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THE METHODOLOGY FOR DESIGNING ACCESSIBLE PUBLIC TRANSPORTATION: THE CZECH EXPERIENCE

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Abstract. This is an attempt to ensure an effective process for creating a barrier-free environment. It is necessary, within the scope of the methodological procedure, to analyse the whole system, search for critical areas and eliminate or prevent them when applying basic and specific properties of the previously defined elementary items. An essential pre-condition for creating an accessible built environment for everyone is knowledge of effective legislation and technical standards and successful application by all responsible persons.

Keywords: accessibility, barrier-free, methodology, public transportation, people with reduced mobility.

1. Introduction

When designing and creating accessible public transportation and a related barrier-free environment, it is crucial to apply a system approach for resolving these complex issues. The effect of the formulated concept results in integrated barrier-free routes in cities or barrier-free travelling chains of public transportation. If transportation is supposed to be accessible as a whole, then all its subsystems have to be solved as accessible. This would include vehicles, infrastructure (roads, traffic constructions), information and communication systems, staff and additional services. No less important is barrier-free traffic technology making public transport completely barrier-free.

The aim of all measures proposed to people with disabilities as well as visually and hearing impaired is to enable these categories of citizens to have independent and safe movement, orientation and communication.

2. Research Conducted in the Czech Republic and Abroad

In the Czech Republic, the problems of the accessible environment of public transport have been studied by the Centre for Transport Research in Brno in the scope of national and international research activities, e. g. international projects COST 335 (accessibility of railway carriages) or COST 349 (low-floor buses). Research and development activities in the field of orientation and communication systems for visually impaired people are conducted by Apex Jesenice (*www.apex-jesenice.cz*) or Czech Blind United, e. g. Dudr and Lněnička (2002) or Novák and Lněnička (2002).

Academic workplaces where barriers and their eliminations have been studied, except for the University of Pardubice, for example, embrace the Faculty of Electrical Engineering of Czech Technical University in Prague where the team of specialists developed a navigation system enabling an easier movement and orientation of visually impaired people in complex buildings.

It is necessary to say that in the Czech Republic, there are only several theoretical studies focused primarily on public transport as a whole. Also, only a few institutions deal with theoretical aspects of creating barrier-free transport from the point of view of transport technology. It is possible that the reason lies in the fact that there is a lack of the systematic approach to this issue at secondary schools and colleges specializing in transportation, thus it frequently happens that experts in the field of barrier elimination usually have qualifications in civil engineering.

European academic workplaces include, for instance, TU Dresden (Germany) – Institute for Transport Planning and Road Traffic where research has been conducted since 1980, Ackermann *et al*. (1996) or Direkt (2001). Fachhochschule Erfurt – Institut Verkehr und Raum deals with the concept of *Design for All*, Rebstock *et al*. (2006) or Rebstock (2007). In Slovakia, the problems of traffic constructions and urban environment have been studied at Slovak University of Technology in Bratislava, Ondrovič (2007).

The Swiss association *Fachstelle Behinderte und öffentlicher Verkehr* (Swiss expert centre for disabled

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persons and public transport) hold an important position among specialised workplaces. Since 1994, they have been processing standards for barrier-free transport chains, requirements for vehicles, infrastructure, information systems and other facilities. HANDISAM is the Swedish agency for disability policy coordination developing knowledge in the public sector, studying ways of making environment, information, facilities and activities accessible to everyone (*www.handisam.se*). ProA Solution from Barcelona (*www.proasolutions.com*) is the Spanish consulting company specializing in the field of the accessibility of services and environment applying the principle of *Design for All* in architecture, urban issues, public transport, information technologies, etc.

3. Barrier-Free Environment and its Users

Different explanations for the term 'barrier-free' (there is neither exact definition nor conceptual approach and the whole process of creating a barrier-free environment significantly differs) can be illustrated with the following examples of several European countries.

The term 'barrier-free' has not been defined in Czech legislation yet, nevertheless, it is still generally in use. It is presumed that 'barrier-free' is the whole complex of measures complying with Regulation No. 398/2009 (Vyhláška č. 398/2009). However, the Regulation is mainly focused on civil facilities (courts, post offices, facilities for culture, sport, public health, public transportation, etc.) and completely neglects transport means, information and communication systems, etc. A similar situation can be faced in Slovakia. Therefore, Matuška *et al.* (2006, 2008) and Matuška (2008a, 2008b) suggests that barrier-free public transportation should be defined as '*a status of a public transportation system that enables safe and independent access, adequate use and movement without assistance to all people*' the employment of which could be considered as adequate only in case it enables the type of use (access and movement) that is locally, timely and functionally independent.

A definition of the term 'barrier-free' used in Germany specifies that '*barrier-free are buildings, special facilities, means of transport, technical subjects, information systems, acoustic and visual sources of information and communication devices and other objects of everyday use accessible to people with reduced mobility, easily available, without undue restrictions and fundamentally without assistance*'.

In Croatia, the term 'accessibility' is defined by Regulation No. 151/2005 as '*a result of using technical solutions in designing and building objects which enable access, movement, stay and work to people with reduced mobility or people with disabilities without any restrictions and on the same level as to other people*'. The whole buildings as well as a part or equipment of those (ramp, lift, entrance, corridor, toilet, bathroom, workplace, restaurant, access to a swimming pool or beach, phone box, bus stop, platform, parking lot, pedestrian crossing, crossroads, etc) are accessible only in cases they comply with mandatory requirements for accessibility defined by this Regulation (Pravilnik o osiguranju… 2005). It is obvious that both German and Croatian definitions have – compared to the Czech Regulation No. 398/2009 (Vyhláška č. 398/2009) – a significantly wider range and also consider people with hearing impairments.

The official Swedish definition of the term 'barrier-free' in the accepted sense does not exist. They use terms defined by ISO standards 16071 'Guidance on software accessibility' and ISO 9241-11 'Guidance on usability'. 'Accessibility' describes the degree to which products, services or facilities are accessible in the widest range by all users. 'Usability' is the extent to which a product (service, environment or facility) can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use. Accessibility is more related to universal design, whereas usability is more individual.

In Norway, they apply conceptual design for planning and creating environments respecting a social status of all people within the meaning of equal opportunities and participation in all-society life. According to Universal Design… (2007) '*Universal Design is the design of products and environments to be usable by all people, to the greatest possible extent, without the need for adaptation or specialized design*'. This definition has been developed by the Centre for Universal design at North Carolina State University.

Another progressive approach is represented by the Spanish strategy of 'Universal Accessibility' and covers '*planning and creating environments, processes, activities, objects and services to make them accessible and usable for all people to the maximum possible extent*'.

The definition of the term 'barrier-free' differs in each particular country. Also, the users of a barrier-free environment are different. The sporadic term 'a person with the reduced ability of movement and orientation' is used in the Czech Republic and Slovakia. According to Regulation No. 398/2009 (Vyhláška č. 398/2009), the above introduced term includes people with disabilities, visually and hearing impaired people, senior citizens, pregnant women, people accompanying baby carriages or children up to three years of age. In other European countries, the term 'people with reduced mobility' is used more frequently and includes people with perceptual disorders or reduced grip strength (in upper limbs), passengers with large luggage and people with short stature. The presented examples show that the group of barrier-free environment users is very variable and relatively large (European statistics indicates it is about 25–30% of the population). Therefore, there are no grounds for the statement claiming that 'frequently costly measures are carried out for a negligible number of handicapped users'.

Specific Measures for People with Vision Impairments in the Czech Republic

Several specific measures – good practice measures are almost unknown in other countries but are used the Czech Republic and specify the so called 'signal lines' (Fig. 1) giving warnings to blind users about important places on the pavement, (e. g. crossings), departure platforms, public transport stops, etc. There are no such measures in other European countries (e. g. in France,

Fig. 1. A signal line leads from a guiding line (a kerb-stone on the right) to a pedestrian crossing

Fig. 3. Glued guiding line (Italy)

Poland, Austria, Hungary, Italy or Croatia) with the exception of Germany. The orientation of visually-impaired people is thus made more difficult.

Other specifics also involve using the so-called 'natural guiding lines' in exterior (foundation wall of fencings, walls of buildings, kerb-stones, etc.) and interior settings, e. g. departure lounges. Visually impaired people use building structures of the built environment, and therefore no other additional measures are necessary. Recently, some countries have increasingly used guiding lines for blind users in departure lounges or platforms which are not so necessary because it would be possible and more effective to lead the blind, e. g. along the wall of the building. Fig. 2 and Fig. 3 show a possibility of seeing different ways of using guiding lines in the interior of the building in the Czech Republic (milling into the surface) and Italy (sticking plastic strips on the floor); unstuck parts are dangerous for other passengers!

Fig. 2. Milled guiding (The Czech Republic)

An acoustic system in the vehicles of mass urban transportation has been in use since 1995, and thus represents another step towards the accessibility of public transportation to people with vision impairments. The system uses a remotely controlled public transport identifier (dimensions circa 85 × 45 × 15 mm) telling the blind user the number of the line and its direction. The remotely controlled identifier can be also used for acoustic location and opening the doors of some train carriages of the new types of trams and Prague underground.

4. State-of-the-Art of Accessibility and its Causes

The level of the accessibility of public transportation including the related environment (pavements, parking lots, crossings etc.) in the Czech Republic became an object of research conducted by the author as a form of questionnaire surveys and monitoring the approved buildings in 2004–2007.

4.1. Evaluation of Accessibility

Research done by Matuška (2004) showed that almost 45% of pedestrian crossings were correctly equipped with 'warning lines' (alerting the blind user to dangerous places). 'Signal lines' (showing the blind how to get to the pedestrian crossing and indicating the direction of road crossing) were used only in 30% of cases the every fourth of which was carried out in a wrong way. On the one side of the pedestrian crossing, the axis was not parallel with that of the pedestrian crossing, etc. An acoustic signalisation system was developed in less than 8% of pedestrian crossings and only about 5% of mass urban transportation stops had access areas with a barrier free kerb enabling level getting on low-floor transport means for wheelchair users. The situation in pedestrian crossing adaptations is significantly better as almost 75% of the crossings were successfully adapted as early as in

2004 (max. height of the kerb – 20 mm, making adjustments on both parts of the crossing).

Accessibility can be theoretically evaluated applying a two-step model defining four basic levels of object (system) accessibility using coefficient β_o. Čtvrtečková and Matuška (2005). To determine the level of the accessibility of an object, e. g. public transport terminal according to relation, the following steps are followed:

1) The first step defines and evaluates the factors of accessibility: H_1 – access to the object, H_2 – entrance area, H_3 – interior, H_4 – the possibility getting the required information and H_5 – toilets adjusted for wheelchair passengers. Based on the performed analysis, each of the above mentioned factors H_j is evaluated by an integer value from the interval (–1; 3) where the low value expresses absence (of barrier-free adaptation) and the upper value expresses either full functionality or barrier-free adaptation.
2) The second step includes assigning the importance $\delta_j \in (0; 1)$ of j-factor, assuming that $\sum \delta_j = 1$. It is necessary to detect importance by research and the best way is to survey people with disabilities or visually impaired passengers. The coefficient of object accessibility β_o is then worked out by substituting to the formula:

$$\beta = \sum_{j=1}^{m} (\pm) H_{ij} \cdot \delta_{ij}. \quad (1)$$

Particular values of intervals are subject to independent research. The suggested range of intervals and a corresponding evaluation of objects is as follows: $\beta_o \in (-1; 0.5)$ – inaccessible, $\beta_o \in (0.5; 1.5)$ – accessible with restrictions, $\beta_o \in (1.5; 2.5)$ – almost accessible and $\beta_o \in (2.5; 3)$ – accessible.

For the analysis of system accessibility with n-buildings (e.g. railway stations) and the evaluation of m-factors in each of those, relation (1) is modified as:

$$\beta = \sum_{i=1}^{n} \sum_{j=1}^{m} (\pm) H_{ij} \cdot \delta_{ij}. \quad (2)$$

Coefficient β will reach values from the interval ($-n$; $3n$) using the same way of evaluation. An overall evaluation based on interval values is a question of consensus.

4.2. Knowledge of Designers and Clerks

As presented in Čtvrtečková *et al.* (2006), the understanding of valid legislation, its correct interpretation and application in practice by designers and building authorities belongs to the basic factors influencing the level of accessibility.

The current regulations, standards, competences and possibilities of how to design and decide on a barrier-free environment are evaluated completely differently. More than 3/4 of designers consider them to be incomplete, incomprehensible, confusing and erroneous as background for administrative and decision-making processes. On the contrary, more than 2/3 of clerks in building authorities consider standards and a legal environment in this field comprehensible, clear and giving them the required competence. Fig. 4 represents the results of applying standards in practice – the accessibility of new and reconstructed buildings evaluated by the users in wheelchairs. It is evident, whether the fault originated in any phase of construction realization (preparation of project documentation, its appraising, building approbation for use) and the ratio of correctly adapted buildings were very low in 2005. This situation reflects not only the level of knowledge and abilities to use them by everyone involved in the process of creating barrier-free built environments but also points out the effectiveness of money spent in this field!

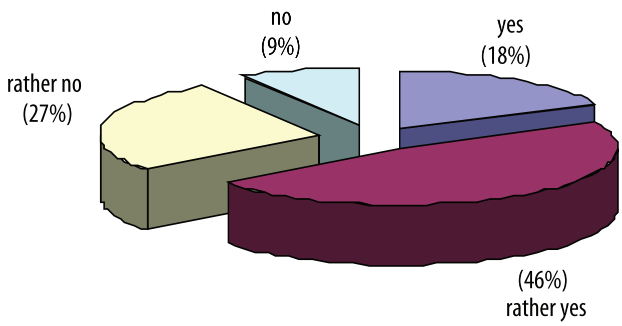

Fig. 4. Accessibility of buildings for wheelchairs (Czech Republic)

5. Methodology for Creating a Barrier-Free Environment

The previous chapter clearly shows that in the Czech Republic, the measures aimed at improving the accessibility of built environments for people with disabilities and visually impaired people are often carried out in a wrong way or simply do not exist at all. The way leading to the correction of this status lies in compiling a methodology for designers and building authorities. In the scope of research performed by Matuška *et al.* (2008) and on the basis of the analysis of the current status causes, we defined principles the application of which can lead to improvements in the quality of the suggested measures and thus increases the accessibility of built environments generally and specifically in public transport.

5.1. Analysis of the System

A basic condition for starting the creation of a barrier-free environment is its analysis of lower structural units. This process proceeds from the assumption that if the whole system (of public transport) is supposed to be barrier-free, all its subsystems and elemental parts must also be barrier-free. On this account, the environment of public transportation including related systems was analysed regarding 4 basic levels:

1) a type of construction;

2) a functional part of construction;
3) the functional component parts of construction;
4) alternatives for the functional component parts of construction.

The types of traffic constructions include railway constructions, road constructions, public transport stops and departure lounges.

Railway constructions cover the following functional parts: island platforms, outside platforms and hard surfaces (e. g. at station buildings). Road constructions consist of these functional parts: pavements, crossing points, points with lowered kerbs, cycling paths, parking lots and reserved places. Public transport stops embrace such functional parts as bus / trolley stops, tram stops, stops with mixed traffic of rail and road transport. Departure lounges can be at railway and bus stations, underground, a terminal of an airport or a cable car/funicular.

The functional parts of constructions are divided into the functional component parts of constructions or their alternatives. Considering the limited extent of this article, only the functional component parts of railway island platforms will be presented. It is necessary to design and check the required parameters, e.g. platform area, access path, shelters, information system for passengers, guiding lines for visually impaired, technical equipment of the platform, tactile items, etc. An example of the functional component part can be a pedestrian underpass with floor with/without difference in height (important for wheelchairs) or an acoustic/visual information system. Every alternative of a functional component part requires specific solutions ensuring usability for people with disabilities, visually or hearing impaired people.

5.2. Critical Points

Every place or situation with increased risk will be the critical point in the process of transporting people with disabilities and visually or hearing impaired passengers.

Such risk is usually based on:
1) safety endangering (e. g. on the border of a pavement);
2) loss of orientation (e. g. entering vast areas of departure lounges, orientation in a pedestrian underpass on the way to the platform for visually impaired people);
3) impossibility of getting information in the required form;
4) failure to observe transportation quality (e. g. when a guaranteed lower-floor connection of public transport is omitted or if transfer times between railway connection do not respect the specifics of the movement of people with reduced mobility and orientation.

Defining critical points for individual groups of people enables their more effective systematic elimination or suggesting improved measures preventing from arising barriers.

5.3. Suggestions and Applications of Basic and Specific Properties

The properties and parameters of the functional component parts of constructions or their alternatives can be divided into basic and specific ones. When designing and checking measures it is necessary to respect differences in some parameters and properties of the environment for visually impaired and people with disabilities.

The basic properties shared by both groups of users include non-slip surfaces, a longitudinal and transverse angle of a slope, passing width, passing height, a handling (free) area for a wheelchair-user, maximum height difference and colour contrast. Important *specific* properties encompass the properties of tactile items including its colour solution, a height and placement of the text, font size/thickness, text/background luminance contrast (which influences its readability) and tactile and acoustic guidance of visually impaired people.

6. Methodological Help

Methodological help is available as a multi-media, interactive software package operating under the Windows environment with the title 'Creation of barrier-free environment for traffic constructions'. The Help (on CD-ROM) was created as one of the outputs of the task, Matuška *et al.* (2008). Its importance for real life was highlighted by the Office Manager of the Government Board for People with Disabilities in the introductory words to this Help consisting of seven parts: Accessibility Checking, Glossary, Photo Bank, Examination of Formal Requirements, Legislation, Responsibility Scheme and Cross-References. The key parts are the Photo Bank and Accessibility Check.

The Glossary presents definitions of the most important terms in the field of the barrier-free environment. Some are less frequent and important terms are presented with photographs (e. g. signal, warning lane, acoustic signalisation).

Examination of Formal Requirements contains information required for project documentation - project designs and explanatory texts for particular traffic constructions.

Legislation consists of basic information on 22 key laws, regulations, Czech technical standards and other technical directives related to this issue.

Responsibility Scheme presents an overview of obligations to designers, building offices and professional inspectors during construction.

Part Cross-References provides information about the Ministry of Transport, the Ministry of Regional Development and the Czech Chamber of Authorised Engineers and Technicians Engaged in Construction.

This Help is the first such kind activity undertaken in the Czech Republic. A similar approach can be found only in Germany and Switzerland. Both countries use the so called 'checklists' which means that they are not multi-media, interactive software packages.

6.1. Accessibility Checking

The basic principle lies in the above mentioned analysis of the type of the traffic construction system applied in the whole environment, the functional parts of constructions and functional component parts or their alternatives. After opening the Help software, the user chooses the type of constructions from the menu (see above railway constructions, road constructions, public transport stops or departure lounges). Then, it is possible to move within the selected type of construction and choose its functional part (e. g. as for public transport stops, it is possible to choose from bus or tram stops). Based on the previous selection, the list of functional component parts or its alternatives (stops on the pavement or island) displays and the user chooses parameters and properties for checking or finding (e. g. bus stop on pavement). After selection, the functional component parts are displayed – the files are in *.*pdf*; when opened, the user can see table arranged parameters which must be observed (basic and specific properties). The overview is supplemented with photographs and comments.

6.2. Photo Bank

The aim of our photo bank is to show rightly and wrongly solved particular measures (crossing, public transport stop, access path, sales point equipment, etc) built in the times of valid Regulation No. 369/2001 (Vyhláška č. 369/2001) and connected standards.

The user works with the data bank of photographs in a similar way as when checking accessibility – selects a group of people (people with disabilities, visually or hearing impaired) and a type of construction where the measures are used. The required situations (items) can be selected from *.*pdf* files, e. g. a termination part of island platform for visually impaired. Each file consists of either wrong or right solutions of the given item and comments on explaining the subject matter of each solution. The authors of this Help suppose that particular solutions described in the photo in a real environment have a greater information value than a mere description in the text.

7. Conclusions

Research and other activities in this field conducted by the author disclose that:

1) The level of public transport accessibility as well as particular solutions/measures for people with disabilities and visually impaired significantly differ in various European countries. Essential importance lies in the approach to creating a barrier-free environment where the author recommends accepting and developing the principles of ‘Design for All’ or ‘Universal Design’ that have not been applied very often yet. We aim at promoting at least the system approach to the process of creating a barrier-free environment that might bring a synergistic effect on the integrated barrier-free chains of public transportation.
2) The basic principle of the effective creation of a barrier-free environment is to ensure a correct and identical interpretation of legal and technical standards used by designers, building authorities and other experts in the field. The above-mentioned Help created for both designers and Building Office staff is supposed to contribute to it. The Czech Chamber of Authorised Engineers and Technicians Engaged in Construction are going to use this software for training and taking educational courses for designers.
3) Another essential precondition for improving the quality of barrier-free environments is long-term and systematic preparation and education of everyone involved in the process of creating barrier-free environments which does not apply to designers and Building Office staff only but also to colleges and secondary schools specializing in transportation. It is necessary to educate a new generation of specialists who will regard accessibility as a common phenomenon rather than super-standard. Lectures on barrier-free transportation have taken place at the University of Pardubice (Jan Perner Transport Faculty) since 2008 and the lecturer-in-charge of the course is the author of this article.
4) Knowledge of the principles of motion and orientation applied for people with disabilities or visually impaired people have fundamental importance for designers and other experts in this field positively influencing the quality of their work. In the Czech Republic, some associations offer ‘experience seminars’ where possible to take a ride sitting in a wheelchair on uneven terrain, blindfold walking with a white stick or other situations in which visually impaired or people with disabilities encounter barriers. We also organise these seminars at the University of Pardubice every year aiming to raise the awareness of this issue and understanding among students.

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