ISSN 1392 - 1207. MECHANIKA. 2006. Nr.1(57)

Parameters of automobile movement in case of braking and bumping by wheels to the vertical protrusion of road covering

E. Sokolovskij
Vilnius Gediminas Technical University, Plytinės 27, 10105 Vilnius-16, Lithuania, E-mail: ESokolovskij@hotmail.com

1. Introduction

It's a usual case when the values of braking parameters, fixed for the automobiles of previously manufactured models, are specified in the literary sources [1], however, these values do not usually suit for modern automobiles. The values of braking parameters of automobiles, specified in some sources, do not suit for modelling of the automobile movement. For example, the values of automobiles deceleration, specified by the manufacturers of automobiles and tires, are usually fixed for the phase of the most efficient braking, not evaluating certain components of the braking process, as a result of which the larger values are obtained. These values are suitable for product advertising and comparison. However, for modelling the automobile movement (for example, for the examination of traffic accidents), the values of average, settled deceleration are necessary [1, 2]. Moreover, in the course of investigation of the braking process, the deceleration of transport vehicles and the braking track are usually fixed, however, the other parameters, such as the time of deceleration increase and the time of disbraking is also important in the course of examination of traffic accidents. Recently the items of usage of antilock brake systems (ABS), installed in automobiles, are often considered both in the scientific and popular literature [3-9]. However, till nowadays not all the items have been solved.

The automobile movement, when its wheels collide with an obstacle, is usually considered in the literary sources, whereas the automobile movement, when the side of its wheel collides with the vertical obstacle, is less investigated [4, 5, 10, 11]. Seeking for a more practical application of the results of these investigations (for example, while carrying out the examination of traffic accidents and while fixing the speed of the automobile movement prior to the traffic accident more precisely), it is necessary to fix the speed of the automobile movement, which is equivalent to the automobile's kinetic energy at the moment of collision of the automobile's side with the vertical obstacle.

2. Experimental investigation of the braking process of the automobiles

The experimental investigation of the braking process has been carried out in the following conditions:

- the automobiles, equipped with the antilock brake system (ABS) and without it, which were produced in the years 1986-2000, have been used for the investigation;
- the automobiles were in a good technical condition and equipped with the factory (non-substituted) brake system;
- two people served as the load of the tested automobiles, i.e. the driver and the "passenger", was taking care of the measuring device (the decelerometer);
- the same person was driving the automobile in the course of all the tests;
- the automobiles were equipped with the tires of the size, which is recommended for this particular type of the model; the depth of the protector notch was not less than 3 mm;
- the automobiles, equipped with the summer tires, were tested on the dry surface of asphalt road, whereas the automobiles, equipped with the winter non-prickly tires, were tested in winter conditions (on the snow and ice);
- air pressure of the tires was nominal for the definite model of the automobile and its load;
- the tests were carried out on horizontal stripe of non-rough asphalt road, where there was no traffic, by calculating the mean number afterwards;
- the tests have been carried out in both directions - not less than three tests in each case, by calculating the mean number afterwards;
- in course of the investigation of deceleration dependence upon the automobile's primary speed, the tests on dry surface of the asphalt road were carried out with the automobiles, equipped with ABS, and driven at the primary speed of 60, 80 and 100 km/h, and with the automobiles without ABS, and driven at the speed of 30, 50 and 80 km/h (for the sake of safety, the tests with the automobiles without ABS were carried out at lower primary speed);
- for the sake of safety, in course of the investigation of ABS functioning influence upon the automobile's deceleration in winter conditions, the automobiles, driven at the primary speed of 30 km/h, were tested in winter conditions (on the snow and ice).

Measurements were taken with the help of an electronic device, which measures deceleration, i.e. the decelerometer VZM 100.

At first, the dependence of deceleration of the vehicles without ABS upon primary speed was investigated. The investigation results are presented in Fig. 1. As we see, the deceleration of the vehicle without ABS decreases with the primary speed increase.

The analogous investigation was carried out with the vehicles, equipped with ABS. The results of these investigations are presented in Fig. 2.

It should be stated that in the course of testing the average settled deceleration of all the vehicles, equipped with ABS, on dry surface of asphalt road was not less than 8 m/s^2 – it was within the limits from 8 up to 8.8 m/s^2. The vehicle's deceleration at the stage of the most efficient braking in most cases exceeded 9 m/s^2, sometimes it reached the value of the acceleration of gravity (9.81 m/s^2).

In course of the investigation it was observed that, for the vehicles, equipped with ABS, sometimes it is difficult to notice visually braking traces of the wheels (especially in certain lighting conditions). However, in most cases the length of the remaining traces is shorter than the brake-path length.

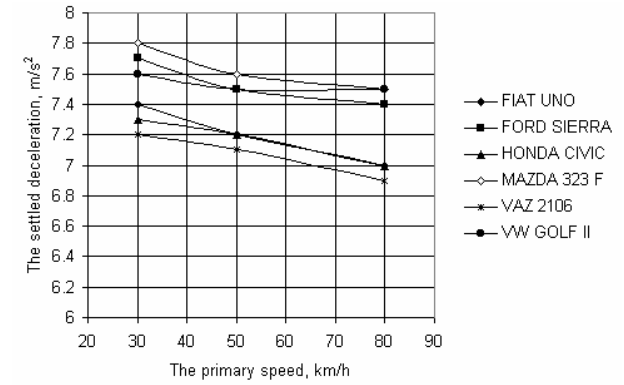


Fig. 1 Dependence of the deceleration upon primary speed for the vehicles without ABS

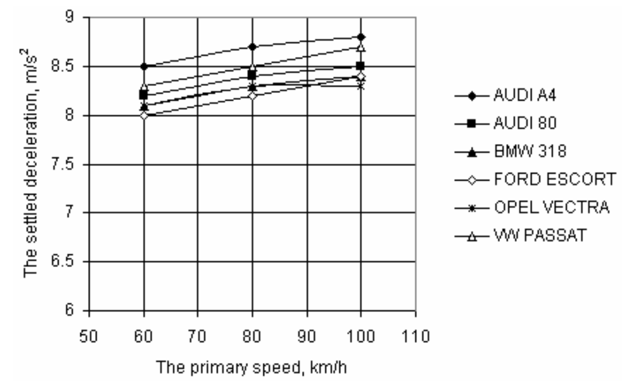


Fig. 2 Dependence of the deceleration upon primary speed for the vehicles, equipped with ABS

It was proved that, for the vehicles, equipped with ABS, the deceleration does not decrease, it even increases with the increase of primary speed of the vehicle. So to explain the above-stated situation, we shall compare the diagrams of braking in both the cases (Fig. 3).

As it is seen from the diagram of braking, the deceleration of the vehicle without ABS, which is in a good technical condition, reaches its peak at the very beginning of braking, till the vehicle's wheels remain unblocked. When the wheels become blocked, the deceleration decreases to a certain extent as holding of the blocked wheel up is less efficient (Fig. 3, b). Thus, for the vehicle without ABS, when it is driven at a lower speed, the above-mentioned peak of deceleration makes the larger part of the whole process of braking and v.v. the peak makes the smaller part of the braking process when the vehicle is driven at a higher speed and the process of braking takes a longer time. Besides, the other factors, such as heating of the tire of blocked wheel, are also significant. The deceleration decrease, typical for the vehicles, which are driven at the increasing primary speed, can be explained by this fact. It should be stated that not always the “classic” diagrams of braking, reflecting the peak of maximal deceleration were obtained in case of braking of the automobiles without ABS.

For the vehicles, equipped with ABS (according ABS functioning principle, the wheels remain unblocked within the whole period of braking), there is no deceleration peak at the beginning of braking. On contrary, for the vehicles, equipped with ABS, when the wheels interact with the road surface (ABS controls the situation and prevents the wheel from sliding), the deceleration continues to increase insignificantly in the course of further braking after the phase of increase of the deceleration. Thus, a bit smaller deceleration values are reached at the beginning of braking, whereas the largest values are usually reached when the process of braking becomes stable at the end of braking. The deceleration increase with the increase of the primary speed of the vehicle, equipped with ABS, can be explained by this fact (Fig. 3, a).

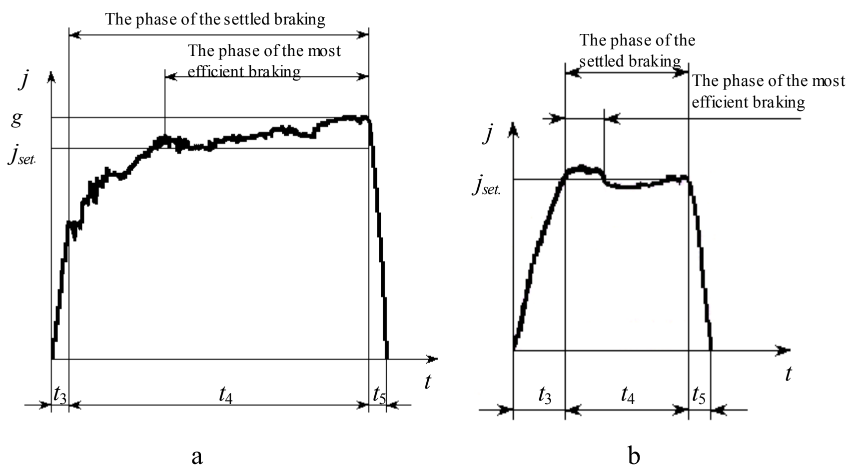


Fig. 3 Diagrams of braking: a – the vehicle, equipped with ABS, b – the vehicle without ABS

Besides, the values of the time of deceleration increase t_3 and of the time of disbraking t_5 were obtained in the course of investigation. The obtained results are presented in Table 1.

As we see, the values of the time of deceleration increase t_3 of all the vehicles, which have been investigated, have not exceeded 0.3 s. The maximal 0.3 s value was typical for the car VAZ 2106. The values of the time of deceleration increase t_3 of most of the Japanese and western vehicles have not exceeded 0.2 s and remained within the limits of 0.1-0.2 s. Only very old-fashioned vehicles make an exception. In this case it was a 15-year old car HONDA CIVIC, the time of deceleration increase of which is 0.25 s.

Table 1

The time of deceleration increase t_3 and the time of disbraking t_5

Vehicle	ABS	Time of deceleration increase t_3, s	Time of disbraking t_5, s
AUDI A4	+	0.1	0.1
AUDI 80	+	0.15	0.1
BMW 318	+	0.15	0.1
FIAT UNO	-	0.2	0.15
FORD ESCORT	+	0.15	0.15
FORD SIERRA	-	0.2	0.1
HONDA CIVIC	-	0.25	0.15
MAZDA 323 F	-	0.2	0.1
OPEL VECTRA	+	0.15	0.15
VAZ 2106	-	0.3	0.2
VW GOLF II	-	0.2	0.1
VW PASSAT	+	0.1	0.1

The values of the time of disbraking t_5, specified in certain literary sources, which have been published earlier, were not proved (for the hydraulic brake system $t_5 = 1.5\ t_3$). The values of the time of disbraking, obtained in the course of investigation, did not exceed the values of the time of deceleration increase and were within the limits of 0.1-0.15 s, except the car VAZ 2106 with the time of disbraking, equal to 0.2 s.

Besides, tests of holding up of the vehicles, equipped with ABS and without it, were carried out in winter conditions, i.e. on ice and snow. In our case these were the cars FORD ESCORT (equipped with ABS) and FORD SIERRA (without ABS). The obtained results are presented in Table 2.

Table 2

Deceleration of the vehicles, equipped with ABS and without it, in winter conditions

Surface of the road, fit for traffic	Average deceleration of the vehicle, equipped with ABS (FORD ESCORT), m/s^2	Average deceleration of the vehicle without ABS (FORD SIERRA), m/s^2
Ice	2.0	1.8
Snow	2.6	3.0

In the course of investigation it was shown that a slightly higher deceleration was typical for the vehicle, equipped with ABS (FORD ESCORT), in the course of its holding up on ice.

A bit different results were obtained while holding the vehicles, equipped with ABS and without it, up on snowy surface of the road, fit for traffic. In this case a slightly higher deceleration was typical for the vehicle without ABS (FORD SIERRA). Such unexpected results can be explained by the fact that blocked wheels of the vehicle without ABS contact wet surface of asphalt road, covered with a thin layer of snow, thus stipulating the deceleration increase. Besides, the blocked wheels push and thicken the snow in front of them. Thus, the area of wheel bearing increases and the effect, similar to holding of the vehicle up on the soft surface (for example, the soft soil) shows itself.

The wheels of the vehicle, equipped with ABS, remain unblocked. Thus, they do not contact wet surface of asphalt road and the deceleration is lower. However, it should be stressed that, in any case, including the case with holding up of the vehicle on the snow (though in this case the deceleration of the vehicle, equipped with ABS, was a bit smaller), the ABS distinguishes by a significant positive influence upon the vehicle operation as the possibility to steer it remains. This is very important for traffic safety as most of the traffic accidents occur because of the absence of the possibility to operate the vehicle.

3. Investigation of interaction of the automobile wheel with vertical obstacle

The investigation of damages of automobile wheels, which have occurred in traffic accidents, proves that one of the most often occurred damage of the wheels, i.e. the mounting sides of the tire, displaced from the edges of the rim, usually occurs in the course of the traffic accident, after the wheel has collided with hard objects, for example, the board [12, 13]. The automobile losses a part of its kinetic energy and speed at the moment of collision. Up to now, while rating automobiles speed before traffic accidents, usually the loss of the automobile's kinetic energy and its speed have not been taken into consideration [1, 2]. Thus, sometimes the reduced values of the automobile speed have been obtained. Seeking to rate the automobile's speed before traffic accident more precisely, it is necessary to evaluate the amount of kinetic energy of the automobile or the automobile's speed, which is equivalent to the loss of its kinetic energy, which have been present and caused the above mentioned damage of the wheel at the moment of its collision with the obstacle (for example, the border).

When the automobile slides sideways and the side components of its wheels collide with the vertical obstacle (for example, the border), contact area of the wheel with this obstacle makes the segment (Fig. 4).

So as to dismantle the tire, the outside force F_i, which produces an impact on it, should be larger than the force F_d, which is composed out of two components, i.e. the force, which is necessary to cope with the inside pressure of the tire, and the force, which is necessary to cope with friction of the mounting side and the rim.

Having carried out the theoretical investigation [12, 14], the condition of dismantling of the tire from the rim was obtained

$$F_i > F_d = \frac{R^2}{2}\left(\frac{\pi\alpha}{180} - \sin\alpha\right)\frac{p\left(\pi R^2 - \pi r^2\right)b}{\left(\pi R^2 - \pi r^2\right)b - \frac{R^2}{2}\left(\frac{\pi\alpha}{180} - \sin\alpha\right)l_d} + mg\mu$$

or

$$F_i > F_d = \frac{1}{2}\left(lR - a\left(R-h\right)\right)\frac{p\left(\pi R^2 - \pi r^2\right)b}{\left(\pi R^2 - \pi r^2\right)b - \frac{1}{2}\left(lR - a\left(R-h\right)\right)l_d} + mg\mu \quad (1)$$

where R is the external radius of the wheel, m; α is sector angle, obtained by connecting the edge dots of the contact area segment with the centre of the wheel, deg. (Fig. 4); p is pressure of the undamaged tire, Pa; r is internal radius of the tire (external radius of the wheel rim), m; b is the tire width, m; l_d is the distance, which is necessary to remove the tire from the edge of the wheel rim to be dismantled, m (Fig. 5); m is automobile weight, kg; g is acceleration of gravity, m/s^2; μ is conventional friction coefficient of the mounting side of the tire and the wheel rim; l is a part of the rim, located in between the edge dots of contact area segment by measuring external perimeter of the wheel, m (Fig. 4); a is length of the straight line, which connects the edge dots of the contact area segment, m (Fig. 4); h is height of the vertical obstacle, m.

However, practically (for example, while carrying out the examination of traffic accidents), not the force, which is necessary for dismantling of the tire, but the speed of the automobile movement v_E, which is equivalent to the loss of its kinetic energy, while dismantling the tire from the wheel rim should be known [12, 14] (m/s)

$$v_E = \sqrt{\frac{2}{m}A_d} = \sqrt{\frac{2l_d}{m}\left(\frac{R^2}{2}\left(\frac{\pi\alpha}{180} - sin\,\alpha\right)\frac{p\left(\pi R^2 - \pi r^2\right)b}{\left(\pi R^2 - \pi r^2\right)b - \frac{R^2}{2}\left(\frac{\pi\alpha}{180} - sin\,\alpha\right)l_d} + mg\mu\right)}$$

or

$$v_E = \sqrt{\frac{2l_d}{m}\left(\frac{1}{2}\left(lR - a\left(R-h\right)\right)\frac{p\left(\pi R^2 - \pi r^2\right)b}{\left(\pi R^2 - \pi r^2\right)b - \frac{1}{2}\left(lR - a\left(R-h\right)\right)l_d} + mg\mu\right)} \qquad (2)$$

where A_d is the work of dismantling the tire from the wheel rim, J.

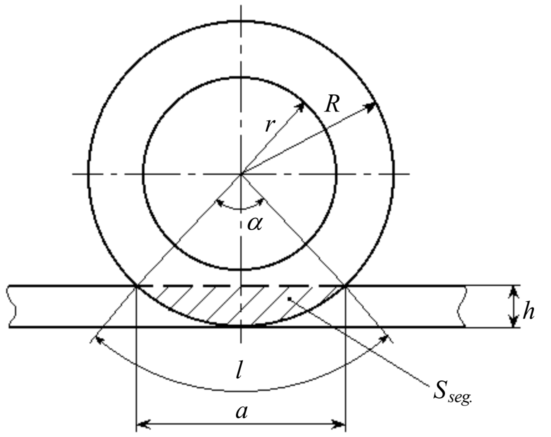
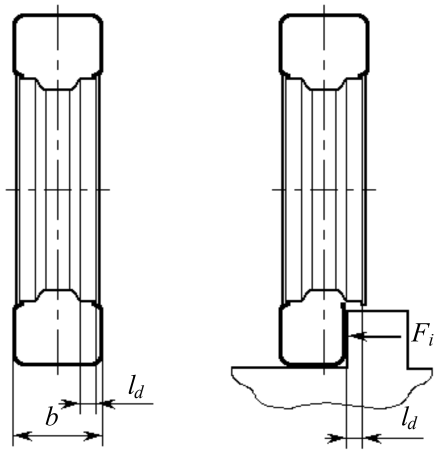


Fig. 4 The contact of the side component of the automobile wheel with the vertical obstacle



a b

Fig. 5 Automobile's wheel: a – before collision with the vertical obstacle; b – at the moment of collision, just before dismantling of the tire

It is a usual case when the values of the angle α, the rim length l and distance a are not known. Thus, they can be expressed by other known values (Fig. 4)

$$\alpha = 2\,arccos\left(\frac{R-h}{R}\right) \qquad l = \frac{\pi R}{180}2\,arccos\left(\frac{R-h}{R}\right)$$

$$a = 2\sqrt{R^2 - \left(R-h\right)^2} = 2\sqrt{2Rh - h^2}$$

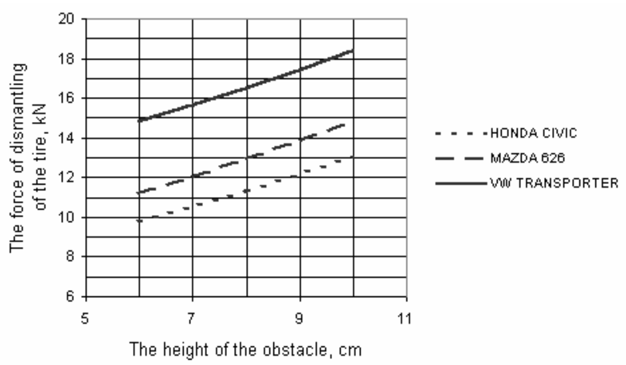


Fig. 6 Minimal force, necessary for the tire dismantling from the rim

Knowing the minimal speed v_E, which is equivalent to automobile's kinetic energy loss, at dismantling the tire from the rim, in cases, when the automobile, sliding to the side, collides with vertical obstacle (for example, the border) and the automobile's wheel becomes depressurized through the displaced mounting side of the tire, it is possible to calculate more precisely the automobile speed before the occurrence of traffic accident (km/h) by evaluating kinetic energy, necessary for dismantling of the tires

$$v_a = \sqrt{26\left(S_1 j_1 + ... + S_i j_i\right) + v_s^2 + v_E^2 z} \qquad (3)$$

where $S_{1...i}$ is the distance, covered by the automobile, sliding along certain road-cover, m; $j_{1...i}$ is the deceleration of the automobile, sliding along certain road-cover, m/s^2; v_s is the automobile's speed, equivalent to its kinetic energy at the moment of its collision with the other object, for example, an automobile, km/h; v_E is the automobile's speed, equivalent to its kinetic energy loss, at dismantling of the tire from the rim, km/h; z is the number of dismantled wheels.

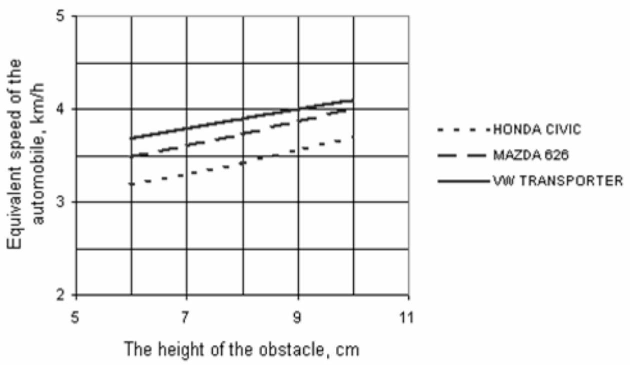


Fig. 7 Automobile's minimal speed, equivalent to its kinetic energy, necessary for the tire dismantling at its collision with the vertical obstacle

The minimal force, necessary for the tire dismantling from the rim, and the minimal speed of the automobile, equivalent to its kinetic energy loss, when the automobile straightforwardly collides with the vertical obstacle, and the tire is dismantled, have been calculated for automobiles of different types, i.e. HONDA CIVIC, MAZDA 626 and VW TRANSPORTER. The results are presented in Figs. 6 and 7.

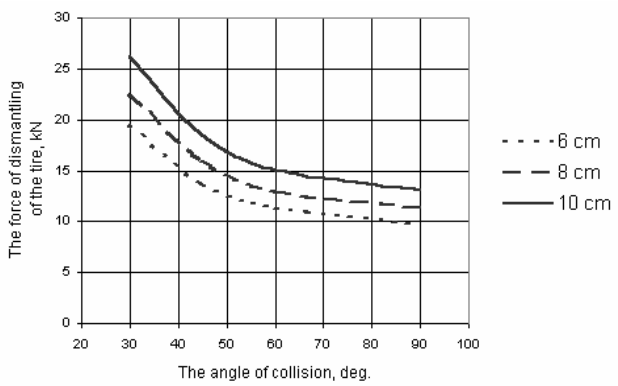


Fig. 8 Dependence of the force, necessary for dismantling of the tire from the rim, upon the angle of collision for the automobile HONDA CIVIC

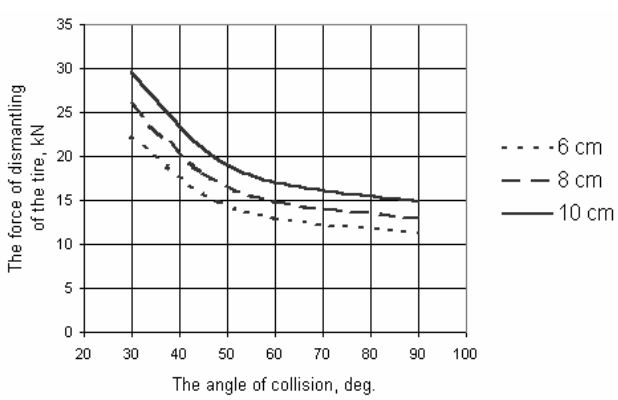


Fig. 9 Dependence of the force, necessary for dismantling of the tire from the rim, upon the angle of collision for the automobile MAZDA 626

As we see, the above-mentioned force and speed increase with the increase of the obstacle height; typically have higher values for the automobiles with the larger mass.

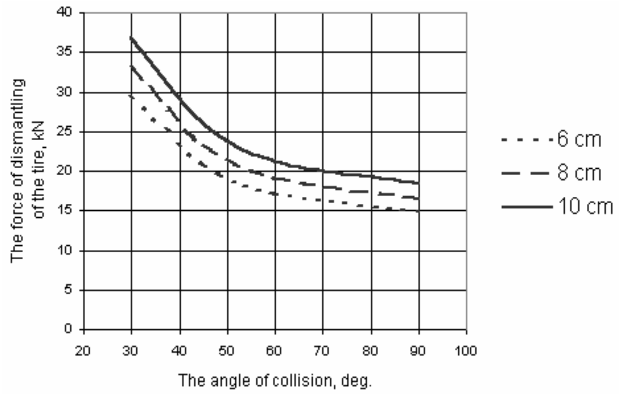


Fig. 10 Dependence of the force, necessary for dismantling of the tire from the rim, upon the angle of collision for the automobile VW TRANSPORTER

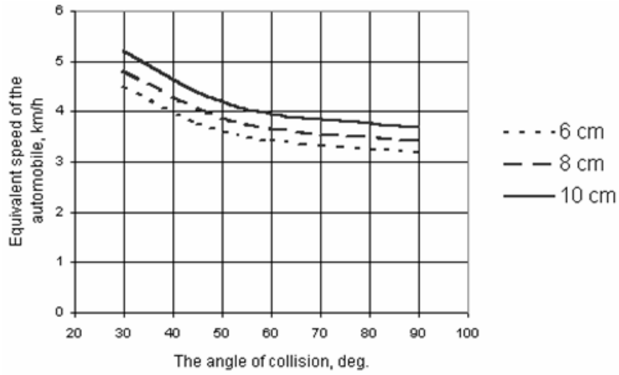


Fig. 11 Dependence of the minimal automobile's speed, equivalent to its kinetic energy necessary for the tire dismantling at collision with the vertical obstacle, upon the angle of collision for the automobile HONDA CIVIC

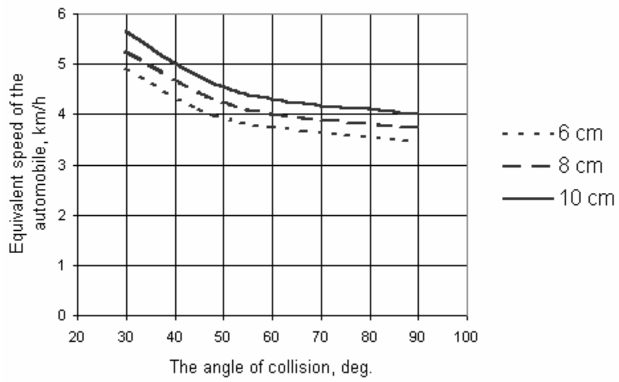


Fig. 12 Dependence of the minimal automobile's speed, equivalent to its kinetic energy necessary for the tire dismantling at collision with the vertical obstacle, upon the angle of collision for the automobile MAZDA 626

The dependence of the force, necessary for dismantling of the tire from the rim, and automobile's speed, equivalent to its kinetic energy loss at its collision with the vertical obstacle, when the tire is dismantled, upon the angle of collision was obtained (for the obstacle height, equal to 6, 8 and 10 cm). The results are presented in Figs. 8-13.

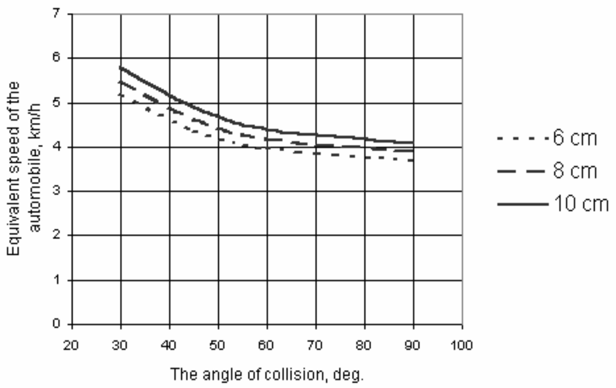


Fig. 13 Dependence of the minimal automobile's speed, equivalent to its kinetic energy necessary for the tire dismantling at collision with the vertical obstacle, upon the angle of collision for the automobile VW TRANSPORTER

It should be stated that the dismantling force and the speed, equivalent to the automobile's kinetic energy loss at dismantling, are minimal as, while calculating, the amount of kinetic energy, which is consumed in the course of distortion of the tire's carcass as well as in cases, when the rim contacts the obstacle and causes the damage, has not been evaluated.

4. Conclusions

1. In the course of braking of the vehicles, equipped with ABS, on dry surface of asphalt road, the average settled deceleration used to be within the limits from 8 m/s^2 up to 8.8 m/s^2. The time of the deceleration increase t_3, typical for the vehicles, equipped with ABS, used to be within the limits 0.1-0.15 s. The time of disbraking t_5 did not exceed the time of the deceleration increase and used to be within the limits 0.1-0.15 s.
2. The average settled deceleration of the vehicles without ABS while holding them up on dry surface of asphalt road used to be within the limits from 6.9 m/s^2 up to 7.8 m/s^2. The time of the deceleration increase t_3 used to be within the limits 0.2-0.3 s. The time of disbraking t_5 did not exceed the time of the deceleration increase and used to be within the limits 0.1-0.2 s.
3. It was proved that for the vehicles, equipped with ABS, the average settled deceleration increases with the increase of primary speed of the vehicle, whereas for the vehicles without ABS, it decreases.
4. After the experimental investigation in winter conditions, it was proved that braking of the automobile, equipped with ABS, on ice is more efficient (by approximately 10%). Braking of the vehicle without ABS on snow-covered surface of the road is more efficient (by approximately 13%) because in this case the blocked wheels of the vehicle contact wet surface of asphalt road, push and thicken the snow in front of them.
5. After creating calculation methods of the minimal force, necessary for dismantling of the tire from the rim, and the automobile's speed, which is equivalent to its kinetic energy, necessary for dismantling of the tire after the wheel has collided with the vertical obstacle, the dependence of this force and speed upon the height of the obstacle and the angle of collision for the automobiles of different classes was obtained.
6. There is a possibility to model the vehicles' movement and to restore the course of the traffic accidents more precisely while carrying the examination of the traffic accidents and to calculate more precisely the speed of the automobile movement prior to the traffic accident.

References

1. **Иларионов В.А.** Экспертиза дорожно - транспортных происшествий.-Москва: Транспорт, 1989.-254с.
2. **Lukoševičienė O.** Autoįvykių analizė ir modeliavimas. Monografija.-Vilnius: Technika, 2001.-244p.
3. **Ahlgrimm J., Grandel J.** Verkehrsunfallaufnahme bei Fahrzeugen mit Anti-Blockier-System (ABS). ISSN 0724-2050.-Verkehrsunfall und Fahrzeugtechnik, 1997, No.3, s.67-74.
4. **Bogdevičius, M., Prentkovskis, O., Vladimirov, O.** Engineering solutions of traffic safety problems of road transport. ISSN 1648-4142.-Transport.-Vilnius: Technika, 2004, v.XIX, No1, p.43-50.
5. **Danner M., Halm J.** Technische Analyse von Verkehrsunfällen.-Eurotax (International) AG CH-8808 Pfäffikon, 1994.-570s.
6. **Mills, V., Samuel, B., Wagner, J.** Modeling and analysis of automotive antilock brake systems to vehicle payload shifting. ISSN 0042-3114.-Vehicle System Dynamics, 2002, v.37, No4, p.283-310.
7. **Sherman, D.** The ABCs of ABS.-Popular Science, v.252, No6, 1998, p.75-79.
8. **Donges, E.** A Conceptual framework for active safety in road traffic. ISSN 0042-3114.-Vehicle System Dynamics, v.32, No2/3, 1999, p.113-128.
9. **Lewandowski A.** Czynniki decydujące o skuteczności hamowania samochodu z ABS.-Zbiór referatów. VII konferencja "Problemy rekonstrukcji wypadków drogowych".-Kraków: IES, 2000, s.227-237.
10. **Lanzendoerfer J.; Szczepaniak C.; Szosland A.** Teoria ruchu samochodu.-Łódź: Wydawnictwo politechniki łódzkiej, 1988.-340s.
11. **Prentkovskis O.** Automobilio sąveika su kliūtimis. Daktaro disertacija.-Vilnius: VGTU, 2000.-117p.
12. **Sokolovskij E.** Rato sąveikos su keliu ir jo elementais tyrimai eismo įvykių ekspertizės kontekste. Daktaro disertacija.-Vilnius: VGTU, 2004.-147p.
13. **Sokolovskij E.** Automobilių ratų pažeidimų, susidarančių prieš pat autoavariją ir jos metu, analizė ir jų statistiniai tyrimai. ISSN 1392-1533.-Transportas.-Vilnius: Technika, 2000, t.XV, No.3, p. 118–122.
14. **Корн Г., Корн Т.** Справочник по математике для научных работников и инженеров.-Москва: Наука, 1968.-720с.

E. Sokolovskij

AUTOMOBILIŲ JUDĖJIMO PARAMETRAI STABDANT IR ATSITRENKIANT RATAIS Į VERTIKALIĄ KELIO KLIŪTĮ

R e z i u m ė

Straipsnyje pateikti automobilių su stabdžių antiblokavimo sistema ir be jos stabdymo parametrų tyrimų rezultatai. Pateiktos eksperimentinio tyrimo metu nustatytos automobilių lėtėjimo pagreičio, lėtėjimo pagreičio didėjimo laiko ir atstabdymo laiko vertės, stabdant ant sausos asfaltbetonio dangos. Pavaizduotos ir paaiškintos automobilių su ABS ir be ABS lėtėjimo pagreičio priklausomybės nuo pradinio važiavimo greičio. Pateikti automobilių stabdymo žiemos sąlygomis, t. y. ant sniego ir ant ledo, tyrimų rezultatai.

Nagrinėjamas automobilio atsitrenkimas ratais į vertikalią kliūtį, dėl kurio demontuojama rato padanga. Nustatyta minimali padangai demontuoti nuo ratlankio būtina jėga ir minimalus automobilio važiavimo greitis, ekvivalentinis jo kinetinės energijos sąnaudoms padangai demontuoti nuo ratlankio, atsitrenkus į kliūtį. Įvairių klasių automobiliams nustatytos šios jėgos ir greičio vertės, jų priklausomybė nuo kliūties aukščio ir atsitrenkimo į kliūtį kampo. Pasiūlyta patikslinta metodika automobilių važiavimo prieš eismo įvykį greičiams apskaičiuoti, įvertinant ir kinetinės energijos sąnaudas padangoms demontuoti ratui atsitrenkiant į vertikalią kliūtį.

E. Sokolovskij

PARAMETERS OF AUTOMOBILE MOVEMENT IN CASE OF BRAKING AND BUMPING BY WHEELS TO THE VERTICAL PROTRUSION OF ROAD COVERING

S u m m a r y

The present article depicts the results of the investigation of braking parameters of the automobiles, equipped with ABS and without ABS. The values of the automobile deceleration, increase of the deceleration time and the time of disbraking, while braking on dry asphalt-concrete surface, which was fixed in the course of the experimental investigation, are presented. Dependence of deceleration of the automobiles, equipped with ABS and without ABS, upon the primary driving speed is reflected and substantiated. The results of the investigation of automobiles, equipped with ABS and without ABS, braking in winter conditions, i.e. on ice and snow, are presented.

Collision of the automobile wheels with vertical obstacle, as a result of which the wheel tire gets dismantled, is considered in the present article. The required force and the automobile's minimal speed of driving, which is equivalent to its kinetic energy loss at dismantling of the tire from the wheel rim after collision with the obstacle, are shown. The values of this force and speed, typical of the automobiles, attributed to different classes, their dependence upon the obstacle height and collision with the obstacle angle are fixed. More precise methods for the calculation of the automobile speed prior to the traffic accident, by taking into consideration its kinetic energy, necessary for dismantling of the wheel at its collision with the vertical obstacle, is suggested.

Э. Соколовский

ПАРАМЕТРЫ ДВИЖЕНИЯ АВТОМОБИЛЕЙ ПРИ ТОРМОЖЕНИИ И СТОЛКНОВЕНИИ КОЛЕСАМИ С ВЕРТИКАЛЬНЫМ ДОРОЖНЫМ ПРЕПЯТСТВИЕМ

Р е з ю м е

В статье представлены результаты исследований параметров торможения автомобилей с АБС и без АБС. Представлены экспериментальными исследованиями установленные значения замедления торможения, времени нарастания замедления при экстренном торможении и времени растормаживания при торможении на сухом асфальтобетонном покрытии. Показаны и объяснены зависимости замедления торможения автомобилей с АБС и без АБС от начальной скорости движения. Представлены результаты исследований торможения автомобилей с АБС и без АБС в зимних условиях – на льду и на снегу.

В статье также исследуется столкновение автомобиля колесами с вертикальным препятствием, в результате чего демонтируется шина колеса. Установлены минимальная сила, необходимая для демонтирования шины, и минимальная скорость движения автомобиля, эквивалентная его затратам кинетической энергии на демонтирование шины, при столкновении с препятствием. Для автомобилей разных классов установлены значения этой силы и скорости, их зависимость от высоты препятствия и от угла столкновения с препятствием. Предложена уточненная методика расчета скоростей движения автомобилей перед дорожным происшествием, учитывая также затраты кинетической энергии на демонтирование шины при столкновении колеса с препятствием.

Received February 28, 2005