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Research Article

An example of a vehicle-pedestrian accident reconstruction by Mathematical and Software Model

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Abstract – During the year 2022, approximately 1165 road accidents occurred in Albania where the number of persons involved in accidents was 1599, while the number of accidents due to the behavior of pedestrians was 167. Referring to the statistics, the increase number of accidents due to the behavior of pedestrian over the year is noticed. In this paper we treat the problem of determining the speed of movement of an accident situation when a vehicle and a pedestrian participate in a crash. As a result of this accident the pedestrian involved remained dead. For determination of speed we focus on the resulting of mathematical simulation and PC Crash software. The aim of this work also is to present a vehicle-pedestrian situation where the accident could not be avoided even with the allowed speed of vehicle.

Keywords – Accident Reconstruction, Vehicle-Pedestrian, Crash, Road, Software

I. INTRODUCTION

Vehicle-pedestrian accidents reconstruction is becoming critical in the field of traffic accident reconstruction. [1] Determining the speed of the vehicle in the accident reconstruction is an important elemt to find the true cause of this accident. In many cases the only elements that remain in place are the final positions of the vehicle and the pedestrian after the crash. Based on these elements, the appropriate model should be used to calculate the speed of the vehicle and to give conclusions about collision process. [2] In this paper, the result of mathematical model is compared with the software method for a vehicle-pedestrian situation. In the study of accidents where the pedestrians are involved, where the analysis must take into account the combination of all relevant information, such as road characteristics (coefficient of friction, slope, physical elements, traces caused by the accident), meteorological conditions, technical characteristics of the vehicle and morphological characteristics of the pedestrian, it is necessary to use specialized calculation tools in the reconstruction of accidents. [3] In this paper we treat the problem of determining the speed of movement of an accident situation when a Benz Daimler Chrysler MLvehicle and a pedestrian who was trying to cross 60km/h signalized road from right to left participate in a crash. As a result, the pedestrian was injured and later died in hospital.

II. VEHICLE-PEDESTRIAN ACCIDENT RECONTRUCTION

Different authors use different methods to calculate the speed of the vehicle at the moment of hit pedestrian. Each of accident have its own specifics so it is important to use them

appropriately methods for concrete conditions of accidents. [4] Some mathematical models treat the pedestrian as a mass point and velocity of vehicle calculated based in throw distance. In this way the total throw distance S as a function of the initial speed v_0 and all of the other quantities (such as pedestrian launch angle θ, initial launch height H, coefficient of friction μ between the pedestrian and the ground, etc.) or the initial speed v_0 as a function of the total throw distance S
and all of the other quantities is obtained. [2] With the help of computer programs, we construct the dynamics of vehicle-pedestrian accident presented in the figures below.

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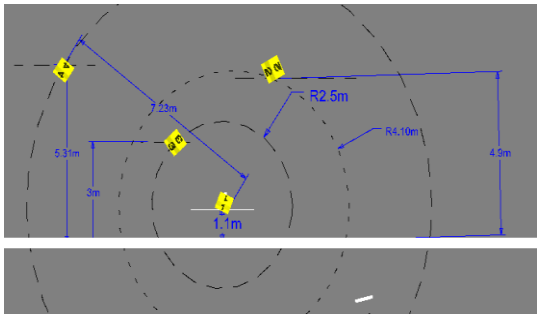

Fig. 1 Analysis of the scene

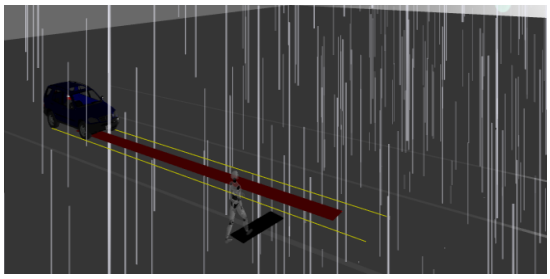

Fig. 2 Conditions of accident occurred

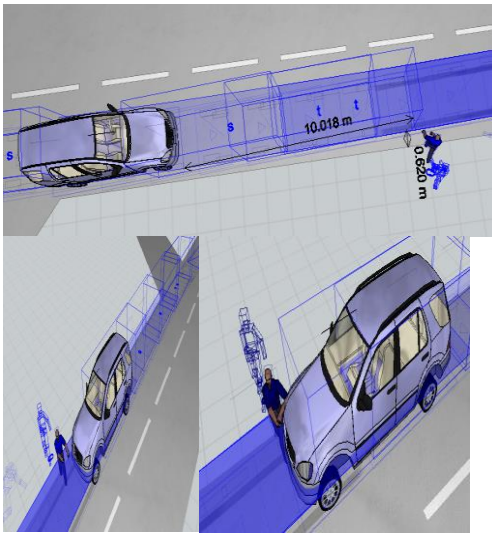

Fig. 3 "Virtual Crash" simulation of "Benz"- pedestrian crash

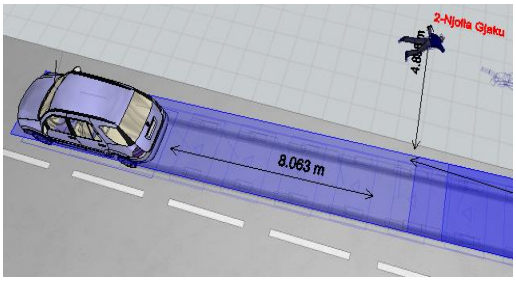

Fig. 4 Pedestrian and vehicle throw after crash moment

III. DETERMINING THE SPEED OF MOVEMENT OF THE ACCIDENT SITUATION BY MATHEMATICAL AND SOFTWARE MODEL

Baset on the distance of the pedestrians throw from the point of hit of impact and until he fell, as well as the fact that the distance of the pedestrian from the boundary line of the inspection of the scene is 4.9 m, and the position of the pedestrian with the vehicle, the point of contact which is located in the right front of the vehicle, we conclude that the speed of the vehicle before the hit is 67.559 km/h, realized by the computer program.

$$V_h = L\sqrt{\frac{g}{2 \cdot h}} = 9.877\sqrt{\frac{9.81}{2 \cdot 1.35}} = 18.8268\ m/s$$
$$= 67.77 km/h$$

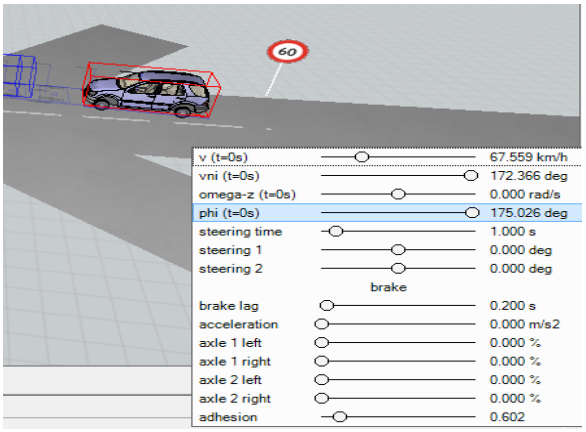

Fig. 5 The speed of vehicle before crash

Furthermore, by computer programs we conclude that the possible point of impact is 1.678 m from the initial position of the pedestrian and 22.337 m from the initial position of the vehicle, fig 6.

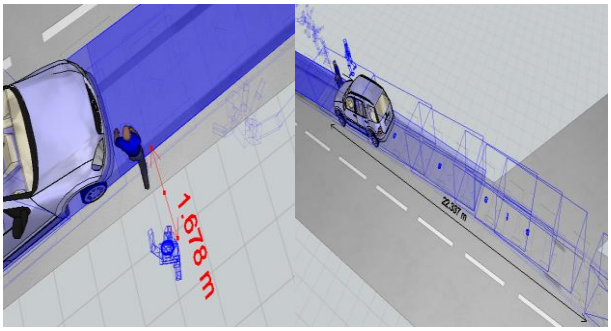

Fig. 6 The distance of the pedestrian and the vehicle to the potential point of crash

The distance of the pedestrian from the boundary line to the possible poit of crash is 0.769 m, while the distance of the vehicle from the boundary line is 0.653 m. The following figure shows the distance from the source of danger to the point of crash for the vehicle and for the pedestrian.

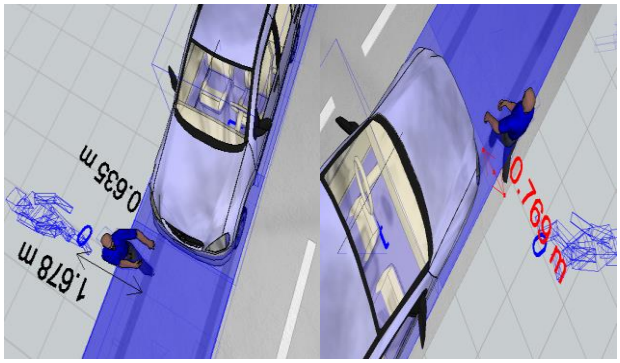

Fig 7. The distance of the pedestrian from the boundary line to the possible poit of crash

Then, we determine the time of pedestrian's movement from the moment of the possible point of crash to the moment of collision according to the formula:

$$t_{pedestrian} = 3.6 \cdot \frac{S_k}{V_k} = 3.6 \cdot \frac{1.678}{5} = 1.20816\ s$$

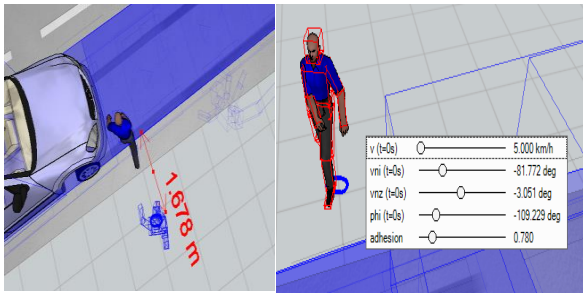

Fig 8. The time of pedestrian

The time it takes the driver of vehicles to slow down:

$$t_{af} = t_1 + t_2 + 0.5 \cdot t_3 = 1.20816\ \text{s} \approx 1.2\ s$$

t_1-reaction time of the driver

t_2-the delay time of the braking mechanism

t_3-deceleration rise time

Since $t_k = t_{af}$ the driver of the vehicle does not have the technical possibility to avoid the crash, because the time of movement was so short that the complete braking of the vehicle could be achieved after the crash. The speed of vehicle by which this accident can be avoid is:

$$V_s = 3.6 \cdot \sqrt{(a \cdot t_{af})^2 + 2aS_d} - 3.6 \cdot a \cdot t_{af}$$
$$= 3.6 \cdot \sqrt{(5.904 \cdot 1.20816)^2 + 2 \cdot 5.904 \cdot 22.337} - 3.6 \cdot 5.904 \cdot 1.20816 = 38.1778\ km/h$$

IV. CONCLUSION

The most important part of the paper is the possibility of determining the speed of movement of an accident situation when a vehicle and a pedestrian participate in a crash. After the above analyses, we conclude that the vehicle-pedestrian accident could not be avoid with the speed of vehicle 67.559 km/h, not with the permitted speed of 60 km/h, also not with speeds lower than 50.40 km/h. According to the software calculation the accident occurred could be avoided at a speed of 39.6 km/h, so the determining cause of the accident is the violation of the traffic rules by the pedestrian.

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