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# NUMERICAL AND EXPERIMENTAL METHODS FOR DETERMINATION FRICTION COEFFICIENT

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## ABSTRACT
*In this paper is analyzed and determined the coefficient of friction between the wheels of the vehicle and asphalt. Coefficient of friction is gained through practical measurements and theoretical methods. It is set changes between values gained through practical measurements and theoretical methods. Coefficient of friction is presented as a system of forces applied in engineering, which is described in a system of forces acting on a rigid body. The model for determining the coefficient of friction is built based on a rigid body and to elaborate was taken the vehicle tires which are loaded with a testing mass, with different physical parameters of roughness (asphalt, concrete, gravel road congestion, ice, etc). Analyzed changes of static coefficient subjected to rigid body forces, changes the dynamic coefficient of friction, geometric constraints, values calculated with mathematical method through variables. Measurements were made with gauge forces applied to enable more accurate measurements and also are seen changes of values depending on the solid foundation for testing.*
**Keyword:** Values of coefficient of friction, static and dynamic friction coefficient, the system of displacement forces.

## 1. INTRODUCTION
Forces acting between two materials are proportional to the load with which they are compressed in contact with the surface. The coefficient of friction depends on the type of material and surface contact and for each material has a certain value, for illustration are taken high quality asphalt, spent asphalt with high roughness, wet asphalt and many other bases for testing, where changes are seen in decimal unit with an approximate value during experimental measurements. Between two same types of materials or even different type of material, during the action of forces applied to a rigid body between the points of contact or seal surfaces, occurs coefficient of friction and kinetic energy during friction heat.

Static friction does not prevent the melting of material with the impact of applied forces $F_{ap}$ and with an additional amount of friction force $F_f$ but in the opposite direction. Forces acting on the material as $G$ which is product of mass $m$ and the acceleration of gravity, the law of physics (the law of action and reaction), opposes with a reaction force which is normal N and is in the opposite direction. If these forces increased reaches their amount to the maximum possible static friction, then it starts static friction $\mu_s$ in dynamic friction of sliding $\mu_d$. Static friction limit values usually do not differ significantly from the value of dynamic friction in sliding. Forces which act on the body in setting rigid friction are shown in Figure 1.

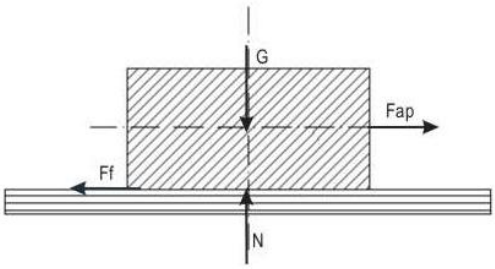


*Figure1- Presentation of the forces that acts in the process of friction.*

Where are:

$G$ - Weight of material,
$F_{ap}$ - Tensile force applied,
$F_f$ - Friction force,
$N$ - Reaction force,
$\mu$ - Coefficient of friction

Equations for determining the coefficient of friction and equilibrium conditions

$$\sum X_i = 0;\ -F_f + F_{ap} = 0 \tag{1}$$

$$\sum Y_i = 0;\ N - G = 0 \tag{2}$$

By solving the equations it is obtained

$$N = G,\ G = m \cdot g$$

$$F_f = F_{ap},\ F_f = \mu \cdot N$$

$$\mu = \frac{F_{ap}}{N} \tag{3}$$

Where are,

$m$ - Mass of material (kg),

$g$ - Acceleration of gravity $9.81\ m/s^2$.

## 2. SIMULATION AND APPLIED PRACTICAL MODEL

Setting the coefficient of static and dynamic friction is done with the method describes below. As a test material is used tire profile of cars and test surfaces for experimentation. In the figure 2.1., it is shown the most appropriate model to analyze the coefficient of friction.

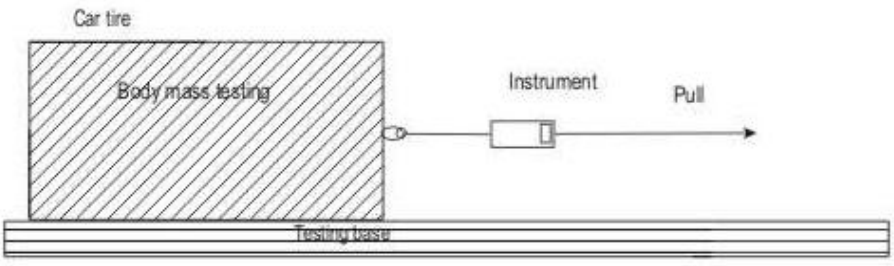


*Figure 2.1- Presentation of the model and the simulation manner with traction force.*

To make the simulation in the process of static friction is that sometimes prevents the melting process of the material that causes other forces. For example, if it is operated with a small force $F_{st}$ in the model of testing material and with an area with less roughness, the body will not move, it means that in the center operates the force which is exactly equal to static friction force $F_{st}$ in the opposite direction. But, if we immediately change the amount of traction force, then the static friction changes to dynamic friction and to the sliding. From this moment the body ranges from static to dynamic state and we have movement from the initial position from the influence of the attractive force. These changes in the attracting force in more perfect manner are read by measuring instrument to calculate the value of the coefficient of friction and friction force. Limit values of the coefficient of friction is at the margins.

$$0 \le \mu \le 1 \tag{4}$$

In the diagram below it is showed a simple example of friction to rigid body (car tire) on a horizontal surface to test the parameters of roughness in a stationary position. Numerical values are read by measuring instrument and mathematical calculations are done by equations $(1,2,3)$.

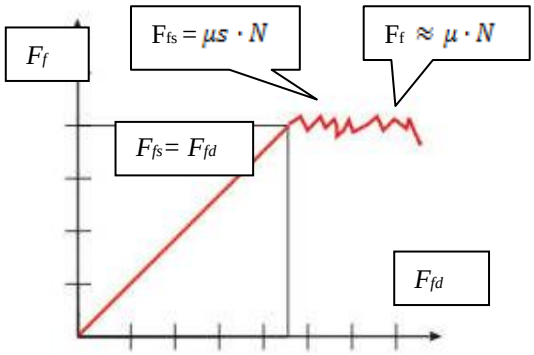


*Figure 2.2- Diagram of force changes through sliding.*

Obtained values during the experiment for various types of contact surfaces are presented in Tab. 2.1.

*Table.2.1. Values for different types of materials*

| | *High quality asphalt* | *Wet Asphalt* | *Concrete (beton)* | *Graveled road* | *Ice* | *Material test. m =2.80 (kg)* |
|---|---|---|---|---|---|---|
| $\mu$ | 0.84 | 0.7 | 0.8 | 0.66 | 0.13 | |
| $F_{ap}$ | 23.24 | 19.32 | 22.07 | 18.27 | 3.72 | $[N]$ |
| $F_{fd}$ | 23.07 | 19.22 | 21.97 | 18.12 | 3.56 | $[N]$ |
| $F_{fs}$ | 0.17 | 0.10 | 0.10 | 0.16 | 0.16 | $[N]$ |

## 3. CONCLUSION

The presented method and the numerical values obtained at any time enable to benefit desired data, as between the contact surface and other bases, where the criteria as the coefficient of friction, traction force, sliding friction force, and other parameters. Coefficient of friction in engineering is a broad phenomenon being studied for, as occurs in many different areas. One advantage of this model and practical simulation to gain data is easy and very professional. It's being used at any time and the likelihood of errors is small and the nature of avoiding table readings for the coefficient of friction. In there is endless space for experiment with other types of materials engineering.

## 4. REFERENCES


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