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Risk assessment methodologies for pedestrian crossings without traffic lights – Warsaw case study – pedestrian safety assessment

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Abstract. Based on data from 2015 [1], it was found that 31% of all fatalities in road accidents in Poland were pedestrians. In places accessible to pedestrian traffic 74.2% of total accidents involving pedestrians were recorded. Approximately 53.9% of accidents involving pedestrians take place in the proximity of pedestrian crossings. In the context of improving the safety of vulnerable road users, an assessment of the condition of infrastructure in this sensitive area is very important. Warsaw took up the challenge of a comprehensive assessment of pedestrian crossings in determining the level of road safety and lighting conditions. Research covered pedestrian crossings without traffic lights in three central districts of the city. The work included field research by teams of experts analysing the geometry of pedestrian crossings, their environment and user behaviour. To complete the task, methodologies for assessing risks to pedestrian safety were developed. In this article the authors have attempted to systematise a description of the method of pedestrian safety assessment in the area of pedestrian crossings.

1 Introduction

The development of road traffic in urban areas carries a number of risks to road users. Particular attention should be paid to road accidents and their consequences. In comparison with other European countries, Poland has a very high number of pedestrian fatalities [2]. Statistical analyses made available annually by the Police Headquarters confirmed these unfavourable data [1]. The main causes of accidents involving pedestrians indicated in the reports are: driver carelessness, pedestrian carelessness and lack of proper visibility of pedestrians. Despite the apparent decline in the number of accidents involving pedestrians [1] since 2000, they are still at risk in traffic. According to the analysis contained in the PH report [1] the highest number of accidents involving pedestrians occurs on the crossings. It would seem that the situation of pedestrians in Poland over the years has been gradually improving. However, a thorough analysis of a statistical report [1] shows an increase in the share of accidents at pedestrian crossings in relation to the total number of accidents per year in Poland.

According to the data [2], the number of pedestrian fatalities dropped by 9.7% (Fig.1) in the years 2010-2014 in Poland. The decrease in fatalities including pedestrians can be caused

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by, among others, taking numerous actions to protect road users. A comparison of the rate of improvement in pedestrian safety in Poland and other countries puts Poland in a bad light. Many countries already by 2010 showed better indicators than Poland.

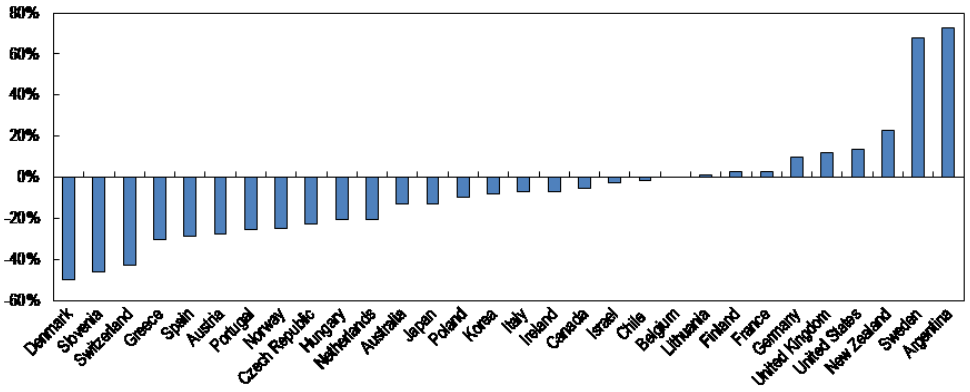

Fig. 1. Percentage change in the number of deaths among pedestrians, 2010-2014 [2].

The level of road safety depends on the users of the road infrastructure, its environment as well as on the technical condition of vehicles. A number of criteria that influence directly or indirectly the occurrence of accidents involving pedestrians in the vicinity of pedestrian crossings could be defined. Polish regulations do not specify how to determine visibility, procedures for selecting the type of pedestrian crossings are not adopted, maximum length of the crossing is not defined and there are no guidelines governing lighting conditions. Lack of these regulations means that pedestrian crossings are built that pose a high individual risk to pedestrians.

1.1 Overview

In the context of improving the safety of vulnerable road users in urban agglomerations, assessment of infrastructure is very important. The City of Warsaw commissioned an Audit of Road Safety and an assessment of lighting on 930 pedestrian crossings without traffic lights in three central districts of the city. The authors of this paper have attempted to systematise the process of assessment of the safety of existing crossings. It should be noted that the actions taken in the field of safety assessments were carried out consecutively with a team of lighting experts whose task was to assess the impact of lighting elements on the level of pedestrian safety.

Despite many efforts to improve the safety of pedestrians in Warsaw from 2011 to 2014 the number of accidents with pedestrians did not significantly decrease (434-490 cases/year). In 2015 there was a decrease to 390 accidents [3]. Because statistically they are a small number, pedestrian accidents are not mapped as "black spots". To act preventatively, a map of the level of risk at pedestrian crossings should be created regardless of whether accidents involving pedestrians took place there or not. Acting on the risk map the road manager can undertake preventative actions, rather than wait for accidents to happen.

It should be emphasised that so far Poland has not had similar research. A study of the literature [6][7] preceding conceptual and field work did not indicate a useful methodology. In the literature the authors encountered one source [6] where an attempt was made to create an objective numerical risk assessment of pedestrian safety, assigning weight factors and weights to individual parameters of a pedestrian crossing. However, they cannot be transferred from Italian to Polish conditions due to the specificity of the local behaviour of drivers and pedestrians and different traffic regulations. Therefore, a new, comprehensive

assessment method had to be developed that would help to identify risk factors occurring at selected pedestrian crossings. The authors of the Polish assessment methodology decided to separate the assessment of the lighting parameters and other parameters of road safety.

2 Pedestrian risk assessment in the area of pedestrian crossings

2.1 Procedure

Step one – site inspection

The developed methodology of pedestrian risk assessment required the participation of experts in the field of road safety. In this particular case they were Road Safety Auditors certified by the Minister of Infrastructure and Construction after completing an appropriate course. The experience of the people assessing the risk is extremely important, because their assessment is based on knowledge and experience.

In the first step, an Auditor, Audit team or lead Auditor and their assistant inspect the site and complete a form with required data:

- accurate GPS location;
- the location of the crossing: on a straight section, on a curve, at a junction (on a priority road, on a minor road);
- surface: the type, condition;
- cross-section of road in the crossing area: the number of lanes, tram tracks, bike lanes, the existence of refuge islands;
- geometric parameters of crossing: length, width;
- the type of vehicles in the crossing area: trams, cars, bicycles;
- organization of traffic: traffic directions, number of lanes, the number of interconnections which pass through the pedestrian crossing;
- road signs related to pedestrian crossing markings: condition, type, completeness, speed limit;
- road markings: condition, crossing and pavement colour, crossing distinctness;
- water drainage: rain inlets in the crossing area, kerbside gutters, puddles;
- parking: distance from the crossing and the position of the vehicle parking (e.g. on the road, in a roadside lane, etc.),
- visibility: visibility measured in real conditions;
- subjective evaluation of the behaviour of users including pedestrians improperly crossing lanes, the speed of vehicles and the behaviour of drivers;
- photographic documentation.

Step two – risk identification

In the second step, on the basis of the collected data and observations the Auditor determines whether there are risks/irregularities. In the methodology, arising risks were predetermined due to:

- insufficient devices for people with disabilities and with reduced mobility:
    - lack of/inadequate equipment for the visually impaired,
    - lack of/insufficient ramp at the edge of the crossing.
- insufficient driver-pedestrian field of vision due to the reduction of visibility by:
    - parked vehicles,
    - fences, poles, advertising,
    - public transport stops,
    - greenery, other.

- irregularities in the road signage or markings due to incompleteness or poor technical condition,
- risks associated with the geometry of pedestrian crossing and road in the area due to:
  - excessive length of pedestrian crossing;
  - pedestrian crossing exceeding three lanes;
  - pedestrian crossing over excessively wide lanes;
  - use of "painted" surface which does not protect pedestrians;
  - insufficient width of the refuge island.
- risks arising from improper drainage in the pedestrian crossing area:
  - rain inlets in the area of pedestrian crossings;
  - lowest point of the vertical alignment/basin causing the formation of puddles.
- other risk factors:
  - bad technical condition of the roads, pedestrian crossings, pavements;
  - crossing prone to obstruction by vehicles;
  - unnecessary pedestrian crossing e.g. duplicating adjacent one;
  - lack of space for the accumulation of vehicles before the crossing.
  - other uncategorised above.

These risks are identified and recorded in a database. At this stage, the level of risk is not specified. The resulting database helps to sort and filter risk groups which can significantly facilitate the implementation of response programmes.

Step Three – defining the required field of view

In the third step of the procedure fields of view are defined that are required based on the speed limit and average speed values of the V85 of a particular cross-section. In order to determine the V85, data from the speed measurements were used and additional measurements were conducted.

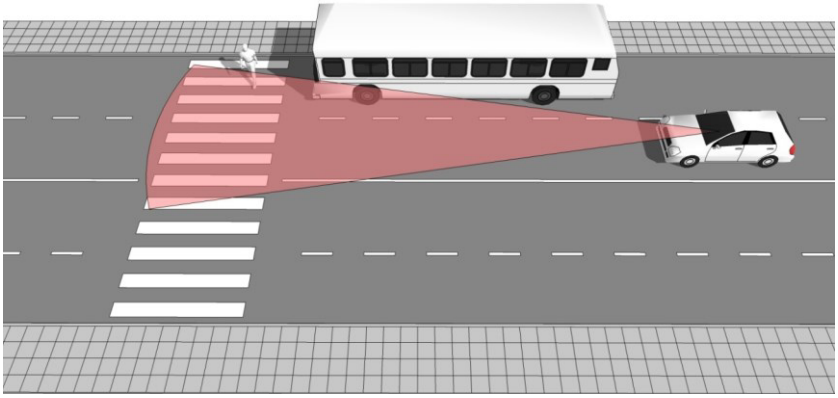

Fig. 2. Risk identification due to limited field of view [8].

Step Four – formulation of recommendations

In the fourth step, the Auditor fills the database on the predefined recommendations aimed at improving the level of pedestrian safety and eradicating the risks. The resulting database helps to sort and filter groups of recommendations, which can significantly facilitate the introduction of response programmes.

Step Five – statement

In the fifth step, the Auditor prepares the statement describing the level of individual risk and indicating as many recommendations as possible aimed at improving the level of road safety.

Step Six - overall assessment

In the sixth step, the Auditor gives an overall assessment on a scale of 0 to 5, where the rating of 0 means the greatest risk for pedestrians and 5 lowest risk for pedestrians (Fig. 3).

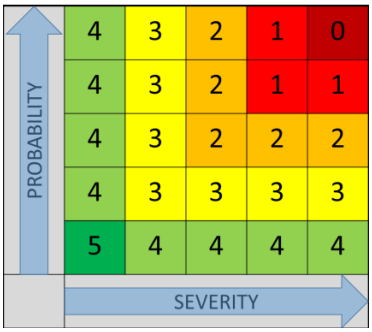

Fig. 3. Method of overall assessment of pedestrian risk in the area of pedestrian crossings.

Step Seven - verification

Due to the risk of subjectivity of each Auditor's evaluation, after the completion of the whole process of risk assessment, the material is evaluated by another party, i.e. the verifying Auditor. This person assesses the risks indicated, the adequacy of the observations and whether the recommendations are adequately and properly formulated. If the verifying Auditor disagrees with the assessment of a pedestrian crossing, a common position is found through discussion. If no agreement can be reached, a third Auditor is appointed who resolves the conflict and has a decisive vote. The procedure implemented in such a way should prevent subjective positions of an individual Auditor.

2.2 Additional data

Because not all data were available during the site inspection and seemed to be necessary for the assessment, efforts were made to obtain information about the road traffic volume (from a Warsaw transport model) and the traffic volume of pedestrians and cyclists by age group (own measurements conducted).

In addition, the method of required visibility was developed by the authors taking into account the position of a pedestrian at a distance of 1m from the edge of the road at drivers' speed of V85.

2.3 The resulting material

As a result of the work a collective database was created containing:
- a unique identification number given to each crossing;
- locations: streets, junctions, road class, number of lanes, description, district;
- assessment of the overall level of risk at a pedestrian crossing;
- a set of risks identified by type and cause;
- a set of recommendations by type;
- a hyperlink to the location of a crossing;
- traffic volume of vehicles;
- traffic volume of pedestrians and cyclists;
- a hyperlink to the individual worksheet of a pedestrian crossing.

In addition, for each crossing a worksheet is created, containing all the data from the site inspection, photographic documentation, assessment and statement by the Auditor.

2.4 Summary

The material enables the implementation of preventive measures. Pedestrian crossings can be filtered according to the ratings awarded. About 10% of the crossings with the worst assessment score were indicated where immediate corrective measures were deemed necessary. The database of risks and recommendations also helps to filter pedestrian crossings by specific problems such as visibility restrictions related to parking or inappropriate devices for the visually impaired.

The material, in the form of a database and specific worksheets, can be used to apply the method "from the general to the specific" which should be of significant benefit considering the high number of pedestrian crossings.

3 Conclusions

The authors took the decision not to link the assessment of lighting with the assessment of pedestrian safety due to the fact that in some cases the lighting expert's evaluation significantly differed from that of the road safety experts. If compiled in the form of a joint assessment, the data would statistically obscure some important problems.

Effective action to improve the safety of pedestrians should include, inter alia, conducting a systematic evaluation of safety at crossings and application of effective measures for the protection of pedestrians at the crossings where there is a particularly high pedestrian risk.

The authors aim to develop a coherent database of measurement results and expert assessments and information on road incidents involving pedestrians. Ultimately, it may be the base material for construction of a model quantifying the share of individual components in the overall level of pedestrian risk.

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