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VEHICLE-PEDESTRIAN ACCIDENT RECONSTRUCTION

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Abstract: *Traffic accident involving pedestrians are much different compared to other types of road events. This is certainly due to the different masses in contacts (average mass of a vehicle is 1200 kg and a pedestrian has 80 kg) and different speeds. The result of this collision is easy to predict: the pedestrian always has to suffer. Traces resulting from this type of accident are very important.*
Vehicle-pedestrian accident reconstruction viability depends on the accuracy with which are extracted and recorded, during the primary investigation at the scene, the two samples: location of the vehicle and pedestrian impact and where pedestrian remained after the accident. If these elements are missing, which allowed the direct identification, should be searched and recorded other collateral evidence necessary to establish precisely the first two.
Keywords: *pedestrian, simulation, dynamics, collision, vehicle*

1. INTRODUCTION

A peculiarity of collisions with pedestrians is the time available for pedestrians on one side and the driver on the other side regarding the best decision to avoid the accident.
If a pedestrian crosses the street and gets hit from the left side, his knee bends properly to the shape of the vehicle bumper. Friction force between pedestrians shoe and road surface, keeps shoe on road initially, while the vehicle gives off a force that pushes forward the knee.
This mechanism can cause a fracture of the lower leg bone and cause pedestrian to rotate left, around its center of gravity, up above the hood or the roof, depending on the speed of impact. There is a transfer of mass from his right leg to left one, preventing, in most cases, a fracture of the right leg that is farthest from the vehicle's bumper and behind the initial impact.
The way that pedestrian rotates toward and over the vehicle and lands on the pavement on the road or on sidewalk area is another significant step of the dynamics of accident that requires a detailed analysis.
In the case of an impact of the pedestrian's head with the windscreen, in the crack area may remain hair, fragments of tissue and blood.

Figure 1: Impact with vehicle windscreen

The impact with the pedestrian body generally produces deformation of the car hood. It is necessary to corroborate trauma, primarily of swollen areas located on pedestrian upper body, like the shoulder or elbow or such as those of the hip or knee. Bumper causes the impact at lower leg pedestrian and by comparing the distance from the ground to the lesion with the height of known bumper, it can be established the contact area.

2. DYNAMICS OF PEDESTRIAN-VEHICLE ACCIDENT

From the made measurements to determine the distance of visibility, is chosen for the case study, the simulation of an accident with a pedestrian dummy dressed in yellow in a particular traffic situation.
For the simulation it was chosen a regular car traveling on a road at night, when at one point hits pedestrian traveling on the same lane in the opposite direction.
Pedestrian is drunk and moves irregularly. The chosen car is a Peugeot 206 that runs with a speed of 90 km/h, with low beam and when driver notifies the pedestrian, breaks vigorously. Yellow was chosen because it was determined from made measurements that it reflects a lot of light and is visible from the driver distances. The road is not heavily traveled, being out of town.
Pedestrian has the following characteristics: mass 75 kg, height 1.72 m, speed 4 km/h.
The objectives of the paper were:
• Dynamics of the accident;
• Place of impact in relation to the road surface
• Pedestrian observation distance by the driver in the following circumstances: with or without oncoming vehicle;
• Collision avoidance ways.

2.1. Collision simulation

Accident reconstruction was performed by using specialized software PC Crash 9.1.

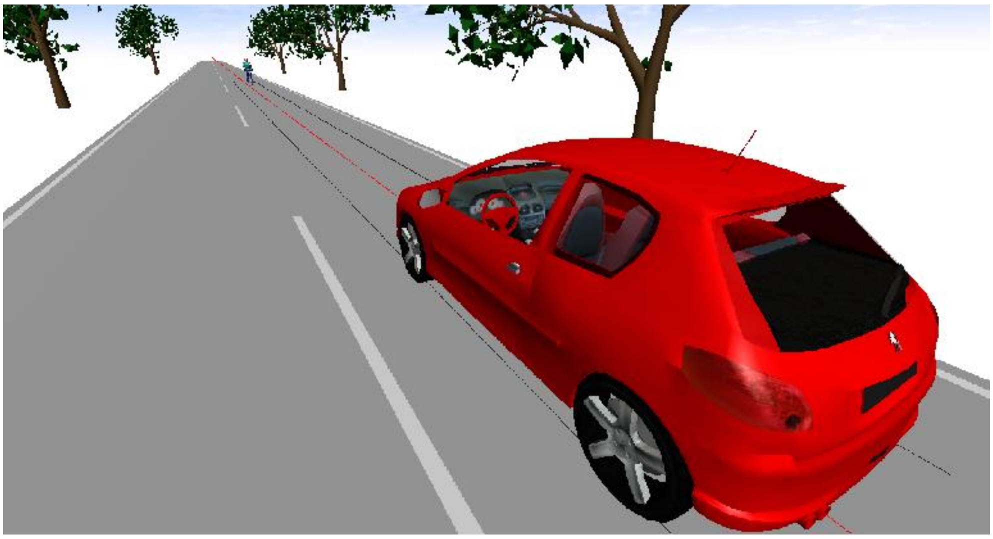

Figure 2: Position of Peugeot 206 when the driver notified the state of danger (about 70m from the pedestrian)

Starting from the set speed ≈ 90 km/h = 25 m/s, it can be calculated the braking space:

$$S_f = \frac{v \cdot t_r}{3.6} + \frac{v \cdot t_i}{3.6} - \frac{\varphi}{12} \cdot g \cdot t_i^2 + \frac{(v - 1.8 \cdot \varphi \cdot g \cdot t_i)^2}{254.2 \cdot \varphi_b} = 45m \qquad (1)$$

where: t_r - reaction time (= 1 s); t_i - the time required to achieve maximum deceleration from the braking start (0.2 s); φ - coefficient of adhesion = 0.7.

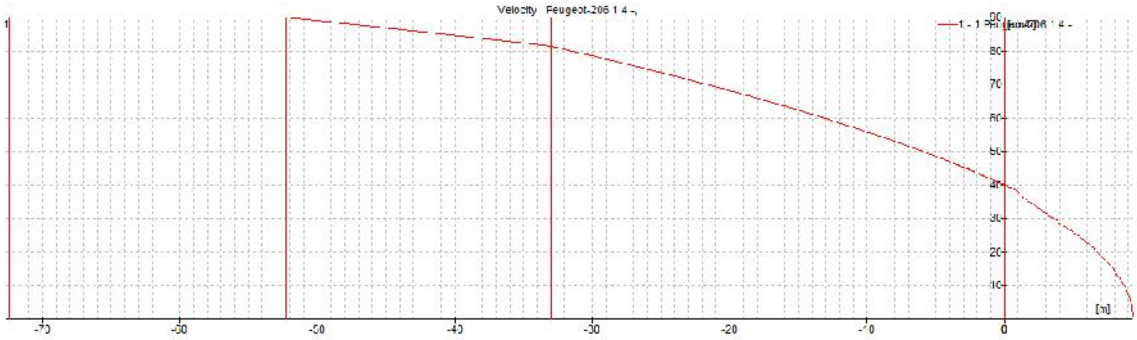

Figure 3: Peugeot 206 speed variation

Average referral distance for pedestrians dressed in yellow, as measured data is about 70m. Following notification exposure to danger, after covering the distance of 25 m corresponding reaction time of 1 s, at night time, the driver does push the brake pedal, resulting in braking printing marks on the road. The time to reach maximum deceleration of -6.87 m/s^2 from the start of braking, for a coefficient of adhesion of 0.7, is 0.2 seconds and vehicle continues to move for approximately 5m. Total braking space is about 46 meters. Pedestrian was hit after the vehicle has braking about 40 m.

The impact was characterized by:

• First contact between car and pedestrian was between the victim's right leg and bumper of the vehicle;

• The impact among the victim's head and the boundary between the hood and windscreen get materialized through the windscreen crack and bruises to the head of the victim;

• slip on the hood and pedestrian separation after completing by the vehicle of a distance of approximately 3.5 m;

• pedestrian slip on asphalt for a distance of about 4.3 m.

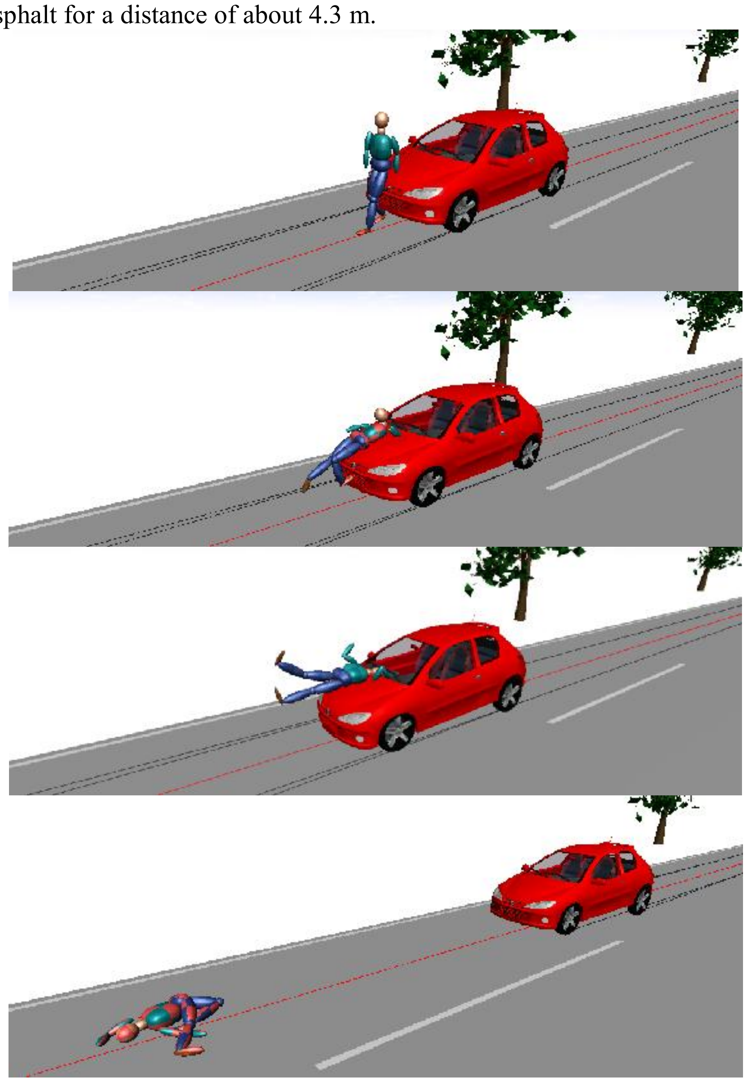

Figure 3: Pedestrian impact stages

The accident was simulated in condition of having an oncoming vehicle or the driver is moving with the low beam. The average distance for a pedestrian is 70 m. Under these conditions the accident cannot be avoided at this distance.
As shown in the table 1, the accident could have been avoided at the speed of 82.8 km/h.
If there is no oncoming traffic and it is used the high beam, the pedestrian would be visible from a distance of between 150 and 200 m, and the accident could have been avoided without problems.

Table 1: Dynamic parameters

	Initial speed **v0 [km/h]**	Speed for maximum brake efficiency **vb [km/h]**	Impact speed **v1 [km/h]**	Braking decelaration **ab [m/s^2]**
Vehicle	90	81.5	40	-6.87
	Time to impact **t [s]**	Reaction time **tr [s]**	Time for braking system activation **tl [s]**	Time elapsed from maximum braking to impact **tb [s]**
	3.56	0.80	0.20	1.96
	Total space **s[m]**	Distance covered during reaction time **sr[m]**	Distance covered from the start of braking until maximum braking efficiency **sl[m]**	Distance covered to impact with maximum braking **sb[m]**
	72.10	20	19.06	33.5
	Avoidance deceleration **aa [m/s²]**	Avoidance reaction time **atr [s]**	Avoidance speed **av [km/h]**	Avoidance space **as [m]**
	7.32	0.38	82.85	82.58

3. CONCLUSION

In real traffic situations, special circumstances most often arise that contribute to road accidents with unpleasant consequences. Among the causes of accidents that occur at night, the most common is the lack of visibility correlated with an improper equipping of the traffic partners.
One with particularly serious consequences is the vehicle-pedestrian accident type, which can be produced from various causes.
This paper aimed to describe the dynamics of the vehicle pedestrian impact by using the simulation software PCCrash, accident generated by the lack of visibility of pedestrians in traffic at night on a road outside the city.
Lack of sufficient visibility is a major contributor to increased risk for driving at night. This is even more evident in the case of accidents involving pedestrians. Human visual performance is limited in adapting to the sudden darkness or from darkness to light.
It may be noted that in these circumstances of the accident occurrence, the speed difference from 90 km/h to 82.85 km/h of the vehicle involved in the accident may determine the avoidance of the accident. We can say that road events that happen in special circumstances, as the lack of visibility at night can be avoided by compliance with road safety regulations, by the use of active safety devices designed to compensate physiological deficiencies of the driver. Under these conditions the improvement of the traffic safety at night, depends heavily on the quality of vehicle lighting systems, whose evolution is growing.

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