THE IMPACT OF ANTI-LOCK BRAKING SYSTEM ON BRAKING DISTANCE OF THE VEHICLE

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INTRODUCTION

Anti-lock braking systems had been developed in order to provide assistance to a driver in avoiding crashes. It is known that anti-lock braking system does not considerably reduce the braking distance, when the road paving is dry, however, increases a stability of the vehicle and possibilities of its control on emergency braking. While braking a vehicle without ABS on a dry road paving, the wheels are locked, but the coefficient of friction is rather high, so the vehicle stops very soon. ABS may even increase the braking distance while braking on loose snow or gravel.

The essential advantage of ABS is its capability to reduce braking distance on wet or slithery way.

ABS causes both positive and negative impact on traffic safety. The statistics show that the probability of "crashes with several vehicles involved" on wet road paving had been reduced by 24% and the probability of fatal crashes – by 14%. However, on the other hand, the statistics also show increase of number of "crashes with one vehicle involved" and "off-going", as compared to vehicles without ABS. The share of events related to "off-going" with fatal result increased by 28% and the share of crashes without fatal consequences – by 19% [3]. It is difficult to say what should be held culpable for such situation: ABS, improper use of the anti-lock braking system by the driver, reaction of the driver or any other factors. So, scientific substantiation of the statistics requires close investigation.

In the present Paper, the braking distance of vehicle with and without ABS on wet asphalt is compared. Their efficiency is assessed and the corresponding conclusions about the impact of anti-lock braking system on traffic safety are provided.

THE CONDITIONS OF THE EXPERIMENT

The efficiency of the service (foot) brake was found using two cars. The experiment was carried out on the straight fragment of road; the speed on the beginning of braking was about 60 km/h. An emergency situation caused by strong stressing of the brake pedal had been simulated. The vehicles of the same age (manufactured in 1993) and approximately same mileage had been chosen for the experiment. One vehicle was equipped with anti-lock braking system (the system was provided with 4 sensors) and the second vehicle was without ABS. Tyres of all vehicles met the manufacturer's requirements (such as size, internal pressure of tyres and so on). The data on the vehicles are provided in Table 1. The masses of both vehicles were almost the same, i.e. about 1400 kg.

Table 1. The brief description of the data on the vehicles used in the experiment

A model of the vehicle	Brakes			Tyres		
	ABS	Front	Rear	Type	Mark	Protector's depth, mm
Honda Civic	No	Disks	Drums	Summer	Hankook	6,8
VW Vento	4 sensors	Disks	Drums	Summer	Viking	5,9

The following parameters were measured during the experiment:

1. The speed of movement of the vehicles;
2. Braking distances;
3. Control force on the brake pedal.

10 tests had been carried out with each vehicle, then the average values had been found on their base.

Force measuring device (K – 614 T – 200 – PCCP – 1 – 219) from the stand K – 208 M was used in the experiment. The case of the device was connected to the brake pedal and the manometer was connected to the steering wheel.

In the experiment, it was found that force of 500 N affects the brake pedal of the vehicle with anti-block braking system. In the vehicle without ABS, wheels are locked during braking. In the experiment on the vehicle with ABS, it was tried to activate the anti-block braking system as soon as possible and to keep the pedal pressing force unchanged until complete stopping of the vehicle. The brakes were pre-heated before the experiment, because the temperature of brake shoes should be about 100ºC according to the methodical requirements [2].

The fragment of road free of dead-water zones on its surface had been chosen for the experiment, because in such zones the braking distance may increase even twice.

THE RESULTS OF THE EXPERIMENT

The results of the experiment are provided in Table 2. The braking distance and deceleration of each vehicle are the average values of all performed tests.

Table 2. Braking distances and deceleration of the vehicles

A model of the vehicle	Mass of vehicle, kg	ABS	Braking distance, m	Deceleration, m/s^2
Honda Civic	1410	No	17,1	8,1
VW Vento	1385	Yes	15,6	8,9

The following formula is used to calculate the deceleration:

$$d_{12} = \frac{v_1^{\,2} - v_2^{\,2}}{2 \cdot S_{12}};$$

where: v_1 - the initial speed of movement ($v_1 = 60$ km/h); v_2 - the speed in the end of the experiment ($v_2 = 0$ km/h); S_{12} - the braking distance.

The results of the experiment in graphical form are presented in Figure 1.

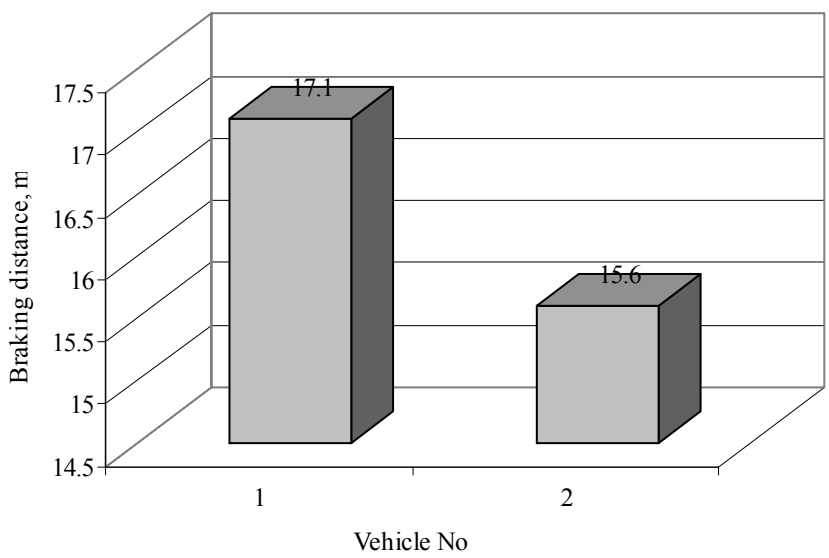

Fig.1. *Braking distances for vehicles equipped with ABS and for the cars without ABS (1 – Honda Civic, 2 – VW Vento)*

ASSESMENT OF ERRORS OF THE EXPERIMENT

The following factors impact the results of the experiment on measuring braking distance:
1. Wear of the braking system of the vehicle;
2. The system "human – vehicle – measuring device";
3. The ambient conditions;
4. The inaccuracies of measuring methods.

The errors appearing in course of the experiment may be divided into two groups:

a) systematic errors, i.e. errors caused by wear and tear of the vehicle brake system, errors of ambient conditions, errors caused by measuring methods;

b) accidental errors, i.e. errors appearing (in this case). in the system "human – vehicle – measuring device".

Accidental errors of the experiment may be described using several statistical responses [1]: the arithmetic mean:

$$d = \frac{d_{x1} + d_{x2} + ... + d_{xn}}{n};$$

where d_x – results of experiments; n – number of tests.

The average standard deviation from the arithmetic mean is calculated according to the formula:

$$\sigma = \sqrt{\frac{x_1^{\ 2} + x_2^{\ 2} + ... + x_n^{\ 2}}{n}};$$

where x_i – an accidental error of a result of measurement from the arithmetic mean.

The probability of detection and error between x_1 and x_2 may be calculated for the probability integral function $\Phi(z)$, where $z = \frac{x}{\sigma}$.

$$\Phi(z) = \frac{1}{\sqrt{2\pi}} \int_0^z \exp\frac{z^2}{2} dz;$$

The results of calculation of statistical responses of accidental errors of the experiment are shown in Table 3.

Table 3. The statistic responses of accidental errors of the experiment

A model of the vehicle	ABS	Arithmetic mean d, m	The average standard deviation from the arithmetic mean σ	Probability integral function $\Phi(z)$
Honda Civic	No	17,1	0,91	0,32
VW Vento	Yes	15,6	0,82	0,30

After the analysis of the data obtained in course of the experiment, it may be stated that the vehicle with anti-lock braking system stopped on wet asphalt 1.5 m earlier as compared to the vehicle without anti-lock braking system. The braking distance was reduced by 9 %. So, ABS provides better safety warranty, in particular on wet asphalt.

CONCLUSIONS

1. On the base of the carried out experiment, it may be stated that efficiency of anti-lock braking system remains high at low speeds (typical in towns) as well upon wet asphalt conditions.

2. In course of the experiment, it was found that braking distance of the vehicle with ABS reduces by 9 per cent as compared to the vehicle without anti-lock braking system.

References

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