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Pedestrian crosswalks safety assessment in selected countries

Summary

This article presents an issue of the assessment of pedestrian crosswalks safety, based on the example of actions undertaken in Norway and Australia. In Oslo, the criteria for safety assessment on pedestrian crossings and the audit results were presented in the TØI Report 1231/2012. In Australia, a draft methodology for pedestrian crosswalks safety assessment, which, according to the authors, needs an improvement at multiple levels, has been developed at Monash University. The examples presented in the article indicate a significant problem with the elaboration of safety assessment methods of unprotected pedestrians and their applications within the framework programs implemented in large urban agglomerations. Despite the difficulties mentioned above, there are undeniably some possibilities regarding the elaboration of an objective pedestrian safety assessment method, which may be the subject to scientific studies.

Keywords traffic accidents, pedestrian crossing, pedestrian safety, unprotected pedestrians safety assessment methods

Introduction

Transport is an indispensable element in the shaping of interpersonal relations in both economic and social context. Over the recent years, a noticeable increase in the dynamics of development of different transport branchs has been observed, including road transport. In addition to measurable economic benefits, this development entails a number of risks related, inter alia, to the safety of traffic participants. During the period 2002–2011, a total of 51 thousand people died on the Polish roads and further 596 thousand were injured (including 154 thousand seriously injured). The analysis of statistical data from the last twenty years showed that the number of fatalities decreased by 28%, injuries by 26% and serious injuries by 33% [1]. However, the share of traffic fatalities reported in Poland in the total number of fatalities in the European Union is about 14%, while the share of the Polish population in the EU population amounts to 8% [1]. A particularly high risk group to bear the negative consequences of road incidents, including death, are the so called unprotected traffic participants, i.e. pedestrians, cyclists and motorcyclists. Together, they constituted almost 50% of all people who died in road accidents, out of which 34% were the pedestrians. Accidents involving pedestrian victims take place mainly in urban areas. The most common causes of accidents involving pedestrians were improper maneuvering and high speed of vehicles, but also failure to give priority to pedestrians on designated pedestrian crosswalks. The problem with pedestrian exposure to highly negative consequences of road accidents does not relate solely to Poland but it is also common in other countries in Europe and world-wide, although on different grounds. A good example is Italy, where, in the recent years an increase in road accidents involving elderly pedestrians has been observed (50% of pedestrians killed were people aged over 65) [2]. People in this group have limited physical capabilities, i.e. restricted mobility, visual impairments (including peripheral vision), difficulties in assessing the distance from and speed of vehicle. The second group of pedestrians in Italy in terms of the number of fatalities are children and youth. These people tend to show impulsive and unpredictable behaviors, often stemming from current educational methods based on modern forms of communication (i.e. computer games). Therefore, the problem with the safty assessment of unprotected pedestrians may relate not only to a particular cultural environment, but also to demographic criteria defining a particular social group.

It is easy to notice that accidents continue to happen, regardless of the sources of hazards and the continuous development of road infrastructure designed to effectively prevent accidents and minimize the related risks. Therefore, it seems that the negative effects of road incidents, including the most tragic ones like death or serious injuries, constitute the unavoidable costs of mobility, regardless of the advancement of social development. In order to counteract such state of affairs, a variety of actions are being undertaken both in formal (written laws) and technical areas, aiming at development of transport system (including road transport) taking into account the human right to move around safely. One of such actions is a systemic approach to traffic organization, particularly in urban areas, with special focus on heavy pedestrian traffic areas, i.e., designated pedestrian crossings. This article presents examples of actions undertaken in the capital of Norway, Oslo [2] and the basic criteria of the selected method of pedestrian crosswalks safety assessment elaborated in Australia.

Inspection of 75 designated pedestrian crossings in Oslo [3]

An inspection of designated pedestrian crossings for their mobility and objective safety was carried out with the purpose of answering the question whether the Gangfeltkriterier program for pedestrian crossings construction initiated in Norway in 2007 has been adequately realized.

The survey involved answering tree basic questions:

1. Criteria: Are the criteria specifically indicated in the Gangfeltkriterier program fulfilling the controlled pedestrian crossings?
2. Risk assessment: is the risk for pedestrians high, medium or low?
3. Regulations: are there any errors in the provisions regulating crossing localization, design, signposting or maintenance?

The following actions have been performed in order to answer the above questions:

1. Estimation of an average daily traffic volume.
2. Determination of the number of pedestrians and cyclists in and near the pedestrian crossing within the 6-hour period.
3. Observation of conflicts in pedestrian crossings.
4. Vehicle speed measurement for about 24 hours.
5. Obtaining the data of registered accident from years 2006-2010, in and near crossings.
6. Controlling the availability of documentation concerning localization, designing and signposting of pedestrian crossings.

For the purpose of this study, 75 pedestrian crossings with frequent occurrence of traffic accidents were selected. The crossings were chosen as follows: 32 were localized at three-way intersections, 11 at four-way intersections, 20 at intersections with circular motion (roundabouts), and 12 at straight road sections. Out of the selected pedestrian crossings, 10 were equipped with traffic lights, 4 were situated on roads with a 30 km/h speed limit, 14 on roads with a 40 km/h speed limit, 25 with a 50 km/h speed limit, and 32 with 60 km/h speed limit.

The inspection showed that 29 pedestrian crossings (39%) did not meet the criteria included in the Gangfeltkriterier program. 12 intersections met the criteria only within a limited scope. In case of 15 crossings the speed limit proved to be too high. 37 crosswalks (49%) were estimated as generating a high risk of pedestrian accidents, 36 (48%) generated medium risk, and only 2 crossings (3%) were of low risk. Numerous accidents occurred at high- and medium-risk crossings. These were the crossings situated on road sections with relatively high speed limit, poor visibility, more than two lanes in each direction, insufficient signposting or illumination.

Objections were raised with respect to each of the controlled crossings being the subject of the study, but in case of 37 (approx. 50%) crossings the objections were particularly numerous. The objections were classified as follows:

- signposting - 38 crossings (51%)
- road illumination - 21 crossings (28%)
- road surface - 14 crossings (19%)
- traffic lights - 9 crossings (12%)
- number of lanes - 5 crossings (7%)
- design - 5 crossings (7%)
- limited visibility - 4 crossings (5%)
- speed limit - 2 crossings (3%)
- localization - 2 crossings (3%).

It should be noted that as a result of the inspection, 14 (19%) crossings were qualified for liquidation, 30 (40%) for maintaining with necessary modernization, 26 (35%) for maintaining with some changes, 2 rossings were approved without changes, whereas another 2 were recommended for re-inspection.

It is clearly visible that the evaluated pedestrian crossings were problematic in terms of traffic safety, especially from the perspective of its unprotected participants. In case of Oslo this such a finding was not surprising as Oslo's most dangerous pedestrian crossings have been selected for the study.

The example presented in this article proves the complexity of the problem considered. It clearly shows that the complexity spreads not only over threat identification and their assessment methods but also its elimination based on the adopted criteria.

Criteria and methods of pedestrian crossings safety assessment, including their main functions, on the example of undertakings initiated in Australia [4]

Actions towards increasing the safety of unprotected traffic participants are generally undertaken all over the world, primarily in regions where transport participation plays a significant role in the society. At Australian university in Monash, a method for assessment of the pedestrian safety in different situations regarding crossing the roadway has been developed. In general, this method comes down to determination of the risk index identifying the danger to which pedestrians are exposed while crossing the roadway. The index is expressed on a scale from 1 to 5 and it is obtained based on the developed mathematical model taking into account key pedestrian safety factors, such as:

- vehicle speed at pedestrian crossings (in this particular case located in the areas frequented by children going to and returning from school)
- hourly traffic volume, taking into account the time during which children were going to and returning from school
- communication passage (roadway) width;
- number of traffic directions (number of possible traffic flows that can generate collision)
- infrastructure dedicated to crossings, i.e. crossing warning signs (horizontal and vertical), including the signs warning about crossings frequently used by children (in Poland, a warning sign depicting a girl, referred to as „Agatka"), traffic lights etc.

Speed limit

The literature presents several interdependencies between impact speed and severity of pedestrian injuries, including fatal injuries.

The described method was based on the dependency presented on Figure 1.

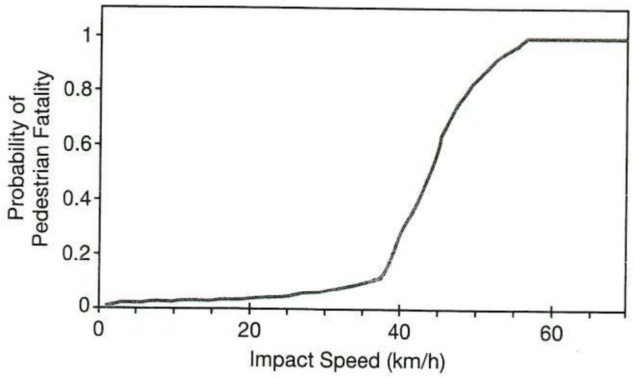

Fig. 1. The relationship between impact speed (speed at which a pedestrian is hit) and probability of pedestrian fatality [4].

The vehicle speed immediately in front of the pedestrian crossing (or any other area where a pedestrian is crossing a roadway) is a determinant of the risk of a collision with a pedestrian and as a consequence – a determinant of fatality or life-threatening injuries. As a speed reference point, a speed limit of 30 km/h was assumed, for which the relative risk of pedestrian fatality was assumed as 1. As shown on Figure 1, at this speed, the risk of vehicle – pedestrian collision amounts to approx.10%.

Table 1 Relationship between the selected vehicle speeds and the pedestrian fatality risk [4]

Speed choice (speed limit) (km/h)	Relative risk of a fatal pedestrian crash (compared to 30 km/h)
30	1.0
40	4.5
50	18.6
60	30.7
70	40.9
80 and above	> 40.9

The authors of this method also determined a pedestrian safety index as related to the speed limits resulting from traffic organization on the signposted road sections as well as those without traffic signs, as shown in table 2.

Table 2 Pedestrian safety index relative to the applicable speed limits [4]

Speed choice (speed limit) (km/h)	Base crossing star rating	
	Crossing facility present	No crossing facility
30 and below	5	5
40	4	4
50	3	3
60	2	1.5
70	1	0
80 and above	0	0

After the initial index values have been estimated, they may be modified, i.e., increased, e.g. in the case of proper road infrastructure (signposting) or decreased, e.g. when noticeable violations of the existing speed limits have been observed.

It is also important to mention yet another method of determination of pedestrian injuries with respect to the speed of a vehicle which caused the accident [5]. In medicine, contractual units have been introduced, i.e., the so called Abbreviated Injury Scale which determines the seriousness of injuries sustained. This scale have been developed for the purposes of medical statistics on the seriousness of injuries. However, it should be noted that the attempts to apply this scale for reconstruction of traffic accidents reported in the literature have been contested by researchers of the Institute of Forensic Research (IES) in Cracow. This was due to the fact that the study negated at IES showed very weak correlation between injury severity and collision speed. Figure 2 below demonstrates estimated pedestrian injury severity in relation to the speed of a vehicle which caused the accident.

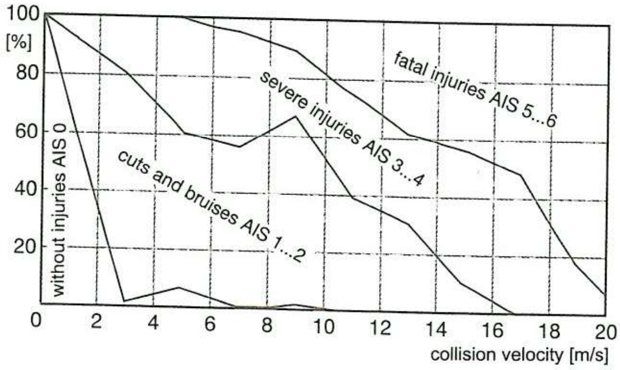

Fig. 2. Estimated pedestrian injury severity [5].

Traffic volume

Traffic volume is defined as a number of vehicles passing through a crossing area (in this particular case, estimated during the time when children are going to and returning from school). The more vehicles pass through an area, the higher the risk of collision with a pedestrian. This is reflected by a linear correlation between the pedestrian - vehicle collision risk and the traffic volume at the particular road section. The risk indexes defined on that basis are shown in Table 3. Traffic volume of 101-300 vehicles per hour with the weighting factor of 0.5. was adopted as a reference.

Table 3 Relative vehicle - pedestrian collision risk and the relevant adjustments for traffic volume measured over a period of 1 hour during child communication peak hours [4]

Note: relative risk values and adjustment rates were rounded to one decimal place

Traffic volume (vehicles / hour)	Approx. relative risk	Star rating adjustment	Star rating adjustment (weighted)
< 100	< 1	+1.0	+0.5
100-300	1.0	0.0	0.0
301-1000	3.3	-1.0	-0.5
1001-3000	10.0	-2.0	-1.0
3001-10000	32.5	-3.0	-1.5
> 10000	> 32.5	-4.0	-2.0

Roadway width

In general, it is assumed that the cognitive difficulties of the pedestrians increase with an increasing roadway width. Most of all, pedestrians experience difficulties with the assessment of distance to approaching vehicles, which related to the difficulties with the proper assessment of safe road crossing. Additional difficulties arise in a situation when a vehicle changes its path (e.g. changes lanes). With significance is also noticeable increase in improper driver behaviors (e.g. exceeding the acceptable speed limit) related to the increase in roadway width. The described method includes a mathematical equation determining the effect of roadway width on the collision risk, i.e.:

$$\text{collision risk} = (\text{roadway width})^{1,5}$$

The authors emphasize the importance of further verification of this correlation, including testing by mathematical modeling.

Table 4 presents relative vehicle - pedestrian collision risk and corresponding adjustment rates in relation to roadway width. The width of 7 m was adopted as a reference point, whereby the corresponding risk level was set at 1. The adjustment rate for the reference point equaled 0.

Table 4 Relative vehicle – pedestrian collision risk and corresponding adjustments in relation to roadway width

Note: relative risk values and adjustment rates were rounded to one decimal place.

Road width (m)	Approx. relative risk	Star rating adjustment	Star rating adjustment (weighted)
< 3.5	< 0.4	+0.7	+0.4
3.5	0.4	0.7	+0.4
7.0	1.0	0.0	0.0
10.5	1.8	-0.9	-0.5
14.0	2.8	-2.0	-1.0
17.5	4.0	-3.3	-1.6
> 17.5	> 4.0	-4.3	-2.1

Number of traffic directions at the pedestrian crossing (number of traffic flows that can generate collision)

When crossing a road, a pedestrian is obliged to exercise special caution. In practice, it should take a form of adequate visual inspection and traffic situation assessment, especially within areas of potentially colliding traffic flows. Obviously, the simplest situation takes place with only one traffic direction (e.g.

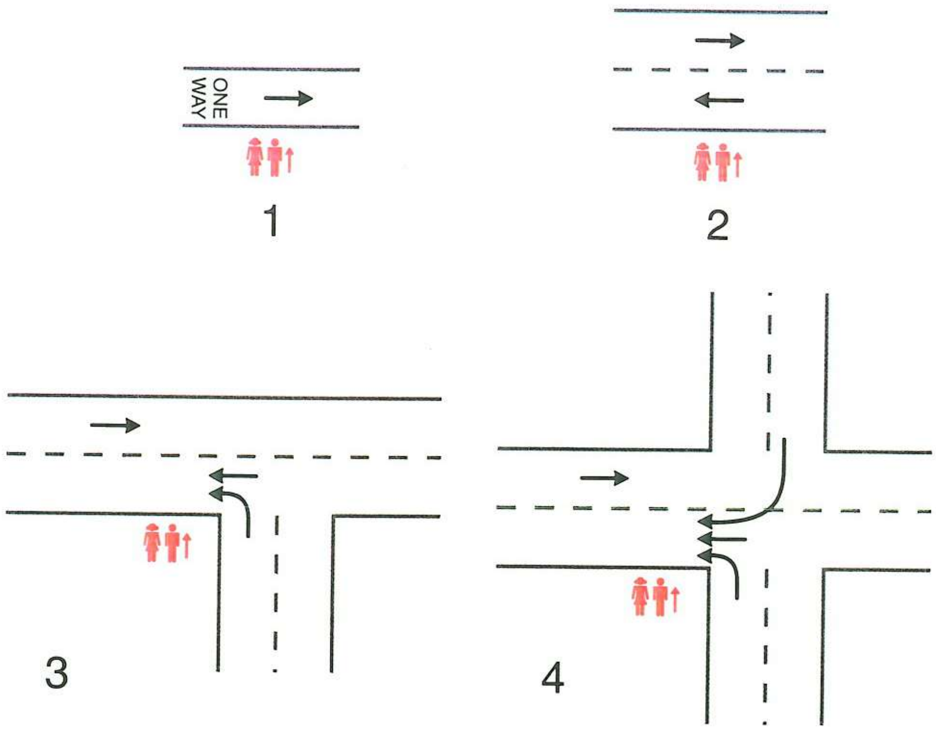

Fig. 3. Exemplary traffic situations at pedestrian crossings [4]

one-way road). The situation becomes more difficult when the traffic proceeds in two directions. Even more problematic from the point of view of the pedestrian's cognitive and assessment capabilities are the intersections, at which pedestrians have to monitor and assess the situation on four (or sometimes more) traffic directions. The exemplary traffic situations are shown on Figure 3.

For the above scenarios, another mathematical formula was developed that determines a vehicle - pedestrian collision risk, i.e.:

$$\text{collision risk} = (\text{number of possible traffic directions})^2$$

Table 5 Relative vehicle - pedestrian collision risk and corresponding adjustment rates in relation to the number of traffic flows that can generate collision [4]

Note: relative risk values and adjustment rates were rounded to one decimal place.

Number of conflicting directions	Approx. relative risk	Star rating adjustment	Star rating adjustment (weighted)
< 100	< 1	+1.0	+0.5
100-300	1.0	0.0	0.0
301-1000	3.3	-1.0	-0.5
1001-3000	10.0	-2.0	-1.0
3001-10000	32.5	-3.0	-1.5
> 10000	> 32.5	-4.0	-2.0

However, the authors highlight that this formula needs further verification just like in case of the roadway width formula.

According to the authors, the number of traffic flows that can generate collision is the second most important factor affecting pedestrian safety (speed is the first most important factor).

Road infrastructure designated for crossing (type of crossing)

A type of crossing is provided for the road infrastructure identification that may be present or absent at the crossing point. The infrastructure includes but is not limited to road signs, anti-skid lanes, or traffic lights. The described method does not consider the direct road crossing (away from designated crossings), which can be included with further development of the method.

Correct determination of the index

The correct determination of the index involves the consideration of described factors that directly affect pedestrian risk. The most significant factor is the one related to vehicle speed immediately before a pedestrian crossing. The safety index is determined on the basis of this factor. Then the obtained index can be further modified by other factors, including roadway width, traffic volume and traffic flows that can generate collisions. The authors of this model developed a simple „X-Assessor" application allowing a relatively quick determination of the crossing safety index. At the same time, they emphasize the possibility for further development of this model, such as an adjustment to the demographic profile of the entire society (this particular model has been developed for the purposes of school-age pedestrian safety assessment).

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Source

Figs. 1, 3: [4]
Fig. 2: [5]
Tabs. 1–5: [4]

Translation Rafał Wierzchosławski