

COMPUTATIONAL ANALYSIS OF THE VEHICLES COLLISION

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Abstract

During the transport, many factors can lead to the traffic accident. The highest number of accidents on the Republic of Serbia, where two vehicles participated are frontal collisions. In the paper are conducted two computational simulations of vehicles frontal collision, where in the first case, the vehicle one had speed of 90 km/h, and the second vehicle had the speed of 60 km/h, while in the second case, the speed of the vehicle 1 was 60 km/h, while the speed of the vehicle 2 was 90 km/h. both simulations were conducted in PC-Crash software package, which represent the special software for traffic accidents simulation. After the simulations, in the paper are presented the propositions and measurements for the reduction of the number of traffic accidents. On the basis of the conducted research, were drawn conclusions what should take into the consideration during the production of new vehicles.

Keywords: traffic accident, frontal collision, PC-Crash, measurements for reduction.

1 INTRODUCTION

According to the data from the Road Traffic Safety Agency, the most often type of the traffic accident for the year 2024., from the group of accident where participated at least two vehicles, was the frontal collision[1]. The greatest number of traffic accidents in the Republic of Serbia was caused by human error. The frontal collision, Figure 1, represents the collision of frontal parts of two vehicles, which are driven in opposite directions. This kind of collision causes the deformation of the frontal part of the vehicle, while the speed of the vehicle before the collision, contributes to the

deformations size, as well as to the damages level. The causes which lead to the frontal collision are [2]:

- Sleepiness,
- High speed driving,
- Driving under the influence of alcohol or narcotics,
- The weather conditions and similar.

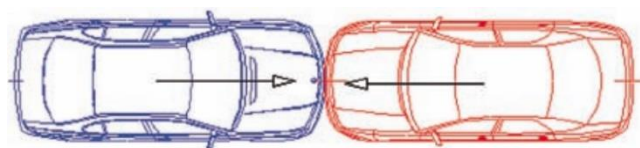


Fig. 1 Frontal collision [3]

In the case of the frontal collision, it can come to the fatal outcome, or to the injury of the driver and passenger, as well as to the damage of the vehicle. When it comes to the traffic accident, it is necessary to determine who have contributed to the traffic accident occurrence, and which speeds vehicles had before the accident. Today, exists a great number of software's which make more easier the determination of the vehicles speed before the collision. The speeds can be determined by application of specialized software's such are the PC-Crash, or by software's which use the finite elements methods such is the LS Dyna [4-6]. Besides the great number of software's, the specialized software's have found the greatest application. The amplification of the level of the traffic safety, is the significant subject. The amplification of the safety will lead to the decrement of the number of injured as well as the number of fatal outcomes, and this can be accomplished by analysis which type of accident is most often, and how to avoid it. The main aims placed in front of this research are next:

- To give the review which types of traffic accidents are the most often.
- To give the methods which are in use for the analysis of traffic accidents, as well as which method have found the greatest application.
- To present on characteristic traffic accident which occurs quite frequently.
- To presents the measures for the reduction of number of traffic accidents, as well as measures for the reduction of consequences of traffic accidents.

In the introduction is presented which is the most dominant type of traffic accident, where participated two vehicles. After that are presented the methods which are in use for the presentation and analysis of two vehicle collision. How the specialized software's found the greatest application, in this paper will be applied the PC-Crash. In the third part of the paper is presented a characteristic case of the example of frontal collision of two vehicles. The fourth chapter of the paper presents the measures and proposals for the reduction of the number of traffic accidents, as well as for the reduction of consequences of traffic accidents.

2 THE METHOD AND SUBJECT OF RESEARCH

In this study it is applied the PC-Crash software package for the analysis of mechanics of the two-vehicle collision.

The analyzed vehicles are considered as linear, while the data about their mass, inertial moments and similar, were taken from the data base of the used software. Before the simulation, the distance between the center of gravity of vehicle 1 and center of gravity of vehicle 2 was 44 m. the vehicles moved straight ahead (Figure 2) on the dry road, where the friction coefficient was 0.7. before the collision, the speed of the vehicle 1 was 90 km/h while the speed of the vehicle 2 was 60 km/h. the restitution coefficient amounted 0.2. the basic characteristics of vehicles are presented in the Table 1. The collision type was frontal. After the collision, both drivers were braking, the driver's reaction time was 0.96 s, the time of the braking system response was 0.2 s. the deceleration for both vehicles was 0.6 m/s^2 .



Fig. 2 Defining of the vehicles position and driving direction

Table 1 Vehicles characteristics

	Vehicle 1	Vehicle 2
Manufacturer	AUDI	FIAT
Name	A3	Brava 1.4 12V
Type	8L	182
Weight, kg	1220	1040
Lenght, m	4.15	4.19
Drive mode	Front	Front
Distance C.G. - front axle, m	1.0	0.94
Roll moment of inertia, $\text{kg} \cdot \text{m}^2$	483.8	421.37
Pitch moment of inertia, $\text{kg} \cdot \text{m}^2$	1612.66	1404.57
Yaw moment of inertia, $\text{kg} \cdot \text{m}^2$	1612.66	1404.57
Stiffness, front axle, N/m	23999.98	21422.36
Stiffness, rear axle, N/m	15894.02	12585.64
Damping, front axle, $\text{N} \cdot \text{s/m}$	2700.00	2410.02
Damping, rear axle, $\text{N} \cdot \text{s/m}$	1788.08	1415.88
ABS	No	

3 RESULTS AND DISCUSION

In this chapter of the paper is presented the collision of two vehicles which are moving in opposite directions. It is given the presentation in which direction will vehicles continue to move after the collision. Besides that, are presented the speeds before and after the collision, as well as the speeds difference. Also are presented the total deformation energy and impulse.

In the first case, the vehicle 1 which has greater mass than the vehicle 2, also had the greater speed than the vehicle 2. On the Figure 3 is given the position of the vehicles after

the collision. Vehicle 1 after the collision continued to move in the same direction, while the vehicle 2, have changed the direction, Figure 3.

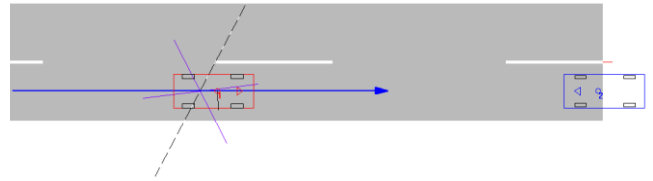


Fig. 3 Vehicles position after the collision – case 1

The graph on the Figure 4 represents the speeds change, as well as the entire road, which the vehicles passed during the simulation. The red line represents the speed of the vehicle 1, while the blue line represents the speed of the vehicle 2. Before the collision, both vehicles had a constant speed, what is presented with the lines parallel to the horizontal axis. After the constant speed, it is recorded the sudden fall of the speeds, what actually represents the moment of the collision. After the collision both vehicles continued to move. However, the vehicle speed had the greater speed after the collision, compare to the vehicle 1. The happened because the vehicle 1 had greater kinetic energy due to the greater mass and greater speed before the collision. Quick after the collision, the drivers started to brake, and vehicles stopped.

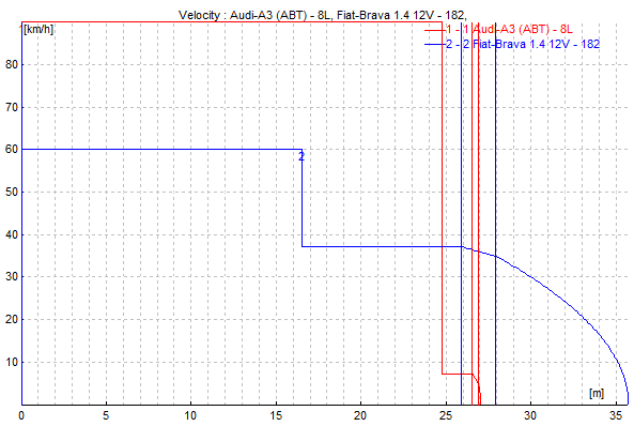


Fig. 4 Simulation of a collision of motor vehicles running in the same direction and their speed–distance diagram – case 1

The detail data about vehicle speeds before and after the collision are given in Table 2. From the beginning of the simulation until the collision, passed 0.99 s. the deformation of the vehicle 1 amounted the 0.46 m, while the deformation of the vehicle 2 amounted the 0.47 m, where the energy consumed by vehicles deformations was 467846.61 J.

Different from the first case, for the second case, that is, for the second simulation, the speed before the collision, of the vehicle 1, was 60 km/h, while the speed of the vehicle 2 was 90 km/h. In this case, the vehicles literately bounced one from another, that is, continued to move in opposite directions, Figure 5. The change of the moving direction can be seen in respect to the plane of collision. The collision plane, on the Figure 5 is presented with dashed line.

The graphic representation of speeds change is presented with Figure 6. After the collision, the vehicle which had

greater speed before the collision, it has lower speed, what can be seen in the Table 3.

Table 2 Report case 1

	Возило 1	Возило 2
Time, s	0.99	
Pre impact velocity, km/h	90	60
Post impact velocity, km/h	7.17	37.17
Velocity change (dV), km/h	82.83	97.17
Deformation depth, m	0.46	0.47
EES (Equivalent Eergy Speed), km/h	70.12	76.76
dV/EES, -	1.18	1.27
Total deformation energy, J	467846.61	
Impulse, Ns	28070.80	

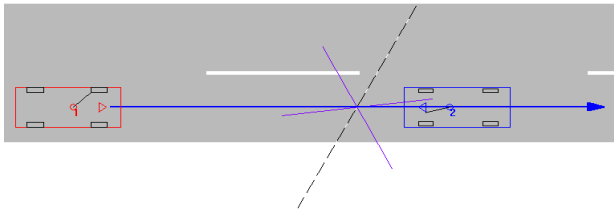


Fig. 5 Vehicles position after the collision – case 2

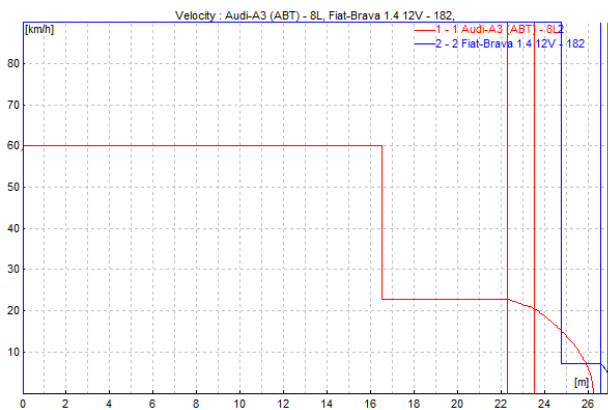


Fig. 4 Simulation of a collision of motor vehicles running in the same direction and their speed–distance diagram – case 2

By observing simultaneously Table 2 and Table 3, it can notice that the speeds change in both cases is the same, as well as the deformation depth, total deformation energy and impulse. Only what is different are the speeds after the collision.

Table 3 Report case 2

	Возило 1	Возило 2
Time, s	0.99	
Pre impact velocity, km/h	60	90
Post impact velocity, km/h	22.83	7.17
Velocity change (dV), km/h	82.83	97.17
Deformation depth, m	0.46	0.47
EES (Equivalent Eergy Speed), km/h	69.92	76.97
dV/EES, -	1.18	1.26
Total deformation energy, J	467846.61	
Impulse, Ns	28070.80	

4 MEASUREMENTS AND PROPOSALS FOR THE REDUCTION OF NUMBER AND CONSEQUENCES OF TRAFFIC ACCIDENTS

Today, with the development of the intelligent vehicles, the systems for the collisions avoidance have drawn a great attention. One of the ways to reduce the consequences of the traffic accidents is the application of collision mitigation systems. Collision mitigation systems is the part of the group of advanced driver assistance systems, which use systems such is the radar, cameras (Figure 6) and lasers for the environment following. Thanks to this, this system prevents the traffic accidents, or at least it reduces the consequences. This system warns the driver on the potential accidental situations, and when is necessary it takes control under some vehicles controls such is the braking, or direction management.



Fig. 6 Advanced driver assistance systems (ADAS)[7]

The advanced driver assistance systems include prediction and detection of protentional danger, as well as decision making [8]. On such system which is in use at vehicles, and which task is to prevent accidents, is the multi-agent coordinated control system. This system consists a great number of agents, such are agents for lane tracking, agents for global planning and agents for actuators control[9].

Besides the use of intelligent systems on vehicles, the consequences of traffic accidents can be reduced and by vehicle redesign[10].

By vehicle redesign, its meant on the optimization of size and layout of frames, all with aim to provide as great as possible absorption of the impact energy[11]. Besides the redesign, also the materials have important role in the reduction of traffic accidents consequences[12].

5 CONCLUSION

Nowadays, the traffic safety is quite actual subject. Traffic accidents with injuries and fatal outcomes, are also and economic lost how for the family also and for the country. The research conducted in this paper, indicates on the next conclusions:

- In Republic of Serbia, for the year 2024., the dominant traffic accident type wherehave participated two vehicles, was frontal collision.
- The specialized software's have found a great application for the expertise of traffic accident.
- The vehicles speed influences on the vehicle's direction after the collision.

- The total deformation energy was the same for both cases of simulation.
- The advantage systems can reduce the number of traffic accidents.
- The vehicle redesign can reduce the consequences of traffic accidents.

In the future researches it should conduct the reconstruction of the traffic accident, in order to avoid traffic accident, or to reduce the consequence of the traffic accident. Also, in the future researches, it should conduct the survey on drivers, in order to determine their habits.

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