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THE BASICS OF DETERMINING THE BRAKING OF VEHICLES IN ROAD TRAFFIC

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Abstract
Among the main parameters describing the movement of the vehicle is its deceleration, which is currently determined only experimentally or selected in the study of vehicle movement parameters based on various road conditions and vehicle-oriented table values. At the same time, in modern expert practice, the specific share of use is significant, which leads to serious errors in the calculation.

Keywords: Friction coefficient, braking parameters, vehicle movement parameters, structural features.

Introduction
In the Republic of Uzbekistan, the traditional methodology of motor transport expertise, which appeared based on studies, is used. Among the main parameters describing the movement of the vehicle is its deceleration, which is currently determined only experimentally or is selected in the study of vehicle movement parameters based on various road conditions and vehicle-oriented table values. At the same time, the specific share of use in modern expert practice is significant, which leads to serious errors in the calculation [1-7].

In the Republic of Uzbekistan, the main common method of determining the car's deceleration is adopted, the adhesion coefficient of the car tire is taken as the basis for calculating the deceleration. A similar method has been proposed to determine the deceleration. However, this technique is based on experimental tests carried out in the 80s of the last century, which calls into question their connection with the development of the automotive industry in general, and in particular with the braking elements of cars [8-14].

In addition, in classical physics, the friction force depends on two parameters: the base reaction force and the friction coefficient. These are. the use of the coefficient of friction in the calculation of friction-related processes is unreasonable or requires scientific justification.

In addition, according to Ilarionov, the decelerations used in the calculation of the braking parameters of vehicles are equal in the same road conditions for vehicles of the same category with different masses and structural characteristics of tires, which currently contradicts the tests being conducted at the time [15-23].

Materials and Methods

Currently, in our country, several tests related to the detection of braking systems and braking elements are being organized, which indicates the growing interest in the problem of selecting the initial data of the braking traffic [24-37]. The results obtained from the deceleration of this car were systematized and issued as a manual for expert auto technicians by the IIB of the Ministry of Internal Affairs of Uzbekistan. However, it should be noted that these tests were conducted only for certain brands of cars and car tires at certain values of braking speed, as a result of which the methodological guide is incomplete and reflects only some aspects of this problem. applies only to vehicles suitable for various tests, this is not possible if they are seriously injured. Expert practice theoretically shows that the development of a universal device capable of measuring in various situations is necessary to optimize the production of expert calculations related to the coefficient of deceleration and friction [38-41].

Conducting experimental measurements is difficult in some cases, for example, when vehicles are not in motion (damaged as a result of an accident) and the technical condition after the accident does not allow conducting tests (Fig. 1).

Figure 1. Vehicles that are not suitable for various tests.

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In addition, the deceleration detection method based on the use of a universal formula does not reflect the variability of driving conditions during car braking, for example, the difference in air pressure on different wheels, the difference in tire wear, the difference in road conditions for different wheels [42-48].

Even in the study of the movement of vehicles, with the increase of the above differences, including the existing methodology of the initial parameters, it increases significantly on average. Also, jobs related to cars will increase [48-55].

In addition, the method of determining the deceleration based on the use of a universal formula does not reflect the variability of driving conditions during car braking, for example, the difference in air pressure in different wheels, and the difference in tire wear for different wheels. The error in the study of the movement of vehicles increases significantly with the increase of the above differences, including in the existing methodology of the initial parameters. In addition, there is an increase in the number of cases involving cars, equipped with anti-lock braking systems (ABS), in accidents, they create research conditions that are not provided for in the table data, which makes it difficult to perform calculations using the traditional method. does not allow [49-53].

The calculation of road traffic accidents in our country is based on the simplest physical laws. In these studies, vehicle movement is expressed as the movement of a material point, and based on this, speed, braking distance and other parameters of vehicle movement, which are necessary for the study of the situation, are calculated. Such an approach to the study of the car braking process takes into account that this is the main parameter, and the process - deceleration - is chosen with some care.

According to scientists, the car's deceleration is directly related to the coefficient of friction. There are many devices for determining the adhesion coefficient of car tires, but they all have their drawbacks. The methodology for determining the correlation coefficient is theoretically available at the moment. This method, based on the balance of forces, is not complete, and in some cases, the dependence on the selected preliminary data, which is very approximate, is unacceptable in the study of traffic accident cases, where the fate of the people involved directly depends on it. These errors are due to the fact that the coefficients of friction chosen when determining the deceleration are often not a parameter of the interaction between the car wheel and the road, but a characteristic of the road [54-62]. This is because the method of determining the coefficient of friction does not take into account the active element of the process of movement and braking of the car, that is, the effect of its wheels, as well as it is not taken into account that all wheels do not have the same contact with the support surface and that the load is redistributed during braking. between the axles of the vehicle.

As a result, taking into account the above, research is required mainly in the field of the movement of the car wheel on a hard surface during braking [59-63]. During braking, the kinetic energy of the car's movement is converted into friction between the pads and brake drums, as well as between the tires and the road [64-68].

When the wheel of the car is blocked and goes into the braking state, a tangential reaction of the road T directed in the direction opposite to the movement occurs in the zone of contact with its supporting surface. This reaction is the brake force. A general diagram of the forces acting on the locked wheel is shown in Fig. 2.

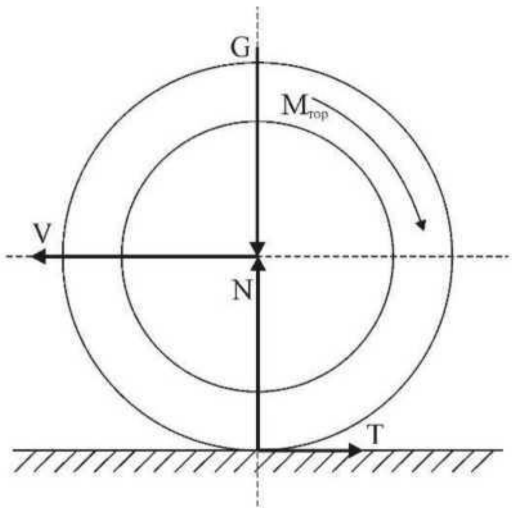

Figure 2. Diagram of forces acting on the brake wheel

At the same time, the braking of all the wheels of the car takes place in the total force.

$$F_{bra} = \frac{M}{r} ; \qquad (1)$$

From the result of transformations, we get the following formula.

$$T_1 = -F_{bra1} - N_1 \cdot \mu \frac{I_1}{r^2} \cdot j \qquad (2)$$

$$T_2 = -F_{bra2} - N_2 \cdot \mu - \frac{I_2}{r^2} \cdot j - F_{xx} \qquad (3)$$

Based on this, an increase in the braking torque leads to an increase in the tangential reaction of the road until it reaches the limit value - the Rsc adhesion force of the tire to the road:

$$T \le F_{sp} = N\mu \quad (4)$$

The braking system of modern cars develops a torque that exceeds the torque of the tires. Based on this, in practice, it is observed when driving a car, that when the wheels slip, the wheels lock up during sharp and intensive braking, and the process of sliding along the road begins, excluding rotation. Before the wheels are locked between the friction pads and the discs, the friction force, the static friction force, is exerted when the tire tread contacts the road. In the final stage of wheel lock, this pattern reverse braking mechanisms, a static friction force is established, and the contact of the tire tread with the supporting surface is accompanied by a friction force. Heat energy costs are also redistributed between these two processes - energy costs for friction between the pads and the disc are lost, and the release of heat energy is generated in the friction zone of the tire connection with the road.

Vehicle dynamics under braking can be calculated using the vehicle motion equation. Braking of the car without taking into account the operation of the engine is based on the condition that frictional mechanisms resist the movement. In this case, the equation of forces acting on the machine takes the following form:

$$T_1 + T_2 + F_i - F_n + F_i = 0 \quad (5)$$

Combining the values of T_1, T_2 and F_i into formula (5), we construct the equation of vehicle motion during braking without taking into account the slippage of the engine and tires on the supporting surface.

$$\frac{G}{g}\left(1 + \frac{Ig}{NG}\right) = \frac{G}{g}\delta_i j = -F_{tor} - F_k + F_n - F_v - F_{xx} \quad (6)$$

Here F_k = F_i+F_k- total braking force, N

It is possible to determine the deceleration of transport from the obtained equation

$$j_3 = -j = \frac{F_{tor} + F_d + F_v + F_{xx}}{G\delta_i} \cdot g \quad (7)$$

Based on this expression, we can conclude that when the car slows down, the friction in the friction mechanisms and transmission elements increases, and the resistance forces of external factors increase. Deceleration decreases with an increase in the mass of the car and the moments of inertia of the rotating parts. The biggest influence on braking is the total braking force F, which depends on the internal braking pressure, configuration and technical condition of the brakes. If the rolling resistance forces are not taken into account, then determining the brake force, its maximum value will depend on the tire holding force.

$$F_{bra} = G\mu \quad (8)$$

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It occurs when the braking force exceeds the traction force, causing the wheels to lock up and begin to slide on the road surface. When calculating the deceleration, the force equation can be written in the following form.

$$F_i = F_{tor} + F_d + F_v \tag{9}$$

The force of inertia is moving, it is used to overcome the braking force F_{bra}, the road resistance force F_d and the air resistance force F_v.

To determine the car's deceleration js, it is enough to use the value of Bu in equation (9):

$$j_s = \frac{F_{tor} + F_d + F_v}{G\delta_i} \cdot g \tag{10}$$

We can assume that $F_v = 0$ under the condition that the car's speed tends to zero during braking. Hence, equation (10) takes the form.

$$j_3 = \frac{\mu}{\delta_i} \cdot g \tag{11}$$

This will be the main insurmountable condition of the braking process

$$j_3 = \frac{\mu}{\delta_i} \cdot g \tag{12}$$

The maximum value of the braking force depends on the adhesion of the tires to the ground, that is, it is not possible to achieve an infinite increase in deceleration by increasing the braking torques. The maximum amount of deceleration occurs when all wheels of the car use the clutch, and the adhesion force reaches the value of the sum of tangential reactions:

$$F_1 + F_2 = (N_1 + N_2)\mu = G\mu\cos\alpha \tag{13}$$

Given the expression (10):

$$G\mu\cos\alpha + F_i + F_n + F_v = G\mu\cos\alpha - \frac{G}{g} j - F_n - F_v \tag{14}$$

Thus, maximum deceleration

$$j_3 = \frac{G\mu\cos\alpha + F_n + F_v}{G} \cdot g \tag{15}$$

During emergency braking, the braking force mainly exceeds the forces F_n and F_v and can be neglected.

$$j_3 = \mu \cdot g \tag{16}$$

Then the ratio of these forces, based on which the use of adhesion by all wheels of the car occurs only at one value of the μ coefficient.

If the μ values differ from the base value, the values describing the car's braking (time and distance) will exceed the calculated values and the deceleration will be less. In this regard, to bring the calculations closer to the experimental data, a braking efficiency factor is added, which reflects the difference between the actual braking deceleration.

Taking into account this coefficient in the car, the deceleration expression takes the following form:

$$j_3 = \frac{\mu \cdot g}{K_e} \qquad (17)$$

It follows that deceleration remains constant when braking with a constant coefficient of adhesion *y*. To ensure full use of the adhesion of the wheels of a paved vehicle, the forces required for braking along the entire braking distance must be proportional to the normal reactions of the road. It is logically obvious that the braking force of the car will be different with different decelerations T_{bra2} .

At the same time, the design of car brakes is created in such a way that the balance of the ratio of these forces is observed, based on which the use of the clutch by all wheels of the car occurs only at one value. If the values are different from the basic value, the values describing the braking of the car (time and distance) will exceed the calculated values and the deceleration will be less.

In this regard, to bring the calculations closer to the experimental data, the braking efficiency coefficient *Ke* is added, which reflects the difference between the actual braking deceleration. Taking into account this coefficient (Ke) in the car, the deceleration factor takes the following form. At the same time, a coefficient equal to 1.2 is taken for cars, for trucks and buses - 1.3 ≤1.4, on wet and slippery roads, this coefficient is *m*< 0.4 for all types of vehicles is equal to 1 for. The above formula is not verified in practice and the deceleration of modern vehicles exceeds the calculated values. Using the coefficient of braking efficiency leads to significant, unwarranted errors.

Based on foreign experience, published the following values for the coefficient of friction: 0.20 for dry roads, 0.15 for wet roads and 0.30-0 for sandy roads, where the low value of friction coefficients special attention is paid. These data were used to calculate the interaction of the solid wheels with the supporting surface. Since 1924, the number of works devoted to the study of the coefficient of friction abroad, the data of which was obtained experimentally, has increased sharply.

Similar articles were presented by the American Research Laboratory, the British Institute of Automotive Engineers and the Berlin Road Research Institute.

Results

All the above studies have shown that the adhesion coefficient mainly depends on the condition of the road surface. It should also be noted that in reality, it is a complex function of many variables. To determine the coefficient of adhesion, tests were conducted by towing a car or a special trolley bus with its wheels braking on the road surface.

Until now, a similar method of determining the friction coefficient using a dynamometer when pulling a braked car or a special trolleybus on a hard surface remains one of the widely used ones. Other methods of determining the coefficient of friction are not so accurate, because during braking the loads are redistributed between the wheels. In addition, the value of the coefficient changes with the change in viscosity deceleration rate, so these methods can only find its approximate value. Based on the data of the indicated research organizations, the average values for the coefficient of friction shown in Table 1 were calculated and the average values of the adhesion coefficient for the indicated high and low-pressure tires were presented.

Table 1. Average friction coefficients of tires

The name of the pavement or its condition	*The value of the adhesion coefficient for the road surface*		
	Clean and dry	dry and wet	Coated with oil or fat
Concrete	0.75	0.5	0.3
Asphalt-concrete	0.7	0.45	0.3
Big cobblestone	0.75	0.4	0.3
Small stone blocks, mosaic	0.65	0.4	0.3
Wooden tips	0.7	0.3	0.2
Asphalt	0.6	0.4	0.25
Stone coating	0.7	0.4	0.34
Highway stone	0.75	0.5	0.4
Dirt (profiled) road	0.7	0.15	-
Snowy road	0.3	up to 0.20	-
Icy road	0.24	up to 0.18	-
Ice road melting	0.2	up to 0.15	-

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Table 2. Average friction coefficients of tires

The name of the pavement or its condition	*The value of the viscosity coefficient for tires*	
	High pressure	Low pressure
Asphalt: dry	0.50-0.70 0.35-0.45	0.70-0.80 0.45-0.55
Sandy Road:	0.60-0.70 0.50-0.60	0.70-0.80 0.60-0.65
Dry wet	0.50-0.70 0.30-0.40	0.60-0.75 0.40-0.50
Wood tips: dry wet	0.50-0.60 0.30-0.40	0.50-0.60 0.30-0.40
Crushed stone coating: dry wet	0.40-0.50 0.30-0.40	0.50-0.60 0.40-0.50
Dirt road: dry wet	0.40-0.50	0.50-0.55
Cobblestones and paving stones/dry	0.20-0.30	0.20-0.40
The road - covered with snow	0.15-0.20	0.20-0.30
Icv road	0.15-0.20	0.20-0.30
Road covered with snow	0.15-0.20	0.20-0.25

High and low-pressure calculated by E.V. Mikhailovsky Table 2 shows that in all cases, low-pressure tires give a high coefficient of friction. G.V. Zimelev recommends the average values of the coefficient of viscosity given in Table 3 for use in practical calculations.

Table 3. Average values of the adhesion coefficient of tires calculated by GV Zimelev

The name of the pavement or its	The value of the viscosity coefficient for tires	
	Dry	Wet
Asphalt	0.7-0.8	0.3-0.4
Brick coating	0.7-0.8	0.3-0.5
Gravel driveway	0.6-0.7	0.3-0.4
Wooden tips	0.5-0.7	0.3-0.4
Dirt road	0.5-0.6	0.3-0.4
Compacted slag	0.5-0.6	-
Mud	0.5-0.6	0.3-0.4
Sand	0.5-0.6	0.4-0.5
Icy road	0.2-0.3	-
Road covered with snow	0.2-0.4	-

The average values of the coefficient are presented in tables 2-3. The viscosity obtained from the analysis of many available studies shows that its value can vary from 0.15 to 0.80, depending on the condition and type of road surface, as well as the design and material of the tires. The difference in friction coefficients is due to different working methods, measurement accuracy and road surface conditions, as well as the use of different tire sizes during testing.

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