A METHOD OF VEHICLE-PEDESTRIAN ACCIDENT RECONSTRUCTION

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Abstract: *In this work a method of vehicle-pedestrian accident reconstruction in case of unlimited driver visibility and accelerating vehicle moving is presented. This method presents are mathematical models for determining the pedestrian visibility time, vehicle speed at the moment of impact, time to vehicle move from the moment of the hazard occurrence until the moment of impact, the vehicle distance from the place of impact, stopping distance, etc.*

Keywords: ROAD TRAFFIC CRASHES, VEHICLE, PEDESTRIAN, ACCIDENT RECONSTRUCTION

1. Introduction

According to World Health Organization about 1.25 million people die each year as a result of road traffic crashes, 90% of the world's fatalities on the roads occur in low- and middle-income countries, even though these countries have approximately half of the world's vehicles and almost half of all deaths on the world's roads are among those with the least protection – motorcyclists (23%), pedestrians (22%) and cyclists (4%). Road traffic injuries are the leading cause of death among young people, aged 15–29 years [7].

In Bulgaria during the first ten months of 2015 were registered 6054 serious accidents. The distribution of accidents on main reasons shows that the highest share of these have occurred due to violations of drivers - 96.4%. The distribution of accidents by type shows that approximately 27% of accidents are vehicle-pedestrian accident [8].

Expertise is a procedural regulated activities carried out at the request of the competent authority of persons who possess special knowledge and skills to study certain subjects. Special knowledge is the knowledge that simultaneously meet the following requirements: not legal; not well known. They received the result of theoretical knowledge and practical experience in a particular discipline. Traffic accident reconstruction is an essential element of the investigation of road accidents and lawsuits.

The aim of this work is to present a method of vehicle-pedestrian accident reconstruction in case of unlimited driver visibility and accelerating vehicle moving.

2. Method and Discussion

Vehicle-pedestrian accident can be classified by various signs and conditions, depending on what part of the car hit the pedestrian; under the terms of visibility; according to the character of the movement of the car; according to the movement of the pedestrian in relation to the vehicle and the road and etc.

There are various approaches and methods for the vehicle-pedestrian accident reconstruction [1-6]. Many of them are focus on analysis of accident with a pedestrian when the vehicle is moving at a constant speed or deceleration vehicle moving. Sometimes in urban areas occur accident in which the car moves accelerating and hitting crossing roadway pedestrian. The reasons for such a mechanism of occurrence of accidents in which the driver does not operate the brake and the car does not start deceleration in the event of hazard are different. These can be a distraction to the driver, insufficient experience of driving fast changing road situation insufficient time for the work of the braking system technical faults of vehicle and others.

The study and analysis of such accidents required to be used different methods. Otherwise, results and reports made will be inaccurate.

Fig. 1 shows a sketch of the place of an accident between a car and a pedestrian. The sketch is prepared according to the protocol for inspecting the accident. If necessary, the expert can make additional measurements of various elements of the road infrastructure. The accident occurred at the intersection. Before the occurrence of the accident the car was stopped and waited enable traffic signal for starting and crossing the road intersection. In this traffic accident from the moment of starting to the point of impact the vehicle was acceleration moving.

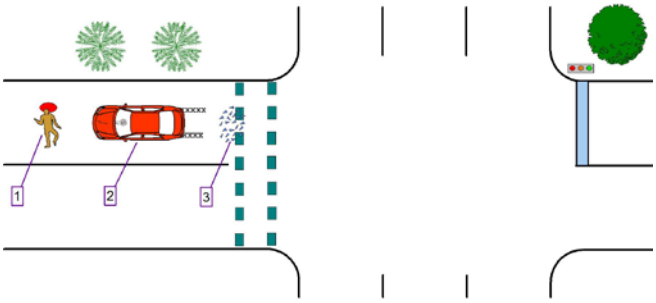

Fig. 1. *Vehicle-pedestrian accident place*

The positions of fig. 1 have the following meaning: position 1 – the location of a pedestrian after impact; position 2 - the location of the vehicle after the collision with the pedestrian; position 3 - scattered pieces of glass and plastic on the road.

The method of vehicle-pedestrian accident reconstruction in case of unlimited driver visibility and accelerating vehicle moving includes the following basic steps:

2.1. Determination of the location of the beginning of the impact

The point of impact between the pedestrian and the car is the place of a pedestrian on the road at the time of initial contact with the car. It is determined by a variety of case data - various evidence and items found at the scene of an accident, sketch of the accident scene, prepared according to the protocol of view of traffic accident, data from witnesses who were eyewitnesses to the accident, forensic medical report and other data.

The place of impact can be determined also using mathematical relationships between vehicle speed at the time of impact and the distance of the rejection of a pedestrian. If near the accident place is located traffic cameras or security cameras at different sites, records of these cameras can help to determine accurately the place of impact and the mechanism of progress of the traffic accident.

Fig. 2 shows a sketch of the same accident. On this sketch indicated the location of the vehicle (position 3) and the location of a pedestrian (position C) at the moment of impact.

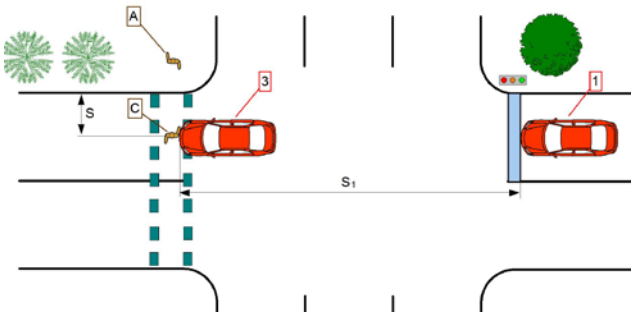

Fig. 2. Location of the vehicle (position 3) and pedestrian (position C) at the moment of impact

2.2. Determination of the distance, traveled by a pedestrian from the moment of occurrence of a traffic hazard to until the moment of impact

The determination of the moment of occurrence of a traffic hazard is a legal question. Most often this is the moment of entry of a pedestrian on the roadway (position B, Fig. 3). It may be referred to another moment of occurrence of a traffic hazard by the investigating authority or court. This moment could be earlier, when the pedestrian has not yet reached the roadway, but the driver of the car has been able to see a pedestrian

The distance, traveled by a pedestrian from the moment of occurrence of a traffic hazard until the moment of impact is indicated by S in fig. 2. It is determined by scale sketch or the geometry of the road in accordance with the place of impact.

2.3. Determination of the pedestrian speed

The pedestrian speed depends mainly on their age, sex and pace of movement (normal move, running, etc.). If the case file has additional information on a pedestrian, relating to his speed of movement it should take account. In accordance with written above the pedestrian speed is determined by reference or experimental studies.

2.4. Determination of the pedestrian visibility time

The pedestrian visibility time is the time during which pedestrian was on the roadway at the time of occurrence of a traffic hazard until the moment of impact. The pedestrian visibility time can be calculated by the formula

$$t_p = \frac{S}{V_p}, s \qquad (1)$$

where *S* is the distance, traveled by a pedestrian from the moment of occurrence of a traffic hazard until the moment of impact, *m*; $\boldsymbol{V_p}$ - pedestrian speed, *m/s*;

2.5. Determining the distance, traveled by a car from the moment of start until the moment of impact

The distance S_1, traveled by a car from the moment of start (position 1, Fig. 2) until the moment of impact (position 3, Fig. 2) can be determined by scale sketch. If necessary, this distance can be determined by measuring the scene of an accident.

2.6. Determination of vehicle speed at the moment of impact

There are various dependencies and methods for determining this speed. In this case, the vehicle speed at the moment of impact can be determined by the following relationship

$$V_{imp} = \sqrt{2S_1 a}\ , m/s \qquad (2)$$

where *a* is the acceleration of the car, m/s^2; S_1 - the distance, traveled by a car from the moment of start until the moment of impact, *m*.

2.7. Determination of the time for the movement of the car to the moment of impact

This time under constant acceleration motion can be determined by one of the following relations:

- $t_{imp} = V_{imp} / a, s;$ (3)
- $t_{imp} = \sqrt{2S_1 / a}\ , s.$ (4)

2.8. Comparing pedestrian visibility time t_p with time to move the car to the moment of impact t_{imp}

In this comparison are possible two practical cases:

- If $t_p \geq t_{imp}$ follows that the pedestrian was entered on the road at the time of starting the car. For this case a traffic hazard was occurring at the time of starting the car. The accident was preventable if the vehicle has started to move after passing a pedestrian.

- If $t_p < t_{imp}$ follows that the pedestrian was entered on the road when the car has started. This option calculations continue.

2.9. Determination of the time for the movement of vehicle from the moment of start until the moment of occurrence of a traffic hazard

The moment of vehicle start is shown in fig. 2, position 1. The moment of occurrence of a traffic hazard is shown in fig. 3, position 2.

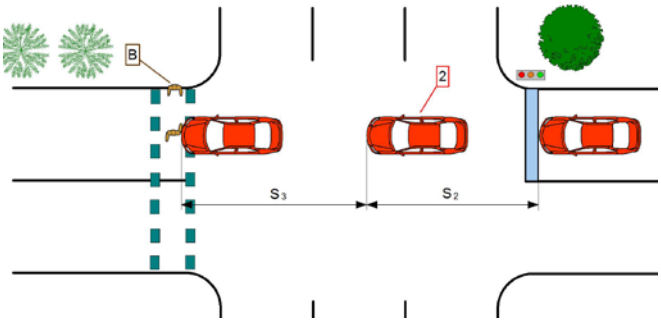

Fig. 3. Location of the vehicle and a pedestrian at the time of occurrence of a traffic hazard

The time for the movement of vehicle from the moment of start until the moment of occurrence of a traffic hazard can be determined by the following relationship

$$t_2 = t_{imp} - t_p, s \qquad (5)$$

2.10. Determination of the vehicle speed at the time of occurrence of a traffic hazard

This vehicle position is shown in fig. 3, position 2. This speed can be determined by the following relationship

$$V_2 = at_2, m/s^2 \qquad (6)$$

2.11. Determination of the distance of the car from the place of impact at the time of occurrence of a traffic hazard

The position of the vehicle at the moment of impact with the pedestrian is shown in fig. 2, position 3. This distance can be determined by the following relationship

$$S_3 = \left(\frac{V_{imp} + V_2}{2}\right) t_p\ , m \qquad (7)$$

2.12. Determination of the vehicle speed at initiation of braking

The initiation of braking of the vehicle is the moment of occurrence of a braking deceleration. The vehicle speed at initiation of braking can be determined by the following relationship

$$V_3 = V_2 + at_{ib}, \; m/s \tag{8}$$

where t_{ib} is the total time which is necessary the driver to initiation of braking

$$t_{ib} = t_{drt} + t_{vrt} + 0{,}5t_{inc}, \; s \tag{9}$$

where t_{drt} is the driver reaction time, s; t_{vrt} – the vehicle reaction time, s; t_{inc} – the time for increase the braking deceleration, s;

The driver reaction time is made up of human perception time - how long the driver takes to see the hazard, and the brain realize it is a hazard requiring an immediate reaction and the human reaction time - how long the body takes to move the foot from accelerator to brake pedal. The vehicles reaction time depends on the brake pedal free-play, hydraulic properties of the brake fluid and working order of the braking system.

2.13. Determination of the vehicle stopping distance

The vehicle stopping distance in this case is determined by the following relationship

$$S_d = \left(\frac{V_2 + V_3}{2}\right)t_{ib} + \frac{V_3^2}{2a_{dec}}, \; m \tag{10}$$

where a_{dec} is the vehicle braking deceleration.

The vehicle braking deceleration depends on tyre pressures, tyre tread and grip, vehicle weight, the co-efficient of friction of the road surface, slope of road, surface smoothness, etc.

2.14. Determination of the opportunity to prevent the accident by stopping the vehicle

The possibility to prevent the accident by stopping the vehicle is checked by comparing the vehicle stopping distance and the distance of the car from the place of impact at the time of occurrence of a traffic hazard

If the vehicle stopping distance is less than or equal to the distance of the car from the place of impact at the time of occurrence of a traffic hazard is that the driver had the technically possible stop before the place of impact.

If the vehicle stopping distance is greater than the distance of the car from the place of impact at the time of occurrence of a traffic hazard is that the accident was unpreventable through braking. For this version of the development of the accident can be checked and the possibility pedestrian to cross in front of the car and leave his lane of travel.

3. CONCLUSION

In this work a method of vehicle-pedestrian accident reconstruction in case of unlimited driver visibility and accelerating vehicle moving is presented. Described a methodical sequence of work. Presented are analytical relationships for calculation of various parameters needed for vehicle-pedestrian accident reconstruction.

This method can be used by accident investigators and in the training of specialists for accident reconstruction experts.

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