STUDY IN VEHICLE RESPONSE DURING STEERING AND BRAKING MANEUVERS

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Introduction

During the acceleration or braking phases of vehicle performance the handling characteristics may vary considerably from those obtained under steady speed conditions [1 to 3]. In certain cases advantage may be taken of the changes to enhance some particular aspects of handling. For example, the application of an accelerating force through the rear wheels of a rear drive vehicle is a means whereby lateral response may be increase. The braking process can in extreme cases result in either complete loss of control, with the outcome that the vehicle moves either in a manner solely dependent on its attitude immediately prior to brake application, or in absolute stability in which the vehicle cannot deviate from a rectilinear motion [4 to 6].

The present work is concerned with experimental study of vehicle response in steering and braking maneuvers in special cases, where the tests were performed with two sets of front/rear tire-inflation pressures: one overinflated and the other underinflated.

Effect of front tire-inflation pressure on the vehicle lateral response and the wheels locking during braking maneuvers was investigated.

Test procedure and measurements

Tests were run on dry asphalt road surface; the test car (type Lada 1200) was in laden condition. Tests were performed by applying different rates of steering input to the vehicle initially costing on straight-line path (at a fixed value of initial speed; $u_0 = 40.50$ and 60 km/h). Steering maneuver tests were performed with fixed steer angle.

The directional response of the vehicle expressed in terms of yaw and lateral accelerations were measured and recorded during test (7).

Steering maneuver test (no braking)

During steering input process, the vehicle yaw acceleration was measured with different tire-inflation pressures and two different constant vehicle speeds ($u_0 = 40$ and 60 km/h).

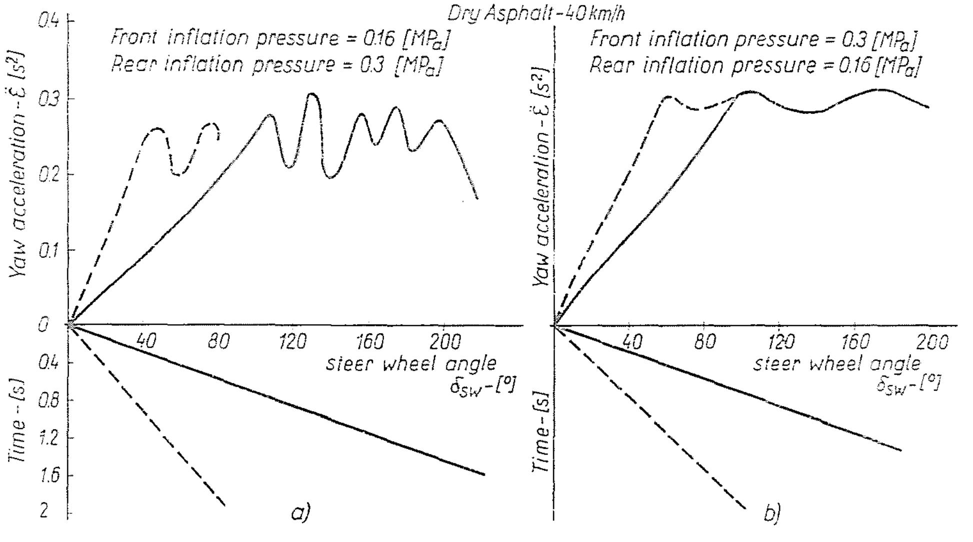

Fig. 1

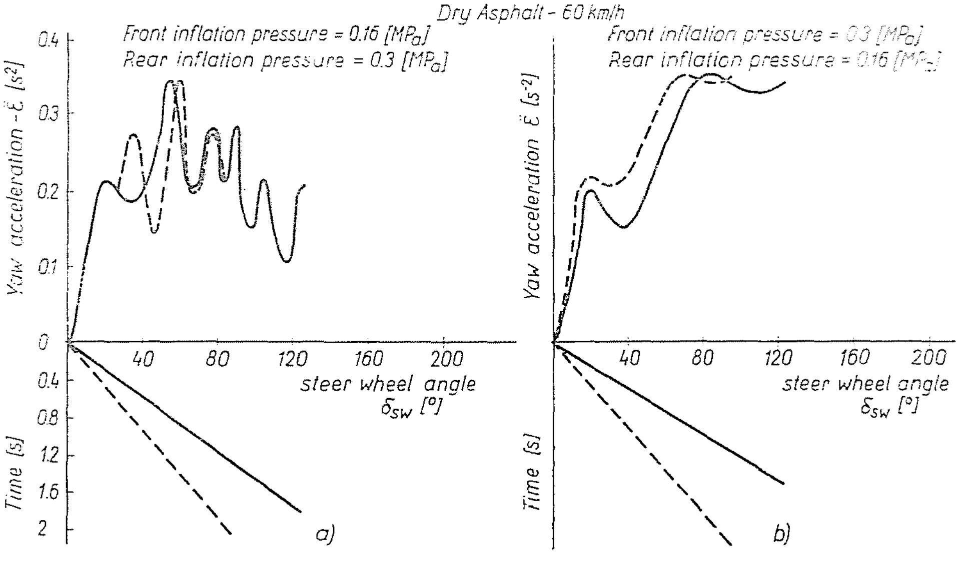

Fig. 2

Test result showed the front tires inflation pressure to significantly affect the vehicle directional response. It was found that at overinflated front tires the vehicle tends to be oversteered (high level of yaw acceleration) and without significant oscillation about the vehicle's yawing axis (yaw acceleration does not oscillate) (see Figs. 1 and 2b). There is an opposite tendency, however, at underinflated pressure of the front tires, the vehicle tends to be understeered (low level of yaw acceleration) and with significant oscillation about the yawing axis of the vehicle (yaw acceleration does oscillate) (see Figs. 1 and 2a).

By comparing Figs. 1 and 2, it can be noted that increasing the vehicle speed at a certain inflation pressure results in increasing the oscillation frequency.

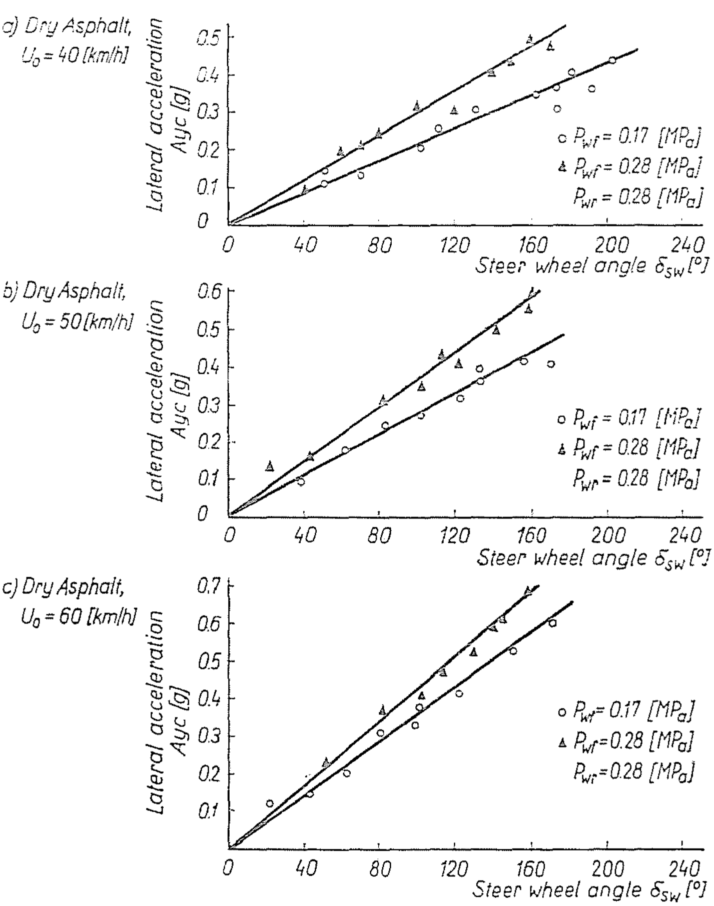

Fig. 3

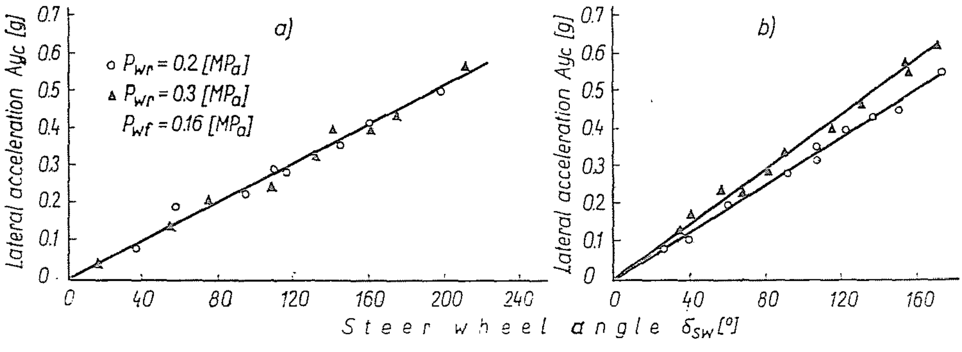

Fig. 4

It was also found that the rear tire-inflation pressures have no significant effect on vehicle motion or oscillation during the utilized range of inflation pressures.

Fig. 3. shows the variation of the vehicle lateral acceleration versus the steering angle in steady-state turn, at different speeds (40, 50 and 60 km/h) with different inflation pressures of front tires. The obtained results indicate that the lateral acceleration increases with increasing inflation pressure, mainly due to the decreasing curvature radius of the vehicle path. Here it can be concluded that upon increasing the front tire-inflation pressure (constant rear-tire inflation pressure) the difference between the front and the rear tires' sideslip angles decreases $(\alpha_f - \alpha_r)$.

Fig. 3 shows the difference between the produced lateral accelerations to be reduced as the vehicle speed increases (compare a, b, and c). This result indicates that increasing the vehicle speed results in reducing the effect of the inflation pressure on the lateral acceleration.

Effect of vehicle speed, steer angle and front tire-inflation pressure on lateral acceleration is given in Fig. 5, pointing out that change of front tires

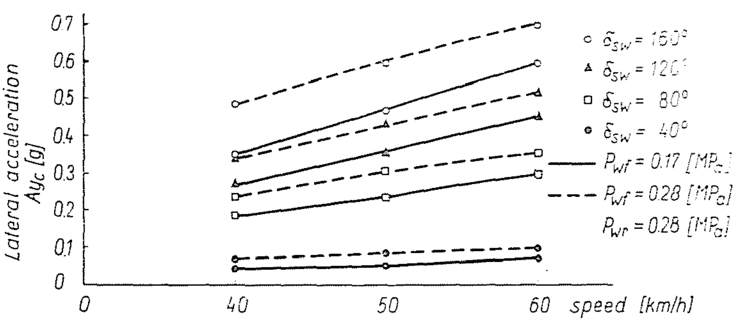

Fig. 5

inflation pressure has an increasing effect on lateral response, as the steer angle increases.

The results indicate the directional response of the vehicle to be highly sensitive to changes of front tire-inflation pressure, and this mainly causes the change of tire characteristics producing change of the tire-road friction coefficient and slip-angle. Also the vehicle speed is of importance beside the front tire-inflation pressure.

Combined steering and braking tests

As shown above the front tire-inflation pressure has a significant effect on the vehicle yaw and lateral accelerations, but in a moderate maneuver the driver can correct the vehicle path by increasing or decreasing the steer wheel angle. In case of combined steering and braking, however, the front tire-inflation pressure is of importance by changing the front wheels' locking time, likely to cause complete loss of vehicle controllability.

Fig. 6 shows typical recording for combined steering and braking tests with 0.25 MPa inflation pressure of front and rear tires. The front wheels are seen not to be locked early and the lateral acceleration to have two peaks, which means that the vehicle twice changes its directional motion, by other words, the vehicle, first, tends to drift-out (decreasing lateral acceleration, and the rear wheels tending to lock) and then the vehicle exhibits spin-out (increasing the lateral acceleration due to the relatively long time between the locking of the rear and the front wheels).

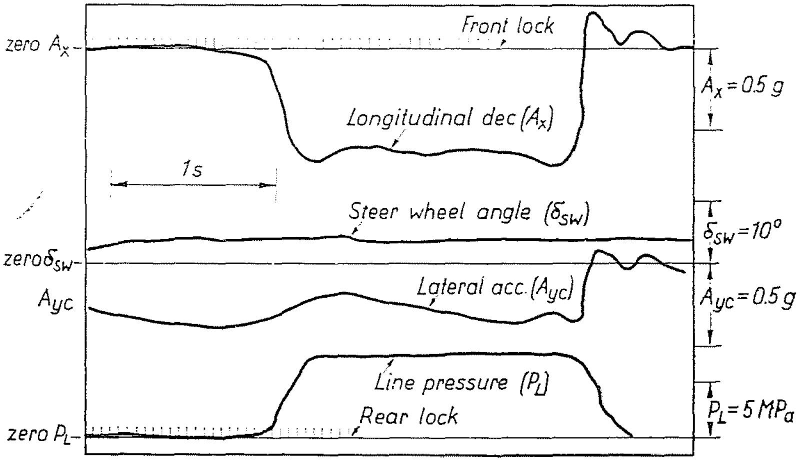

Fig. 6

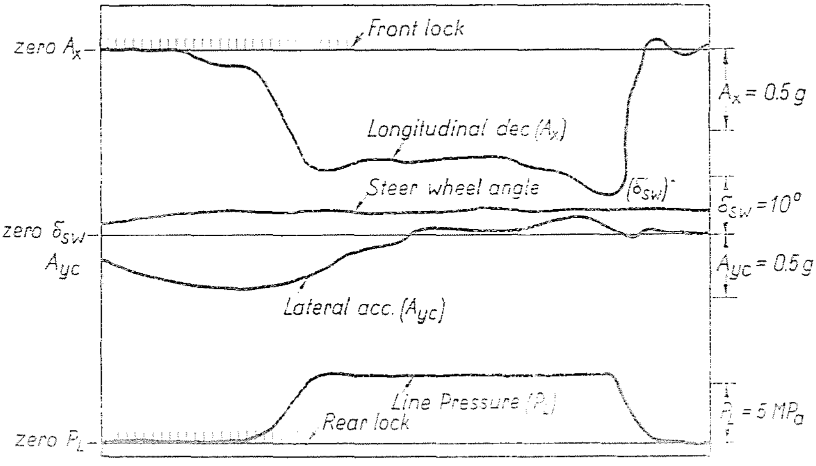

Fig. 7

Fig. 7 shows typical recording for the same maneuver test with front tire-inflation pressure of about 0.16 MPa and the rear of about 0.25 MPa. It can be noted that the front wheels were locked quickly at lower brake oil pressure than that needed to cause locking at higher tire-inflation pressure. Also the lateral acceleration is seen to have a single peak and the vehicle tends to move in straight line.

It can be concluded that the directional response of the vehicle during combined steering and braking depends not only on its situation prior to application of braking (8), but also on the front and rear tire characteristics (inflation pressure).

Summary

Vehicle directional response has been studied during steering and braking maneuvers, in special cases of tire-inflation pressures (underinflated and overinflated).

Test results showed that:

1 — During steering maneuver tests (no braking), the lateral and yaw accelerations are highly sensitive to the front tire-inflation pressures. No significant effect of the rear tire-inflation pressures on the vehicle response could be observed.

2 — During steering and braking maneuvers, the vehicle response was influenced by the front tire-inflation pressures. Increasing the front tire-inflation pressure results in increase of the lockup time difference between front and rear wheels.

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