

## The Effect of Degraded Shock Absorbers on the Safety-Critical Tipping and Rolling Behaviour of Passenger Cars

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**Abstract :** In Germany, the number of road fatalities has been falling since 2010 at a more moderate rate than before. At the same time, the average age of all registered passenger cars in Germany is rising continuously. Studies show that there is a correlation between the age and mileage of passenger cars and the degradation of their chassis components. Various studies show that degraded shock absorbers increase the braking distance of passenger cars and have a negative impact on driving stability. The exact effect of degraded vehicle shock absorbers on road safety is still the subject of research. A shock absorber examination as part of the periodic technical inspection is only mandatory in very few countries. In Germany, there is as yet no requirement for such a shock absorber examination. More comprehensive findings on the effect of degraded shock absorbers on the safety-critical driving dynamics of passenger cars can provide further arguments for the introduction of mandatory shock absorber testing as part of the periodic technical inspection. The specific effect chains of untripped rollover accidents are also still the subject of research. However, current research results show that the high proportion of sport utility vehicles in the vehicle field significantly increases the probability of untripped rollover accidents. The aim of this work is to estimate the effect of degraded twin-tube shock absorbers on the safety-critical tipping and rolling behaviour of passenger cars, which can lead to untripped rollover accidents. A characteristic curve-based five-mass full vehicle model and a semi-physical phenomenological shock absorber model were set up, parameterized and validated. The shock absorber model is able to reproduce the damping characteristics of vehicle twin-tube shock absorbers with oil and gas loss for various excitations. The full vehicle model was validated with steering wheel angle sinus sweep driving maneuvers. The model was then used to simulate steering wheel angle sine and fishhook maneuvers, which investigate the safety-critical tipping and rolling behavior of passenger cars. The simulations were carried out in a realistic parameter space in order to demonstrate the effect of various vehicle characteristics on the effect of degraded shock absorbers. As a result, it was shown that degraded shock absorbers have a negative effect on the tipping and rolling behavior of all passenger cars. Shock absorber degradation leads to a significant increase in the observed roll angles, particularly in the range of the roll natural frequency. This superelevation has a negative effect on the wheel load distribution during the driving maneuvers investigated. In particular, the height of the vehicle's center of gravity and the stabilizer stiffness of the vehicles has a major influence on the effect of degraded shock absorbers on the overturning and rolling behaviour of passenger cars.

**Keywords :** numerical simulation, safety-critical driving dynamics, suspension degradation, tipping and rolling behavior of passenger cars, vehicle shock absorber

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