All, guiding lines, safety, visually impaired people

1. Introduction

Safety of all pedestrians, not only of the passengers with reduced mobility (PRM), is an important aspect taken into account when assessing the quality of the public environment (Lazou et al., 2015, Susnienė, 2012). Visually impaired people (the blind, the partially sighted) belong among those PRM who need very specific adjustments for their movement. The accessibility of the urban environment, public transport, and other environments is conditioned by specific adjustments that allow the visually impaired to move freely and safely. Independent movement and safety play an important role in the life of the blind and the partially sighted. It is not possible to treat these aspects separately (Matuška, 2009).

To enable the blind to move independently, various technical devices utilising new technologies have been worked on in the last few years. For example Suzuki et al. (2010) conducted an experiment on pedestrian crossings with traffic lights using the assisting technology VLC (visible light communication). He assessed the ability of the blind to maintain straight direction when crossing the road, and their speed. These two parameters affecting the safety of the blind on pedestrian crossings are conditioned by the age of the pedestrians, the time and way of losing their sight (from birth, later in life, suddenly, gradually). Peraković, Periša, and Remenar (2015) showed the possibilities of how to increase mobility and safety of the visually impaired with the help of information and communication technologies. Further, they presented a dynamic model of guiding the blind on an example from the city Zagreb. Periša et al. (2015) investigated the utilisation of the RFID[3] technology for guiding the blind in the urban environment (pedestrian crossings). Zhou et al. (2012) focused on the utilisation of the information & communication technologies enabling easier access of the visually and physically impaired to public transport. Further, Brian et al. (2012) studied the utilisation of modern technologies in the process of guiding the blind in the urban environment. In addition, Kurian and Pillai (2009) conducted research on the system of guiding the blind inside and outside buildings with the help of ultraviolet rays and digital technologies transmitting the information into acoustics.

The blind in the Czech Republic (CR) can make use of a navigation centre, whose staff can monitor the blind via the GPS technology, and when needed the staff can inform him about his position, and tell him the right direction. A research team at the Faculty of Electrical Engineering has been working on the navigation system NaviTerier, designed for mobile phones, which should help the visually impaired in the CR move freely in exterior and interior (https://www.fel.cvut.cz/).

Despite all the newest devices and assisting technologies, the blind agree that the white cane remains their primary and most easily accessible device for acquiring necessary (tactile) information (Brian et al., 2012; Matuška, 2009). That is why correctly conducted tactile adjustments for the blind are of vital importance. Training of independent movement and spatial orientation with a mobility instructor is a prerequisite for an effective utilisation of the tactile adjustments.

The article aims to explain the logic of the tactile elements (TEs) in the CR and draw attention to the critical points which should be solved consistently and meaningfully.

2. Legal environment

The tactile contrast elements for safe guiding of the blind appeared, for the first time, in the late 70s of the 20th century, in Japan, and from there they spread to Europe (Aoki, Mitani, 2012). The tactile adjustments for the blind are different in each country in terms of law, design, and utilisation. There are states with a large variability

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[3] Radio Frequency Identification

of the used tactile surfaces for the same situation, or ambiguously defined requirements for products prevailingly used by the visually impaired (e.g. visual contrasts and slip resistance).

2.1 Public transport accessibility

The general terms of the air, rail, bus, and water transport accessibility for the PRM are determined, in the EU, by the relevant regulations. The PRM are guaranteed the right to travel under specified conditions. For example transports or assistance needs requested are subject to advance warning of usually 36-48 hours. This mainly concerns the wheelchair users. The blind people, who do not need any assistance, do not have to report their trip in advance. However, it is impossible to guarantee the given rights throughout the EU as some countries have taken the possibility of exceptions e.g. access to bus terminals.

The general requirements for using the TEs for safe movement and orientation of the visually impaired in transport facilities, in the EU railway system, are a part of the Technical Specifications for Interoperability (TSI PRM, 2014). Unlike the ISO standard, the regulation TSI PRM is applicable only in the EEA[4] countries. Tactile contrast marking must be used for example on platforms and their access paths/roads, on roads leading to check-in halls, or at other places where it is appropriate. The TSI PRM defines the general requirement for using the tactile signs; it does not distinguish between the artificial and natural guiding lines, or other elements.

The railway platform tactile adjustments are, in principal, almost identical throughout the EU. The safety strip at the platform edge (usually 800 mm wide) is separated by tactile and colour contrast adjustments. In some countries (not only in Europe) both surfaces with grooves and blisters are used.

In Great Britain, Loo-Morrey (2005) states six different surfaces with different functions (5 with the warning function and 1 with the guiding function); what more each surface has a precisely defined utilisation (railway platforms, public transport stops, stairs, pavement/ pedestrian crossings, etc.).

In Germany, the basic adjustments for the PRM are conditioned by the standard DIN 18040-3: 2014 or DIN 32984. In Switzerland, the adjustments are conditioned by the regulation SIA 500 or SN 640075. In Slovakia, this issue is addressed in the directive Ondrovič (2011) and Decree No. 532/2002 Coll. The most important decree in the CR is the Decree No. 398/2009 Coll. The Czech Technical Standards (CSN), which deal with specific measures such as at pedestrian crossings, cycle tracks, railway platforms, crossings, and others, build on this decree.

2.2 Accessibility of the built environment

The international standards ISO 23599:2012 and ISO 21542:2011deal with the tactile and visually contrastive adjustments for the blind at building constructions. Both the standards distinguish the attention and guiding patterns. These two patterns are similar to the tactile elements found in European countries. In other TWSIs[5] installation requirements, the adjustments do not fully correspond to the logic of spatial orientation of the visually impaired. The currently set standards for the CR are only provisional as they do not comply with the law and relevant implementing regulations, and technical standards.

3. The logic of tactile adjustments for the visually impaired in the Czech Republic

In a very simple way, visually impaired people can be divided into two groups. The first group comprises the moderate and severely sight impaired people. The second group includes the blind. The ratio of the two groups is, according to WHO[6], 10:1. Each 120th person in the CR is severely visually impaired.

To ensure their independent movement, it is important to transfer the visual information to a combination of TEs. The moderate and severely sight impaired people have different priorities for the combinations. "A sufficient number of easily identifiable points, whose connectors create guiding lines (GLs), forms the basis of safe movement of the blind or partially-sighted" (Dudr, Lněnička, 2002, p. 5). The term '*guiding line*' is prevailingly used when designing barrier-free adjustments for the visually impaired at public facilities, public spaces, and transport environment. The adjustments are those who prevent injuries and loss of spatial orientation, while simultaneously support the targeted transport in exterior and interior. The users of such adjustments are not only temporary and permanently visually impaired people but also people who move through large areas such as transport terminals, or passages of civic facilities because it is difficult to orientate in such places. The fuzzy logic has proved that artificial guiding lines (AGLs) can be intuitively used by people without any visual impairment (Košťálová, 2016). For example, if a user is in a given space for the first time or does not understand the local language or pictograms, his eyes perceive the surroundings more intensively and he intuitively uses the GLs. Therefore, it can be said that GLs are used by a wider range of people than those whom they were originally designed for.

"When walking along a guiding line, it is necessary to keep a 300 - 400 mm safety distance in interior and 800 mm in exterior in order to minimise the risk of crashing into obstacles at the waist level and above" (Slouka et

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[4] European Environment Area

[5] tactile walking surface indicators

[6] World Health Organization

al., 2013, p. 189). A blind person follows the GLs and therefore it is important to maintain a free passage area, which is min. 800 mm wide and 2100 mm high in interior, and 2200 mm in exterior, without any obstacles. This is a fundamental problem of all TWSIs. Not knowing the characteristics of the movement of severely visually impaired people results in placing obstacles in the unobstructed width. The most common examples of such obstacles are promotional items, racks with displayed goods, tables and chairs placed freely around the refreshment shops, unsecured scaffolding and excavations, including technical equipment.

3.1. Natural tactile elements forming guiding lines

Natural tactile elements (NTEs) forming guiding lines are created during common construction work or by thoughtful arrangements of the sites; they can assist the blind in terms of orientation and wayfinding. Examples of these NTEs are fence retaining walls, walls of buildings, underpasses, railings with lower guiding bars, garden kerbstones increased by 60 mm above the walking surface. Further, while maintaining the safety principles of guiding the blind, it is possible to use garden adjustments which are increased above the walking surface, palisades, outdoor planter flower pots, and bases of information or ornamental elements, see Fig. 4. Yet, they have to be easily found and identified by a white cane, and must be constant. The legislation of the CR defines these elements as 400 mm wide, 300 mm high, 1500 mm (new buildings) or 1000 mm (reconstructions) long.

3.2. Artificial tactile elements forming guiding lines

An artificial tactile element (ATE) forming a guiding line guides a visually impaired person with a white cane safely at places where another guiding is missing. It is a specially created part of a facility helping the visually impaired to orientate and move independently. After training, a visually impaired person is capable of keeping a straight walking line up to the distance of 8 m, within an acceptable deviation, that is why this distance is incorporated in the Czech standards as a maximal possible interruption of a guiding line.

The basic requirements for TEs in the CR are: min. width 300 mm in interior and 400 mm in exterior, a min. length necessary for directing the visually impaired is 1500 mm at new buildings and 1000 mm at reconstructions, guiding in straight direction, artificial lines cannot be bent, a change in direction is allowed only in necessary situations and preferably at a right angle (90°), crossing of an AGL is done by a flat surface (a paving block without TEs) in the width of the line.

The installation of an artificial guiding line must be logical and simple. The artificial tactile elements forming a GL must be, at both its ends, linked to a natural guiding line or an acoustic guiding device (e.g. an acoustic guiding beacon). Ensuring this continuity is a necessary prerequisite for independent movement of the visually impaired. A continuous line can be formed by visual and TEs or their combination.

3.3. Basic visual elements

A visually contrasting strip, min.150 mm wide, marks the edge of the safety distance at the bus, trolley, and tram stops (500 mm from the edge), is defined by the CSN 73 6425-1:2007. A 150 mm wide yellow strip forms a warning strip and is a part of a GL on level crossing railway platforms. The strip is situated 800 mm from the platform edge, and is defined by the CSN 73 4959:2009, and the Specification of Railway Infrastructure Administration in Ž 8.7, change 2.

3.4. Basic tactile elements

The system of tactile adjustments comprises a combination of basic elements differing in dimensions (effective width) and surface (see Table 1). The products forming the TEs cannot be used for any other purposes. These elements are, in the CR, precisely defined in terms of material, shape and dimensions (see Fig. 4), and must be '*the products*', which comply with the detailed technical and user characteristics defined by the Technical Centre TN TZUS 12.03.04-07. Each element must have a product verification complying with the Government Decree No.163/2002 Coll. The material used, in the CR, is not innovative; mostly, it is concrete or stone paving blocks, or stone blocks forming a mosaic. Paving blocks from artificial stone, polymer concrete slabs or plastic belts (rubber, recycled material, PVC) are used to a limited extent.

Table 1
Basic tactile elements

SURFACE	**WIDTH** [mm]	**FUNCTION**
BLISTERS *according to the material used walking areas: truncated cones or hemispherical pins, irregular stumps*	150	warning
	400	warning
	800 - 1000	directing, orientation important point
LONGITUDINAL GROOVES *cross sections of grooves: a sinusoidal rib, a triangle, a rectangle, or a trapezoid*	300 inter. / 400 ext.	guiding – walking area for pedestrians
	550	guiding – vehicular way

Source: Decree No. 398/2009 Coll.

Important visual information for the blind has to be transferred to tactile or acoustic information. The requirement is also applied to road signs, where the combination of basic elements signals a change in the traffic mode and differentiation of the function groups on the roads; e.g. the differentiation between a pavement and a cycle track or the differentiation between pedestrian and residential areas and the roads (see Fig. 4).
The sequence of adjustments in parts of buildings, roads and public places for the visually impaired:

- the priority is to organise the disposition of a sufficient number of appropriate (and clear) orientation points and NTEs forming GLs,
- it is important to utilise the acoustic guiding and visual contrasts to improve the orientation situation, (see Fig. 1)
- an AGL is used only as a complementing element (interior and exterior) for ensuring independent movement.

All the elements must be perceptible by a white cane and sole while maintaining the visual and tactile contrast.
The surface area, at a minimal distance of 250 mm from the elements, must be flat and in compliance with the slip resistance requirement. To ensure the tactile requirement, it is necessary to design the paving without any skews, and with a straight edge, which does not create any gaps noticeable by a white cane (see Fig. 2, 3).

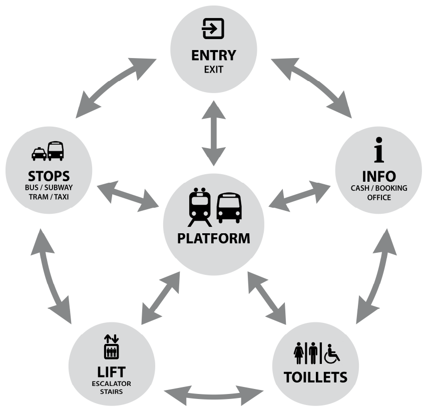


Fig. 1.
Accessibility scheme
Source: J. Košťálová

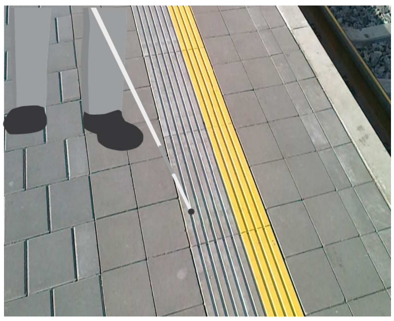


Fig. 2.
Resolving TE in the concrete pavement – railway platform
Source: P. Lněnička

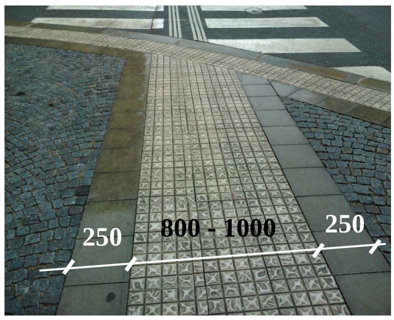


Fig. 3.
Resolving TE in granite paving - pedestrian crossing
Source: J. Košťálová

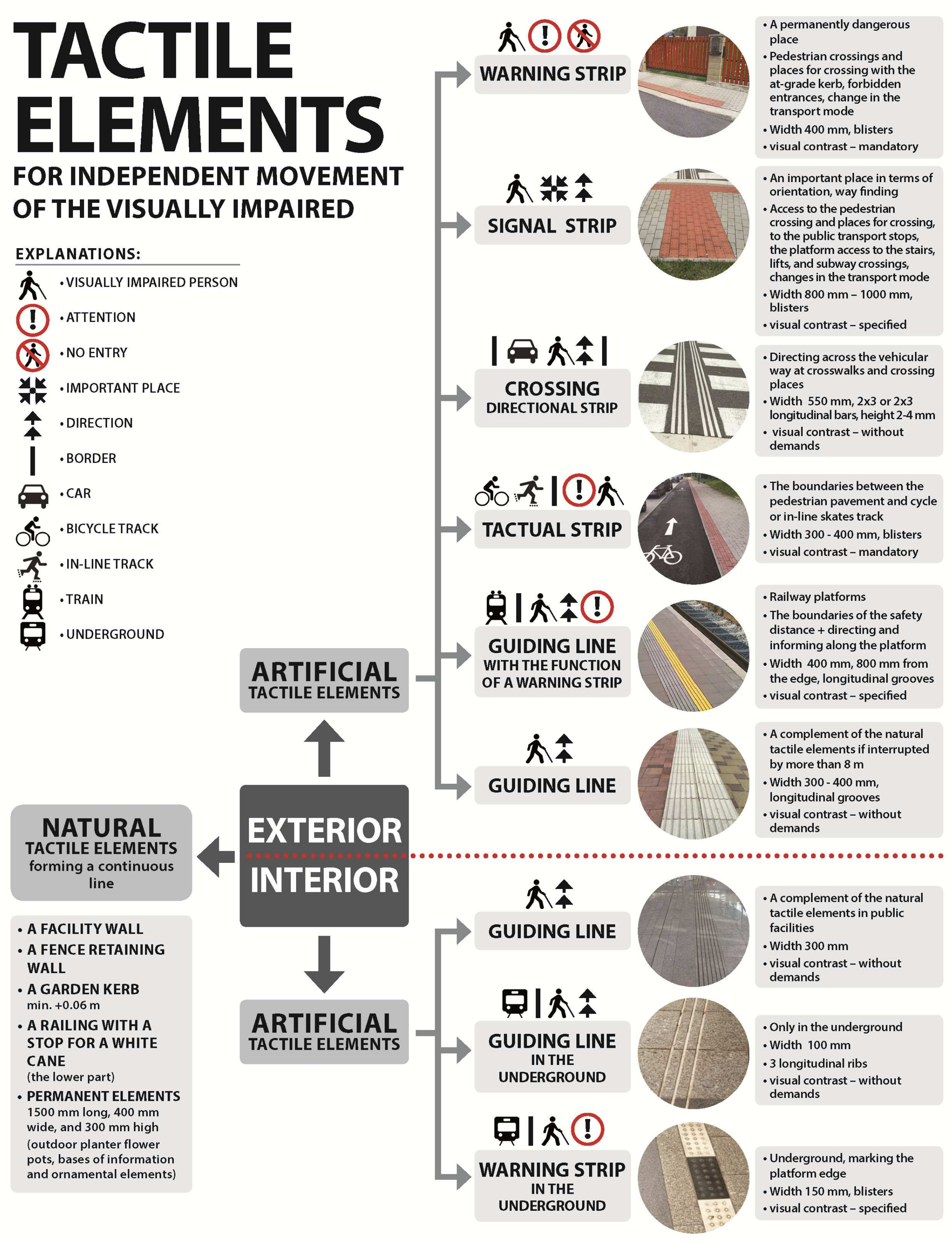
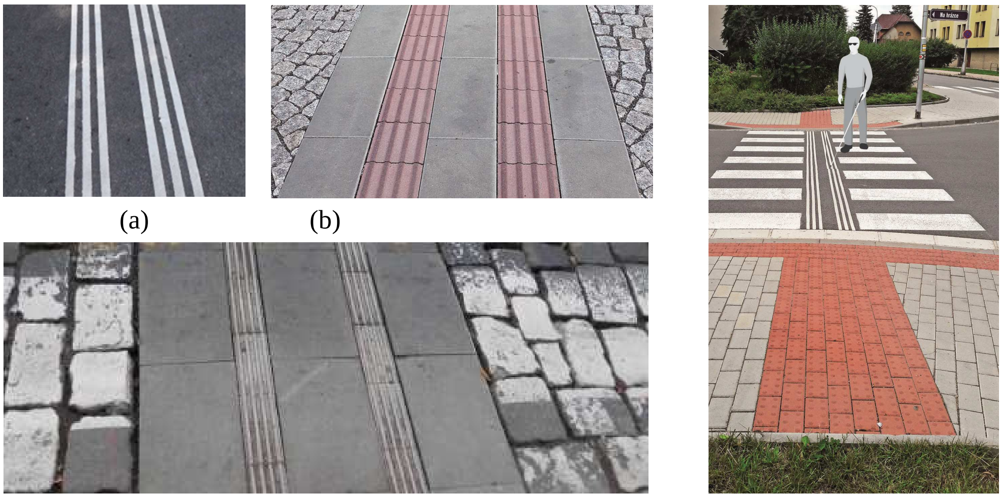


Fig. 4.
Tactile elements in the CR
Source: Author J. Košťálová

4. Differences between the Czech Republic and other countries

The analysis of the current situation in safe guiding of the blind indicates that:

- The majority of European countries currently use AGL and TE made of a wide range of **material**. Stone or concrete tactile paving is the most widely used but ceramic tiles and PVC belts, products from polymer concrete, and stainless steel are also used; e.g. in Slovakia (Ondrovič, 2011), and in Poland (Poliński, 2013).
- The standard ISO 21542, similarly to some other transnational regulations (e.g. the TSI PRM), defines the **colour contrast of the elements**; this is not included in the Czech legislation. The standard describes a simple method of light reflectance value difference, and, for a comparison, other three methods widely used in the world (Michelson, Weber, Sapolinski). When defining the necessary colour contrast, it is important to take into account the character of the displayed information (orientation or safety).
- A rarely used TE in Europe is the **crossing directional strip** in a vehicular way, which helps to shorten the time in dangerous places, see Fig. 5 (d). In the CR, it is only installed at pedestrian crossings, where it is difficult to keep the direction: the signal strip is not long enough (< 1 m), the axis of the crossing is not perpendicular to the axis of the road and its length is longer than 8 m, or the crossing comes from the rounded curbs of $r > 12$ m in diameter. It is necessary to maintain the colour contrast depending on the material used, see Fig. 5(a) – (c).



(a) (b) (c) (d)

Fig. 5.
Crossing directional strip
Source: J. Košťálová

- **Surface structures** are unfamiliar with the negative relief (groove in the surface), which is commonly used in the CR. Such structure is used for guiding the blind on platforms, or inside terminals.
- Research in V4 countries has proved that **acoustic information** is important for the visually impaired, yet insufficiently used (Rights, 2015).
- A wide variety of **guiding patterns** is used for the same situations, which are difficult for the blind to remember (one bar, two bars, two triples of bars, paving with 5-7 grooves, a combination of a negative relief[7] and steel guiding riband).[8]
- **Tactile elements** with an attention pattern are not used in the CR in front of sloping barrier-free ramps and stairs as the visually impaired are guided by the AGL, from the side, to the railing. No tactile element should create an obstacle for other users (people in wheelchairs, people with physical disabilities and small children) when entering and leaving the ramps, see Fig. 6. According to the Czech Statistical Office, there are, in the CR, six times more people with severe physical disabilities than visual.
- In the subways, malls, corridors, the TEs are often situated in the centre of the walking area and they do not respect the usable lines of the walls. Should the load increase, the elements rising above the surface have reduced durability and create obstacles, see Fig. 7.

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[7] milled grooves
[8] e.g. on the platform in Warszawa Centralna

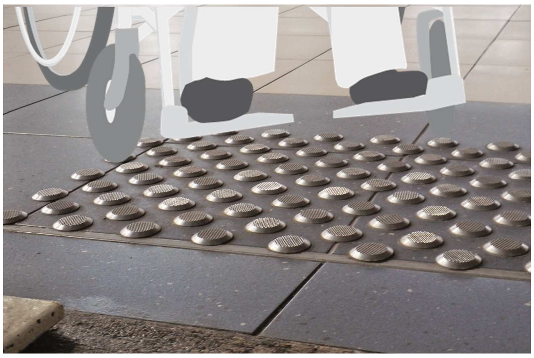

Fig. 6.
TE before a ramp
Source: J. Matuška

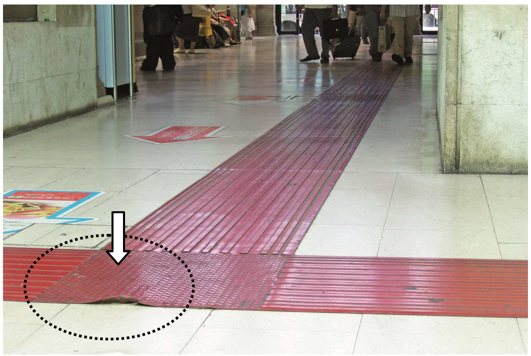

Fig. 7.
Additional adjustments in Udine, Italy
Source: J. Matuška

5. Conclusions and recommendation

The function of individual elements (different according to the national standards) must not be confusing, as the user safety is the priority. The legislation of most European countries addresses these requirements, yet the reality shows the more the information and details have to be solved additionally, the more incorrect and life-threating the situations. Instead of a simple functional solution, the result is incomprehensible for severely visually impaired people and causes restrictions for other users.

NTEs used in interior or on roads are advantageous for:

- **the blind -** as they get permanent information, which is more recognisable by the white cane and is less dependent on the weather and pollution,
- **investors –** NTEs save financial means spent on adjustments for safe guiding of the blind, allow easier cleaning and maintenance of the walking areas,
- **other users** of the environment – NTEs do not create any obstacles (for small children, people in wheelchairs, people with rollators, crutches, or sticks, etc.).

The process of creating a barrier - free environment (user-friendly) has to take into account not only the legislation (design and planning) but also the finances. Long-term sustainability can only take place in the cities with smart municipal politics, with cost-effective and accessible public transport and the modification of its conception; further, with the education of the experts forming the public environment (transport and building civil engineers, architects, representatives of governments and legislators).
Some good examples are not only seen in some European cities, Japan, the USA and Canada, but also in some cities in South America. Therefore, it is necessary to pay attention to all the TEs forming tactile GLs, which are and will be a necessary part of Design for All.
Experts including the members of the European Blind Union should discuss the following topics: effects of the increased use of NGLs in interior and exterior; materials suitable for guiding the blind in interior and exterior; the unification of basic adjustments for the blind across Europe; the use of acoustic information for the blind.

Abbreviations used:

AGL: *artificial guiding line*
ATE: *artificial tactile element*
CR: *Czech Republic*
CSN: *Czech Technical Standard*
GL: *guiding line*
NGL: *natural guiding line*
NTE: *natural tactile element*
PRM: *passengers with reduced mobility*
TE: *tactile element*
TSI PRM: *Technical Specifications for Interoperability passengers with reduced mobility*
TWSI: *tactile walking surface indicators*

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