

MODEL PROPOSAL FOR DETERMINING THE DISTANCE OF THROWING A PEDESTRIAN IN A FRONTAL COLLISION WITH A VEHICLE, USING THE SOFTWARE PACKAGE PC-CRASH 9.0

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Abstract

Traffic accidents between a pedestrian and a vehicle are complex expert accidents that require analysis in determining the speed of the vehicle, the place of contact with the pedestrian, the distance of a pedestrian throwing, etc. With the development of computer technology, the distance of a pedestrian throwing in a frontal collision between a vehicle and a pedestrian now can be calculated. This paper determines the throwing distance in a frontal collision between a vehicle and a pedestrian of ten different passenger motor vehicles. By applying the software package, the throwing distance was determined, and 540 simulations with ten different vehicles were simulated. It is also mentioned and analyzed that the front of the vehicle that meets the pedestrian in a traffic accident has a certain impact, as well as simulating traffic accidents with vehicles with different front shapes.

Keywords: traffic accident, pedestrian, frontal collision, vehicle, simulations.

1 Introduction

While analyzing a traffic accident in which a vehicle hit a pedestrian, it is specific that there are clear analytical links to the vehicle speed and the traces found. Contrary to this, pedestrian speed is often not possible to be calculated empirically, except in individual cases, in the moment of collision. Having into the consideration that the analysis of the accident determines the order of characteristic positions of the participants in the accident and the way of movement of the participants in the accident in the moment of the dangerous situation, at the moment of the collision and after the collision, means their movement is analyzed spatially and temporally.

Before determining the distance of the pedestrian throwing with the front of the vehicle, it is necessary to determine the damage to the vehicle and what it results from. The distance of throwing away the body of the pedestrian by the vehicle depends on the speed of the collision, the shape of the front of the vehicle, and the height of the pedestrian. Pedestrian traffic accidents require analysis where the distance of the pedestrian throwing from the point of contact to the final position of the pedestrian body should be found. In this paper, the distance of throwing of the pedestrian with the front part of the vehicle on the pedestrian is determined, with simulated traffic accidents with the software package PC-Crash 9.0.

2 Collision of a vehicle with a pedestrian

2.1 Generalities for a pedestrian-vehicle crash

In road traffic, the pedestrian is the most vulnerable participant in the traffic, to the driver of the vehicle. If the speed of the pedestrian and the vehicle are considered, there will be a discrepancy-disproportion.

The speed ratio between the pedestrian compared to the speed of the vehicle in the city is 1:12, and outside the city, it is over 1:28. Unfortunately it must be confirmed that pedestrians are often unaware of this disproportion. This fact, as well as the fact that the education of pedestrians is not at a high level, greatly endangers road safety. The pedestrian, today, in developed traffic, must learn objectively, to anticipate the situations before getting involved in traffic. In addition to these predictable capabilities, the

pedestrian should take into account and count on the unpredictable behaviors of some traffic participants and should also pay attention to the technical possibilities of the vehicle range.

In the total number of various traffic accidents, the most common and most complex type of expertise for traffic accidents is the collision of a vehicle with a pedestrian. In this type of traffic accident expertise, according to the rules, it should be concluded whether the driver who was driving at a certain speed, was able in time to notice the pedestrian and by braking or turning the steering wheel to avoid the accident. For the expertise to answer this question, it is necessary to ascertain the most important parameters during the accident, such as:

- the position of the hit pedestrian in relation to the vehicle,
- the path of movement of the pedestrian to the point of contact,
- manner and speed of pedestrian movement in front of the point of contact,
- time and direction of movement of the pedestrian to the point of contact,
- manner of movement of the pedestrian in the process of scratching the vehicle,
- classification of primary, secondary and tertiary contacts of the pedestrian body with the vehicle on the road,
- a place of collision between the vehicle on a pedestrian,
- the striking speed of the vehicle on a pedestrian,
- vehicle speed before a dangerous situation occurs,
- time of perception and reaction of the driver to the appearance of the pedestrian,
- the speed of the vehicle in the moment of separation of the pedestrian from the vehicle,
- the place of reaction of the driver in the moment when the pedestrian appeared on the road,
- the place from where the driver could see the pedestrian,
- speed of the vehicle with which the collision would be avoided, i.e., safe speed of the vehicle,
- the place of stopping of the vehicle,
- impact force, work of traumatic force and comparison of powerful and working values of the actual pedestrian injuries in the accident, and
- other less important elements.

2.2 *Types of collision of a vehicle with a pedestrian*

A collision of a vehicle with a pedestrian means any contact of the pedestrian's body with a moving vehicle. In the kinematics of the collision of the vehicle with the body of the pedestrian, the manner and speed of movement of the vehicle, the pedestrian, as well as the shape of the vehicle and the parts of the vehicle with which the body of the pedestrian touches or comes in contact have also a significant impact.

To determine the point and kinematics of the collision, first, both the damage to the vehicle as well as the bodily injuries of the pedestrian is important, then to the passengers and the drivers of the vehicles. It is recommended that the photographing of the vehicles and the injured persons involved in the accident be done in detail, because this position of the impact can be determined exactly based on the damage to the vehicle and the injuries of the persons involved in the accident. Therefore, because of the accident – the collision of a vehicle with a pedestrian or bicycle, or a moped, first there is reciprocal contact between them and then on the one hand deformation of certain parts of the vehicle and on the other hand injury to pedestrians or passengers, the driver in a certain place or an organ of the human body.

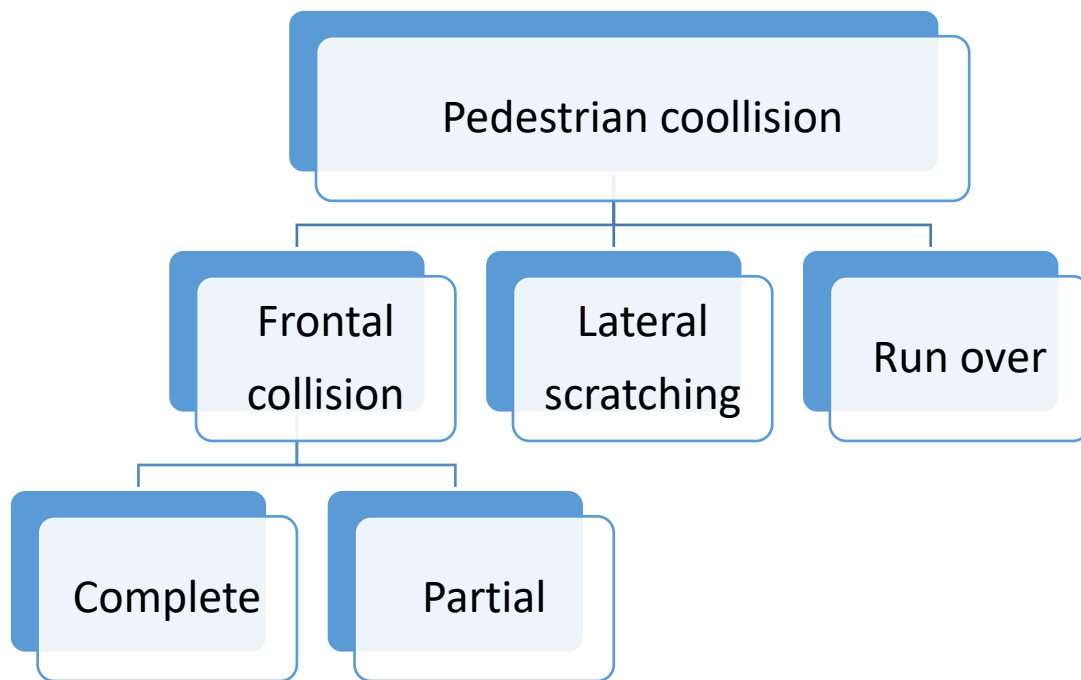
Deformations and damage to vehicles in accidents - collisions, are identified and assessed by a traffic expert, and the most difficult and most complicated cases by a mechanical expert.

Given that injuries caused to persons in traffic due to the specific nature of the human body, are identified and assessed by a physician, i.e., a forensics doctor.

The traffic expert needs to know the following about the injuries of people in an accident:

- the part or organ of the human body,
- the exact place (position) in that part or body,
- side, front, back, right, or left,
- shape, size, and nature,
- direction and course of the collision,
- the type of impact that caused the injury, elastic, or plastic,
- impact intensity: mild, medium, or strong, etc.

This information is important, where the expert, among other things, by analyzing and comparing the positions, shapes, sizes and nature of vehicle damage and injuries to persons involved in the accident, can make a reasoned conclusion about the place and mechanism of the collision, causes and consequences from the accident.



Scheme1. Types of vehicle collisions with pedestrians

3 Vehicles with different front shapes

The kinematics of the frontal collision of a pedestrian vehicle is not always the same, in some cases there may be several specifications that depend on many factors:

- from the profile shape of the front part of the vehicle,
- from the dimensions of the vehicle,
- by the weight of the vehicle,
- from the speed of the vehicle at the place of contact with the pedestrian,
- the sustainable properties of the structure of the part of the vehicle with which the pedestrian was hit,
- from the position of the pedestrian's body in relation to the width of the front part of the vehicle,
- the direction and speed of the pedestrian in the moment of the collision,
- from the height and weight of the pedestrian,
- from the characteristics based on where the pedestrian's body is thrown.

The factors describe or define the position, size, and manner of the impact of the collision force (F_{ud}) depending on the front shape of the vehicle as shown in Figure 1.

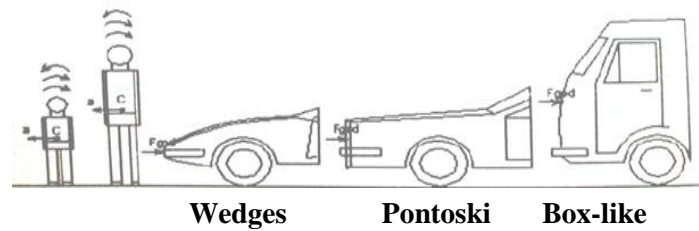


Figure 1. The ratio of the impact point of the vehicle to the center of gravity of the pedestrian body h_c (a - acceleration, F_{if} - impact force).

4 Determining the distance of throwing of a pedestrian in a vehicle collision, using PC CRASH 9.0

The investigation of traffic accidents between vehicles and pedestrians was performed with the software package PC CRASH 9.0. 540 traffic accidents were simulated between ten different passenger motor vehicles with different front shapes and pedestrians, specifically, the length of the pedestrian throwing from the point of contact to the final position of the pedestrian was investigated.

The vehicles used for the simulation of these accidents were:

1. Smart City Coupe 0.8 CDi, 30 KW - 2001,
2. Opel Tigra Twin Top 1.4, 66 KW - 2008,
3. Peugeot 206 1.9D - 1999,
4. Ford Escort 1.6, 16v, 66 KW - 1997,
5. VW Passat Variant 3.2, 184 KW FSi - 2008,
6. Mercedes Benz E Class E240 2.4 V6 18V, 125 KW 1998,
7. BMW 530i 200 KW - 2008,
8. VW Sharan 1.8 20v Turbo, 110 KW - 2001,
9. Jeep Cherokee / Liberty 3.7 V6 - 2006,
10. Audi Q7 4.2 FSi, 257 KW - 2010.

Characteristics of the pedestrian: weight: 80 kg and height: 1,795m.

The data on the length of pedestrian throwing by the vehicle are obtained for all ten passenger vehicles where traffic accidents are simulated with a collision speed of each vehicle of 20, 25, 30, 35, 40, 45, 50, 55, 60 km / h with the right side of the vehicle, the middle and the left side, and the position of the pedestrian was explored once with the left foot resting on the ground, and the other was in the air, ie the pedestrian was moving and vice versa with the right foot in the ground and with the left in the air.

5 Empirically obtained data and through software package PC CRASH 9.0

Table 1 shows the results obtained from the analysis of pedestrian throwing in a frontal collision between a vehicle and a pedestrian, ie between ten different vehicles that have a different shape of the front on a pedestrian with a height of 1,795 m. This table compares the data obtained from the software package PC Crash 9.0 and the obtained analyzes using empirical formulas.

Table 1: Data obtained with PC CRASH 9.0 software package and mathematical formulas.

Speed (km/h)	PC CRASH 9.0 (m)	Empirically (m)	Difference (%)
20	4,961	2,778	78,5
25	6,843	4,340	57,67
30	9,293	6,25	48,68
35	12,098	8,507	42,2
40	14,217	11,111	27,95
45	19,095	14,062	35,79
50	22,709	17,361	30,8
55	26,975	21,006	28,41
60	32,309	25,00	29,24

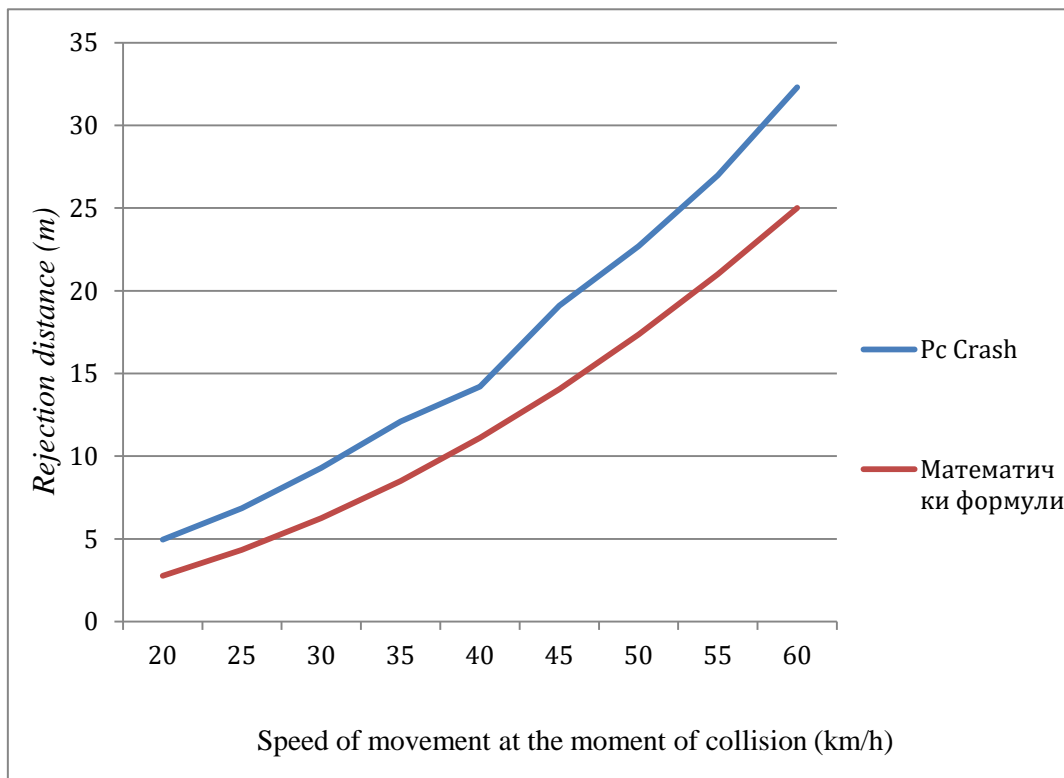


Diagram 1. Comparison of data obtained with mathematical formulas and PC Crash 9.0

6 Vehicle damage caused by a collision with a pedestrian

Fig. 18 by way of simulations shows the vehicle damage in a collision with a pedestrian with a speed of 40 km/h, shows the damage to the side of the vehicle where it covers the windshield.

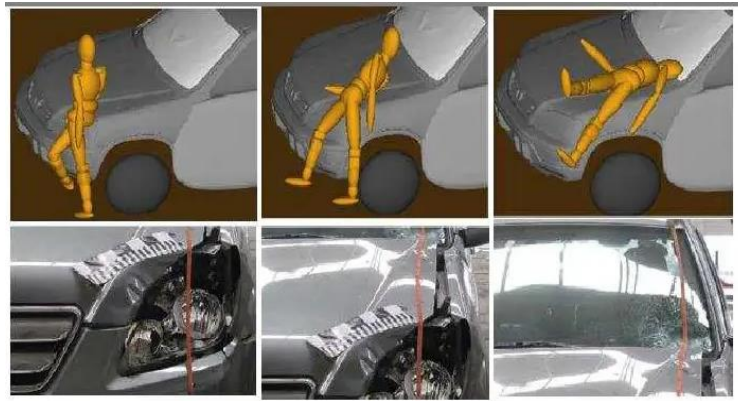


Figure 2. Vehicle damage in a collision with a pedestrian at 40 km/h.

Figure 3 shows the vehicle damage in a collision with a pedestrian at a speed of 60 km/h. At this speed, the damage to the windshield is greater.



Figure 3. Vehicle damage in a collision with a pedestrian at 60 km/h.

Conclusion

Pedestrians are the most vulnerable in traffic, who are often victims in traffic accidents. It is normal that measures should be taken to eliminate or reduce the number of victims in traffic accidents in our case, specifically pedestrians.

The precaution measures that are most often taken to reduce the number of injured pedestrians and reduce the consequences of car accidents are the following:

- Awareness-raising education;
- Organized, restrictive and regulatory measures of the traffic regime of vehicles in the zones with the highest concentration and mobility of pedestrians;
- Technical measures;
- Repressive measures.

Through comparative analysis of the distance of throwing of a pedestrian using different traditional methods and the PC CRASH 9.0 software package, it can be concluded that there are significant differences.

There is also a difference in pedestrian throwing distance between all types of ten different vehicles that have a different shape of the front forehead that comes in contact with the pedestrian body. It is worth noting that from ten different vehicles with different shapes of the front forehead, there is a big difference in the distance of the pedestrian throwing in the Jeep Cherokee vehicle.

There are also small differences depending on whether the pedestrian was leaning on the ground with his left or right foot and whether the pedestrian was hit in the first contact with the left side of the vehicle, the middle, or the right side.

It is preferable to use software programs for analysis of traffic accidents when making traffic expertise. The data obtained from traffic accident simulations with the help of software packages such as PC CRASH, etc., should and is desirable to be compared with the empirically obtained data.

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