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VEHICLE SPEED DETERMINATION IN CASE OF ROAD ACCIDENT BY SOFTWARE METHOD AND COMPARING OF RESULTS WITH THE MATHEMATICAL MODEL

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Abstract: The paper addresses the problem to vehicle speed calculation at road accidents. To determine the speed are used the PC Crash software and Virtual Crash. With both methods are analysed concrete cases of road accidents. Calculation methods and comparing results are present for analyse. These methods consider several factors such are: the front part of the vehicle, the technical feature of the vehicle, car angle, remote relocation after the crash, road conditions etc. Expected results with PC Crash software and Virtual Crash are shown in tabular graphics and compared in mathematical methods.

KEYWORDS: Velocity, vehicle, collision, road angle, distance simulation.

1 Introduction

In many court cases involving traffic accidents, the determination of the speed of the vehicles participating in the accident is the most important analysis in delivering final results to find the true cause of the accident.

Different experts use different methods for calculating the speed of the vehicle. Each of the accidents has specific specifications, so it is important to use adequate methods for the concrete conditions of accidents. In this paper are the results of some calculation forms with the software method for two different accidents

Accidents occurred in different conditions and in those cases four vehicles with different technical characteristics were included.

2 Accident data analysis between "Opel Vectra", "Nissan", "Audi" and "Renault

Technical characteristics of vehicles involved in the accident are shown in Table 1.

Table 1. Main characteristics of vehicles

Technical characteristics	*Vehicles included in road accidents cases*			
	Opel Vectra	*Nissan*	Audi	Renault
Type	X16SZR	CG A3 DE	***8E***	-
Engine type:	*Gasoline*	*Gasoline*	*Otto*	*Otto*
Engine power [kW]:	55	55	110	43
Weight [kg]:	1185	810	1460	855
Length [m]:	4.5	3.72	4.55	3.43
Width [m]:	1.71	1.58	1.77	1.63
Height [m]:	1.42	1.42	1.42	1.42

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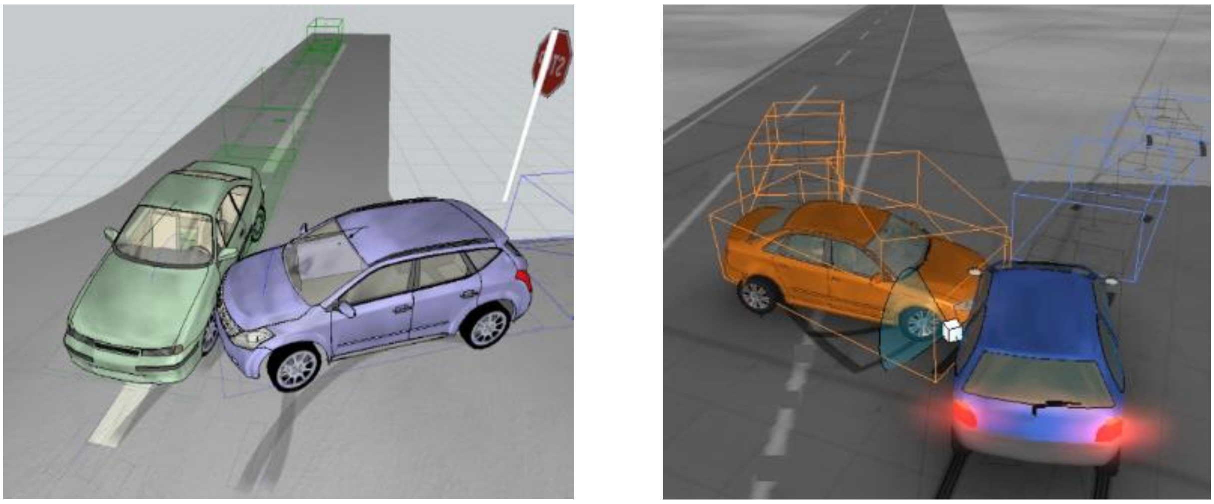
Track width [m]:	1.465 / 1.47	1.365	1.52	1.415
Wheelbase [m]:	2.64	2.36	2.65	2.35
Tire dimensions :	195/65R15/5.5J	175/60R 13/5J	205/55R16W	205/55R16W
Accel. 0-100 [km/h]:	15.5	12	10.5	13.4
Type of road	*Local road*			
Number of lanes	*1 lanes for directions*			
Vehicle traffic	*average*			
Road condition	*asphalt and dry*			
Visibility	*Not good*			

The collision process between vehicles "Opel Vectra" and "Nissan" occurred while those vehicles were moving in different directions at angles around 70 ° (Fig. 1a). After collision with "Nissan", "Opel Vectra" with frontal part hit a collision with an Obstacle outside the street. After the crash, the final position of the Opel Vectra was approximately 58 m from the collision position, while the Nissan vehicle was stopped at a position of about 5 m from the collision position (Fig. 2a). While the collision process between vehicles "Audi" and "Renault" occurred while Audi was turned left and “Renault” was moving straight ahead (Fig. 1b). After the crash, the final position of the “Audi” was near collision position and “Renault” was stopped at a position about 32 m from the collision position (Fig. 2b).



a) b)

Fig. 1 Collision positions

3 Speed of vehicles by software PC-Crash

With software simulations “PC-crash” based in final positions of vehicles “Opel Vectra”, “Nissan”, “Renault” and “Audi” (Fig. 2.) after crash and approximately in the same condition of road are acquired those results of velocities, Fig. 3.

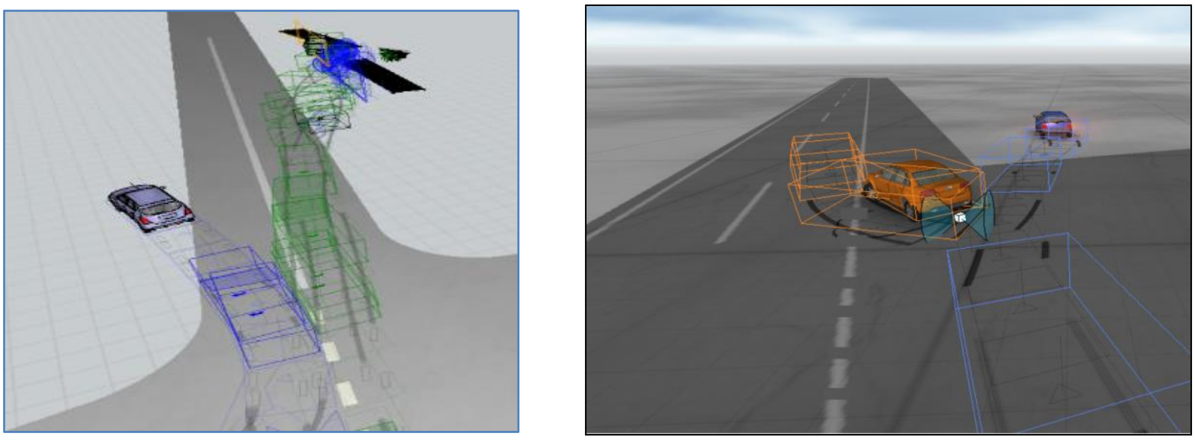


Fig. 2 Final positions of vehicles after crash

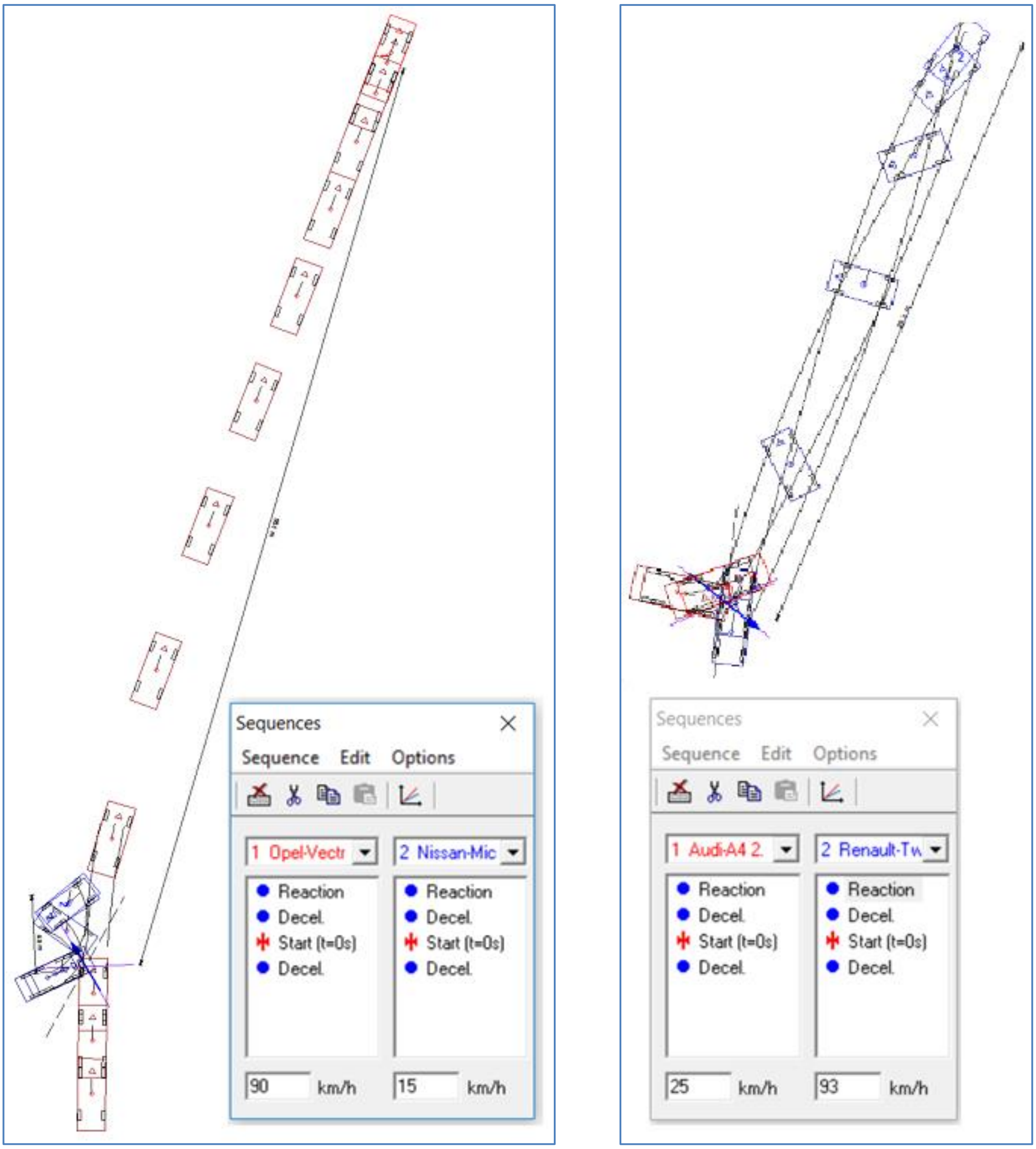
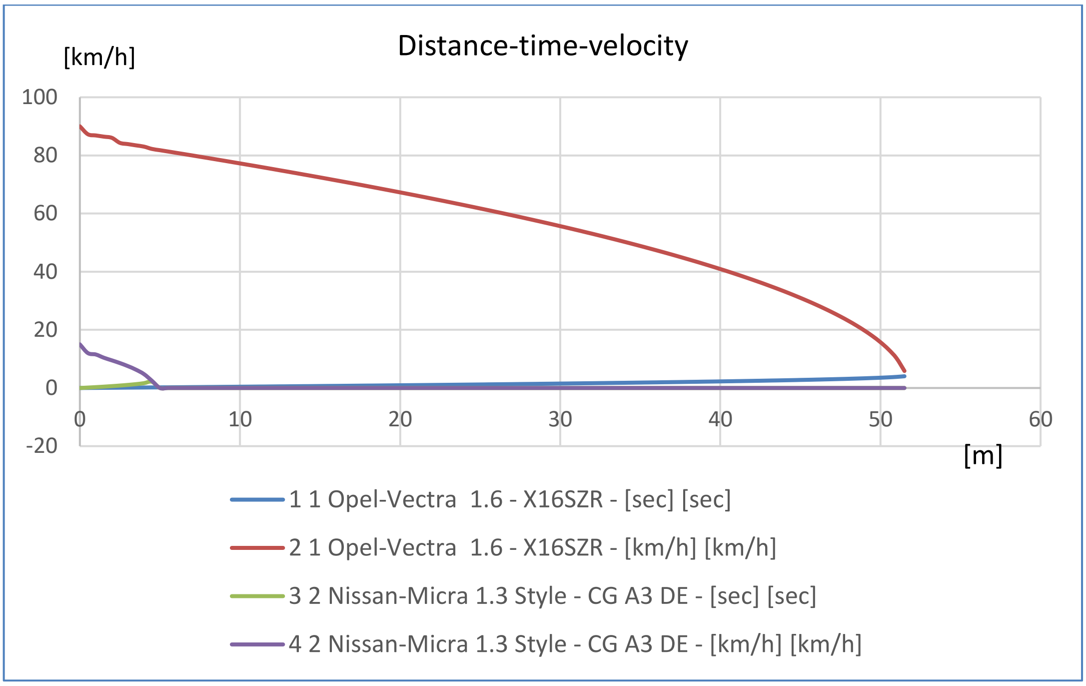


Fig. 3 PC Crash simulation and calculation of velocities of vehicles



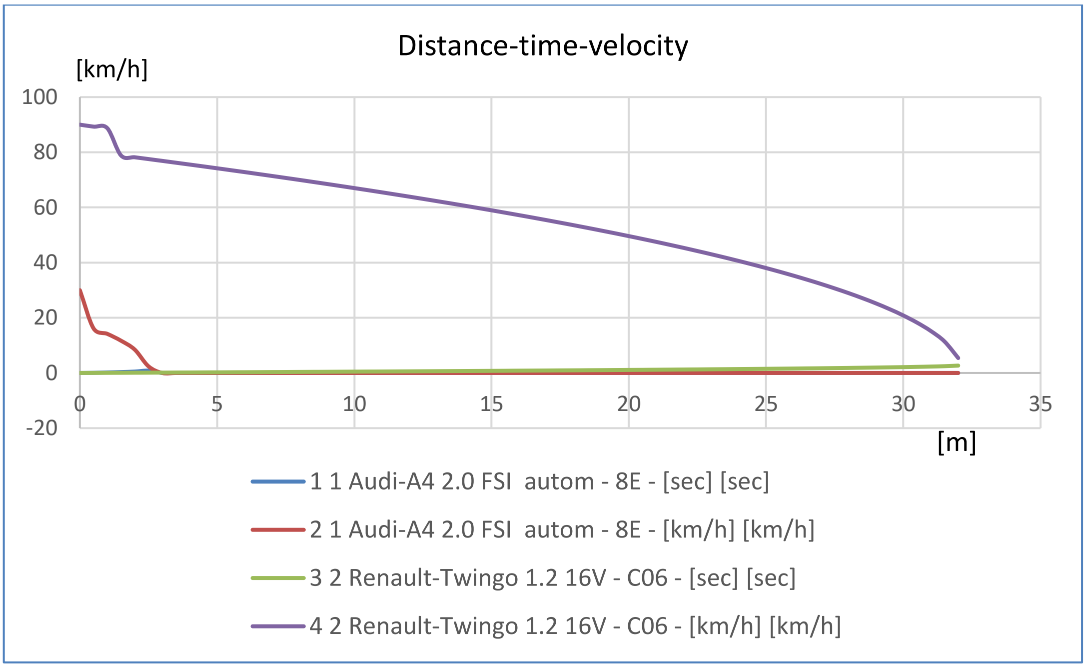


Diagram 1. Report distance – time – velocity

From the simulations and the diagram shown above, we conclude that for the obtained velocity with PC-Crash, the technical process of the accident and final positions of vehicles are identical with the first data from the venue of the crash.

Also with PC-Crash Software, based on deformation of vehicles (Fig. 4) "Renault" and “Audi” is calculated as lost velocity in deformation (Fig. 5). Same procedure is used for vehicles “Opel Vectra” and “Nissan” and results are shown in Table 3.

Fig. 4 Deformations of vehicles “Renault” and “Audi”

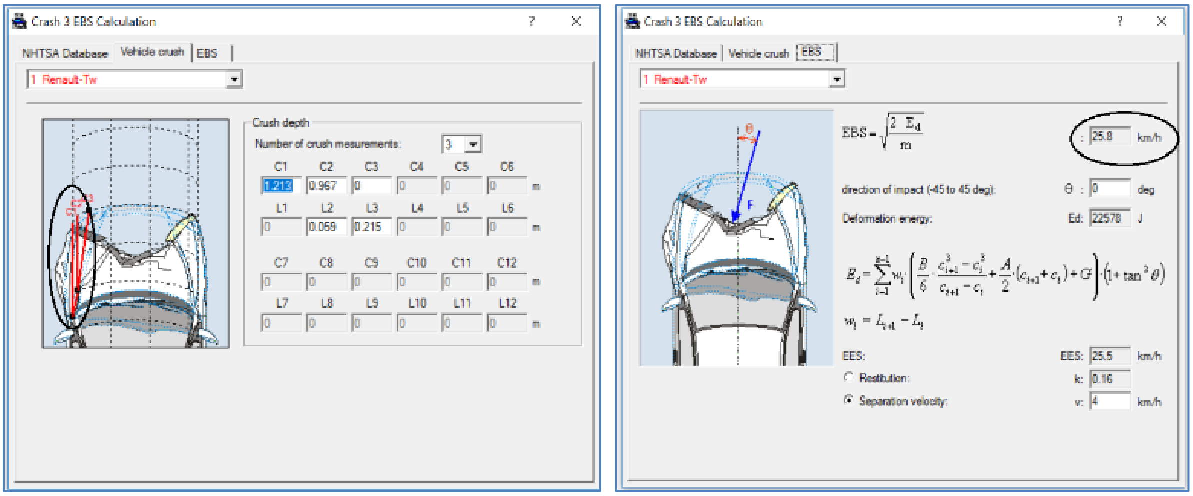
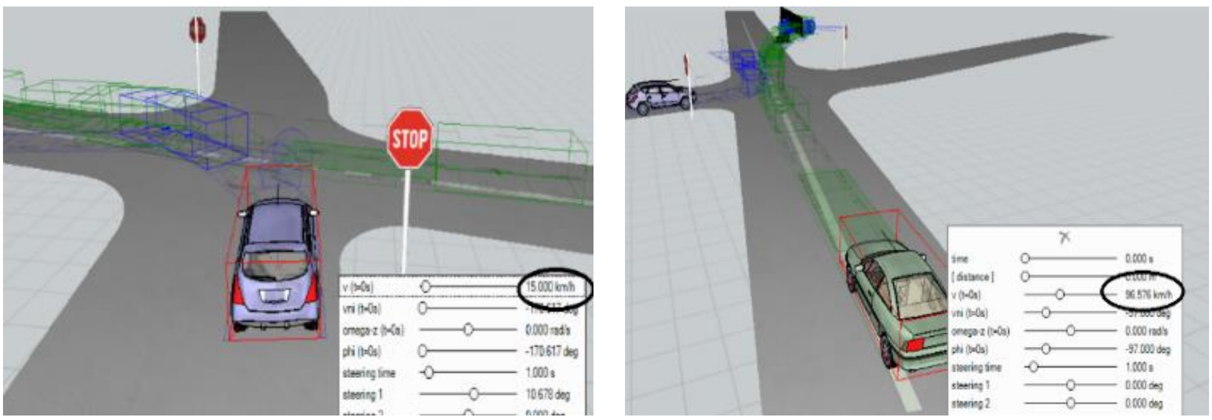


Fig. 5 PC Crash calculation of lost velocity in deformation of “Renault”

4 Speed of vehicles by software Virtual Crash

For the same data of accident, with simulations by Virtual Crash software based on the final positions of vehicles "Opel Vectra", “Nissan”, "Audi" and “Renault” after crash and approximately in the same condition of road are the acquired results of velocities shown below (Fig. 6).



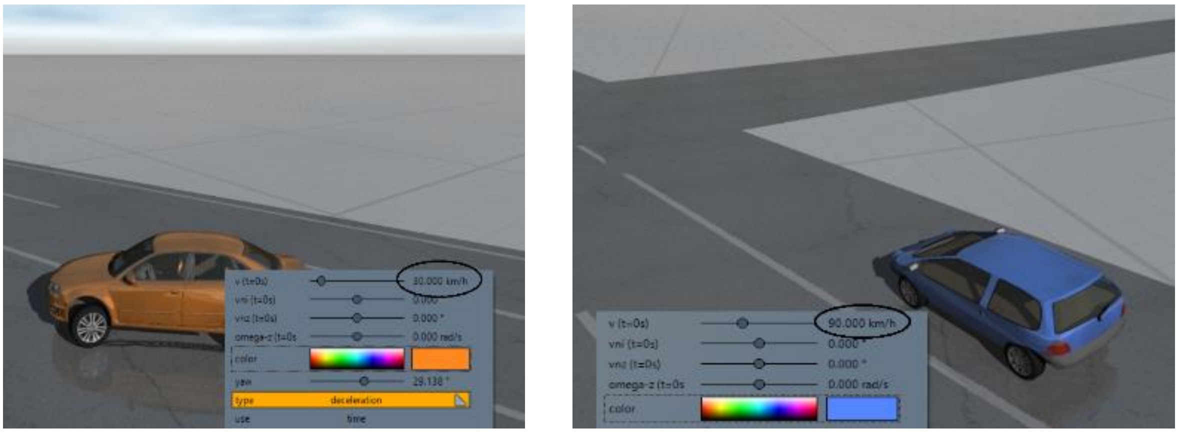


Fig. 6 Virtual Crash simulation and calculation of velocities of vehicles “Opel Vectra”, “Nissan”, “Audi” and “Renault”

Results obtained by Software Methods (PC-Crash and Virtual Crash) are shown in Table 2.

Table 2. Results of speeds

Results of speeds *v* [km/h] Software method	Vehicles			
	Opel Vectra	Nissan	Audi	Renault
PC-Crash	90	15	30	90
Virtual Crash	96	15	25	93

5 Speed of vehicles by mathematical model

This mathematical model is based on the vehicles distance from collision position to final position, break (m/s^2) and deformation energy (EBS).

Based on the mathematical model, the speed of the Opel Vectra Vehicle is calculated and presented below:

$$V_{Vectra} = 3.6 \cdot \sqrt{2 \cdot a_2 \cdot S_{pgn} + (\Delta v)^2} = 3.6 \cdot \sqrt{2 \cdot 2.5 \cdot 58 + (20)^2} \approx 94.5\ [km/h]$$

Deformation energy (EBS) for Opel Vectra vehicle is calculated based on deformation of this vehicle. This vehicle had deformation at the frontal and the left side. Lost velocity at deformation is calculated by this equation:

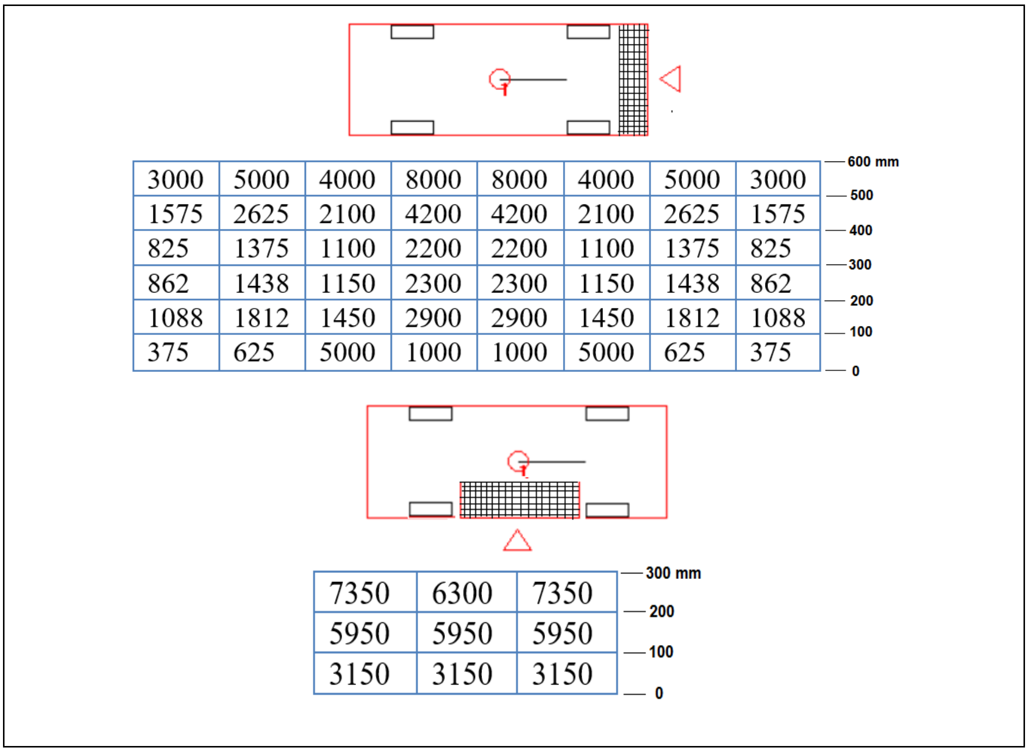
$$\Delta V_{gVectra} = 3{,}6\sqrt{\frac{2 \cdot A \cdot K_1 \cdot K_2}{m_0}} = 3.6 \cdot \sqrt{\frac{2 \cdot 137996 \cdot 1.2 \cdot 1.24}{950}} \approx 75\ [km/h]$$

$K_1 = 1.2$, coefficient of sustainability correction

$K_2 = \frac{m}{m_0} = \frac{1185}{950} = 1.24$, coefficient of mass correction.

$A_d \approx 137996\ [N \cdot m]$, deformation energy (Fig. 7).

Same procedure is used for vehicles “Audi” and “Renault” and results are shown in table 3.



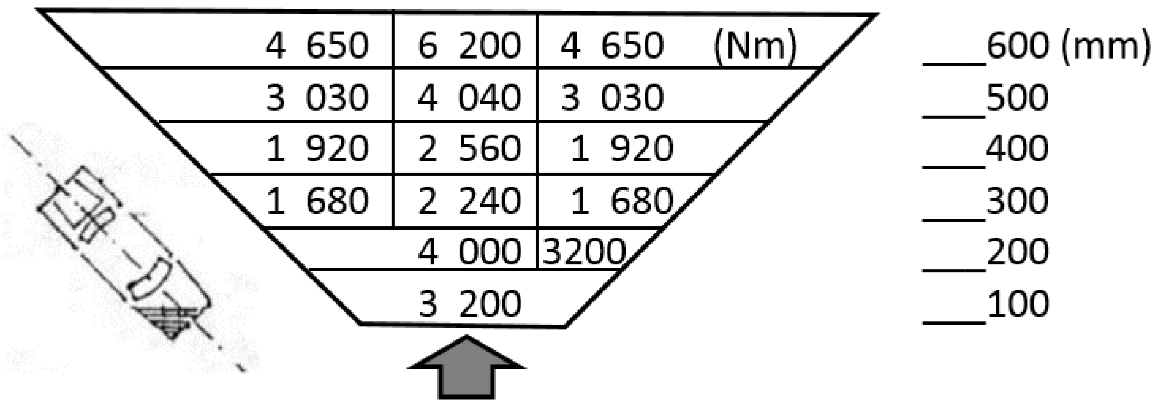
3000	5000	4000	8000	8000	4000	5000	3000
1575	2625	2100	4200	4200	2100	2625	1575
825	1375	1100	2200	2200	1100	1375	825
862	1438	1150	2300	2300	1150	1438	862
1088	1812	1450	2900	2900	1450	1812	1088
375	625	5000	1000	1000	5000	625	375

7350	6300	7350
5950	5950	5950
3150	3150	3150

Fig. 7 Energy deformation for frontal and side deformations of vehicle

Same, based on mathematical model, the speed of Nissan vehicle is calculated and presented below:

$$V_{Nissan} = 3.6\sqrt{2a_2S_{pgn} + (\Delta v)^2} = 3.6 \cdot \sqrt{2 \cdot 3 \cdot 5 + (3.8)^2} \approx 23 \ [km/h]$$



4 650	6 200	4 650 (Nm)	600 (mm)
3 030	4 040	3 030	500
1 920	2 560	1 920	400
1 680	2 240	1 680	300
	4 000	3200	200
	3 200		100

Fig. 8 Energy deformation for angular deformations of vehicle

$$\Delta V_{gNissan} = 3.6\sqrt{\frac{2A \cdot K_1 \cdot K_2}{m_0}} = 3.6\sqrt{\frac{2 \cdot 6800 \cdot 1.2 \cdot 0.85}{950}} \approx 13.7 \ [km/h]$$

$$K_1 = 1.2$$

$$K_2 = \frac{m}{m_0} = \frac{810}{950} = 0.85$$

$$A_d \approx 6800[N \cdot m].$$

Same procedure is used for vehicles "Audi" and "Renault" and results are shown in Table 3.

6 CONCLUSIONS

In this paper, several input parameters have been defined and their influence in software and mathematical model. Real collision simulations done in crash tests, where the largest number of input parameters has been known, have been used for determining which of the input parameters has the biggest influence on the simulation error of determination of velocity. In simulation process with PC Crash and Virtual Crash is important to find the adequate collision angle between vehicles because this determination the speeds of vehicles that consist with final positions vehicles after collision. As seen from the comparison of results obtained in Diagram 2, results obtained by software PC Crash, Virtual Crash and mathematical model are approximate same.

Differences between results obtained of velocities through three methods used (PC Crash model, Virtual Crash model and mathematical model) for vehicles with different technical characteristics showed in Table 3 and Diagram 2.

Table 3. Results from PC Crash model, Virtual Crash model and mathematical model

Vehicles	Results of velocity v [km/h]			Results of lost velocity in deformation Δv [km/h]	
	PC Crash	Virtual Crash	Math. model	PC crash	Math. model
Opel Vectra	90	94	94.5	72	75
Nissan	15	15	23	14.1	13.7
Audi	30	25	27	25.8	28
Renault	90	93	90	10	14.5

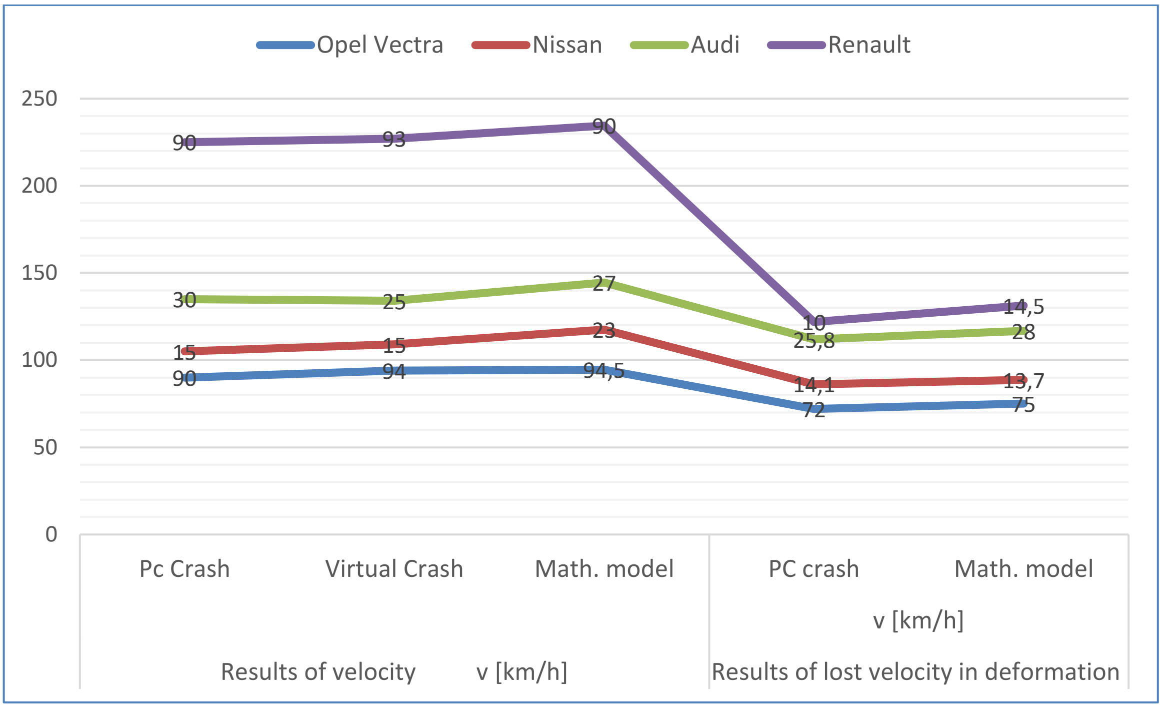


Diagram 2. Comparing the results

The mathematical method is the appropriate method for calculating the velocities of motion of vehicles before the crash. Especially when the brake parameters and deformation energy are accurate. The paper findings can help researchers work in collision simulation and make it more efficient.

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