Abstract. The article deals with investigation of the possibilities of the program PC CRASH, meant for the computer modeling of the movement of vehicles. The computer modeling of the process of overturning of the automobile with the help of the program PC CRASH is introduced. The cross profile of the road, the height of the centre of gravity of the automobile and the other parameters are evaluated while modeling. The influence of the introduced parameters upon the computer modeling results is investigated. The possibilities of application of the computer modeling programs in the expert assessment of the traffic accidents are considered, the items on reliability of the results of modeling and the requirements, raised towards the experts, who work with such programs, are analyzed.

Keywords: automobile, overturning, computer modeling, traffic accident, examination.

1. Introduction

At present many computer programs for modeling of the movement of vehicles, which are usually meant for investigation of the traffic accidents, have been created in the world. These programs become more and more improved, seeking to evaluate as many factors as possible so that the results of the computer modeling are brought closer to the results of the real experiments.

Modeling of interaction of the wheel with the road is one of the most important components of the computer modeling. The main goal is to bring modeling of interaction of the wheel with the road as close to reality as possible. Firstly, it depends upon the selected mathematical model. The more factors are evaluated while creating the program or while improving it, the more precise results will be obtained while using this program. On the other hand, much depends upon the introduced parameters. While modeling the movement of the vehicle with the help of the computer program, many various data are introduced; for example, while modeling the process of braking, it is necessary to introduce the coefficient of cohesion (or the deceleration), loading of the automobile, the time of starting the drive of the braking system to operate, the time of increase of the deceleration, if necessary, the time of disbraking. There could be more parameters, if the automobile moves along different surfaces or when the movement of several automobiles is being modeled; for example, the mechanism of the traffic accident and the automobiles, which are moving according to different regimes. Non-precision of each introduced parameter increases the error of the results of modeling. Thus, it is very important to introduce as more precise parameters as possible [1–10].

2. Computer modeling program PC CRASH

The program PC CRASH is one of the computer programs, meant for modeling of the movement of vehicles [11, 12]. New versions of this program are being created. The version 5.0 of the computer program PC CRASH will be investigated further on.

The coefficient of cohesion is set for the whole surface, afterwards the other coefficient of cohesion can be introduced for separate sections (Fig 1).
While modeling with the help of the computer program PC CRASH, firstly the definite model of the automobile, the movement of which is to be modeled, together with its appropriate characteristics is selected from the database (Fig 2).

Various regimes of the movement (braking, acceleration) of the automobiles, parameters of the deceleration and acceleration of the movement can be set.

There is a possibility to select and, while modeling, to evaluate such parameters of the automobile as the parameters of suspension, the degree of loading of the automobile, the type of the tires, distribution of the braking forces, etc. (Fig 3).

After having selected the coefficient of cohesion, the program automatically selects the maximum possible deceleration of the automobile. It is possible, on the contrary, to introduce the value of deceleration, afterwards the coefficient of cohesion is to be recalculated (Fig 4). Besides, there is a possibility to introduce deceleration as the function, from the speed. In this case, deceleration is modeled as the hyperbolic function, the parameters of which are calculated by introducing the values of deceleration, taking into consideration the speed of movement of the automobile, equal to 20 and 80 km/h. This model mostly suits for braking on a wet section of the road, when the speed is faster. However, it does not suit for modeling of the movement of the automobile after the crash, when dependence of the deceleration upon the speed may be of a completely different nature.
3. Modeling of overturning of the automobile

In case of overturning of the automobile on its roof, the speed of its movement prior to its overturning can be calculated according to the following formula:

\[ v = \sqrt{\frac{26g}{\left(\sqrt{\frac{B^2}{2}} + h^2 - h\right) + \left(\sqrt{\frac{A^2}{2}} + \frac{P}{2} - \frac{P}{2}\right)}} \]

where \( g \) is the acceleration of gravity (9.81 m/s\(^2\)); \( B \) is the width of the track of the automobile, m; \( h \) is the height of the centre of gravity of the automobile, m; \( A \) is the height of the automobile, m; \( P \) is the width of the automobile, m.

If, prior to overturning, the automobile had been sliding or, after overturning on its roof, had been overturning, this can be correspondingly evaluated by applying the formula. Besides, the expenditures of the kinetic power of the automobile for causing deformation of the automobile can be evaluated.

However, while modeling with the help of the computer program PC CRASH, it is possible not only to ascertain the speed of the automobile prior to its overturning, but to restore the movement of the automobile while overturning as well.

The possibility to model the movement of the automobile in the space (i.e. of the movement in the three planes), taking into consideration such parameters as the profile of the road, including the cross profile, location of the centre of gravity of the automobile, is one of the advantages of the program PC CRASH. It is very important because, without this possibility (for example, while modeling in the plane), it would be impossible to restore such a complex movement of the automobile as the process of overturning of the automobile. Figs 5–7 reflect the modeled overturning of the automobile, when the latter moves down from the slope of the road.

The following data were introduced:

**Vehicle:** ROVER-620
- Length, m: 4.65
- Width, m: 1.72
- Height, m: 1.38
- C.G. height above ground, m: 0.50
- Wheelbase, m: 2.72
- Front track width, m: 1.48
- Rear track width, m: 1.48
- Mass (empty), kg: 1255.00
- Velocity, km/h: 50.00
- Mean brake acceleration, m/s\(^2\): 6.00

Besides, the program PC CRASH provides the possibility to observe the view in the space (Figs 6–7).

In this case, while modeling the movement of the automobile according to the available data, the cross profile of the definite road section was introduced (Fig 8). Without having evaluated the latter, the automobile would be moving further on, without overturning.
Thus, seeking for reliability of the results of modeling of the course of the traffic accidents, it is very important that the experienced expert, having the appropriate qualification in introducing the necessary parameters and having enough skills of work with the computer modeling program, carries out the computer modeling. Only in this case the results of modeling will be reliable and can be used in the expert assessment of the traffic accidents.

4. Conclusions

1. Such programs of the computer modeling of the movement of vehicles as the program PC CRASH, make the work, carried out by the experts of investigation of the traffic accidents, easier, especially wishing to model several possible variants. The programs permit to evaluate various parameters, such as the parameters of the surface of the road (the parameters of cohesion), the parameters of the vehicle (the parameters of suspension, the degree of loading of the automobile, the type of the tires, distribution of the forces of braking, etc.) and provide the possibility to model various regimes of the movement of the automobile and such complex processes as overturning of the automobile.

2. The computer modeling of overturning of the automobile, which was carried out, proves that the results of modeling depend upon the introduced parameters very much. In this case, having not evaluated the cross profile of the road, the height of the centre of gravity of the automobile and the other parameters, a completely different result may be obtained.

3. Seeking for reliability of the results of modeling of the course of the traffic accidents, it is very important that the experienced expert, having the appropriate qualification in introducing the necessary parameters and having enough skills of work with the computer modeling program, carries out the computer modeling. Only in this case the results of modeling will be reliable and can be used in the expert assessment of the traffic accidents.

References


