Features of the spring suspension operation during transverse roll

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Abstract. The paper deals with the issue of determining the roll stiffness of the truck suspension. The actual roll stiffness of the spring suspension differs from the theoretical one due to the design features of the spring suspension. The real roll stiffness of the spring suspension, in addition to the vertical stiffness of the springs, is affected by the stiffness of the silent blocks and the stiffness of the springs during lateral bending, as well as the stiffness of the springs during torsion. Analytical dependences for calculating the roll stiffness of the suspension are given. A mathematical model is considered that allows calculating the roll stiffness of the suspension by simulation modeling. Simulation studies have shown that the actual roll stiffness of the spring suspension may differ by 53% from the roll stiffness obtained by calculating the vertical stiffness of elastic elements.

1 Introduction

There are a lot of features in the operation of the spring suspension due to the fact that the elastic element simultaneously acts as both a guide and an elastic element of the suspension [1]. It is generally assumed that these features mainly consist of the S-shaped deformation of the springs caused by braking or turning torque on the axle. But even when the body rolls, the features of the spring suspension manifest themselves.

Taking into account the actual values of roll stiffness will allow to determine the characteristics of vehicles more accurately [5-6].

Let's consider the question of determining the real roll stiffness of the front spring suspension of a truck with a gross weight of up to 15 tons and a load on the front axle of up to 4 tons. Fig. 1 shows the object of the study.

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The object of the study. A truck with a gross weight of up to 15 tons [7]

Vertical stiffness of the front axle suspension

When calculating the vertical stiffness of the suspension of the front axle, the deformation of the tires is not taken into account. Movements are measured between the front axle beam and the vehicle frame. The suspension of the front axle on the test bench is shown in Fig. 2. The initial data for calculating of the suspension stiffness are the vertical force acting on the front axle wheels and the vertical movement of the axle beam.

Fig. 2. The positions of the front axle suspension in the study of vertical stiffness: a) suspension in the free state; b) suspension in the loaded state.

As a result of the calculation, the dependency of forces on the vertical movement of the front axle beam is obtained (Fig. 3).
The suspension stroke from the free state up to the stop in the limiter is equal to 145.3 mm. The stiffness of the suspension on the linear section is 490 N/mm.

3 Calculated roll stiffness of the spring suspension

The vertical stiffness of the suspension obtained by simulation is 490 N/mm. The stiffness of each spring in the vertical direction is 245 N/mm. The distance between the springs is 850 mm.

The roll stiffness of the suspension can be calculated using the following formulas:

$$\Delta Z = L/2 \cdot \sin \alpha$$

where $\Delta Z$ is vertical movement of the axle beam at the spring attachment point, m; $L$ is distance between spring axles, m; $\alpha$ is roll angle, deg;

$$M = \Delta Z \cdot c \cdot L$$

where $M$ is the torque required to twist the axle, Nm; $\Delta Z$ is vertical movement of the axle beam at the spring attachment point, m; $c$ is vertical spring stiffness, N/m; $L$ is distance between spring axles, m;

$$c = \frac{M}{\alpha}$$

4 Roll stiffness of the spring suspension, calculated by simulation
The difference between this calculation and the theoretical one is that it takes into account the rigidity of the silent blocks, the peculiarities of the spring operation during torsion and changes in the distance between the spring mounts in projection onto a horizontal plane.

The roll stiffness of the front suspension was studied with a 4-ton vertical load on the axle, which corresponds to the load on the front axle at full weight of the car. The position of the front suspension when calculating the roll stiffness is shown in Fig. 4. The calculation determines the vertical forces acting on the wheels and the angle of the transverse inclination of the axle beam.

![Fig. 4. The position of the suspension of the front axle in the study of the roll stiffness of the suspension: a) roll to the right side; b) roll to the left side](image)

The obtained dependence of the suspension roll stiffness on the angle of axle inclination is shown in Fig. 5.

![Fig. 5. Roll stiffness of the front suspension depending on the transverse roll](image)

The roll stiffness of the front suspension in the neutral position is 2365 Nm/deg. The increase in roll stiffness at rolls of more than 8 degrees is due to the inclusion of suspension stroke limiters.

The deviation of the roll stiffness of the spring suspension, obtained by calculation and simulation, is equal to
5 Conclusions

The deviation of the roll stiffness of the spring suspension, obtained by calculation and modeling and taking into account additional factors, is 53.17 %. It follows from this that when modeling a spring suspension, additional features must be taken into account, such as the torsional stiffness of the spring, the stiffness of the spring during lateral bending, and the stiffness of the silent blocks. All these factors together, when the suspension is working with body rolls, make a significant contribution to the overall roll stiffness of the spring suspension.

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