Experimental design of control strategy based on brake pressure changes on wet and slippery surfaces of rough road for variable damper setting during anti-lock brake system braking

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Abstract
In this study, the control strategy based on experimental study is established for a variable damper setting with activated anti-lock brake system. For this, anti-lock brake system braking tests have been conducted by using hard, medium–hard and soft dampers on a rough road which has wet and slippery surfaces. In anti-lock brake system tests, brake pressure has been measured. The brake pressure increasing and decreasing rates have been obtained using measured brake pressure. The control strategy has been designed by using threshold values acquired from these test results related to brake pressure. For this, firstly, the brake pressure change thresholds of damper providing the shortest braking distance are determined. Then, the damping capacity stage rules are designed by depending on the brake pressure thresholds corresponding to the road conditions. The control strategy performance has been evaluated during transitions between wet and slippery roads. The results show that this control strategy is effectively applied to passenger cars without any change in electronic control unit configuration of anti-lock brake system. For this control strategy, it is considerably important that the damper setting to provide the shortest braking distance is detected.

Keywords
Anti-lock brake system, variable damper setting, brake pressure, rough road

Introduction
Recently, antilock brake systems (ABS) have become indispensable equipment for safety during braking of a vehicle. ABS is mainly composed of the wheel speed sensors, hydraulic pressure modulator, pressure control valves (PCVs) and ABS controller. Wheel speed sensors on wheels detect the angular speed of each wheel. The electronic control unit (ECU) receives, amplifies and filters sensor signals to determine velocities which serve as the basis for calculations of reference speed, brake slip and the wheels’ acceleration and deceleration. An hydraulic pressure modulator modulates the braking pressure according to the commands issued by the ECU. In addition, PCVs are used to control automatically brake levels at the wheel brakes.1,2,3 In this way, ABS has controlled tire slip and wheel acceleration by preventing the wheel from locking. This duty is performed by reducing, increasing and holding of the brake pressure. Since the slip is function of the friction, these brake pressure changes should match the friction between tire and road surface during braking with ABS. For this reason, ABS braking performance depends on how accurate the friction is estimated from tire slip using sensor signals. Mauer et al.4 stated that the most important variables in determining the quality of the ABS control were friction coefficients. Yi et al.5 demonstrated that there are two main factors to determine the braking capacity during emergency braking. These are tire–road contact and available braking torque. Bogdevicius and Vladimirov6 determined that the uncontrolled dynamic interaction between road and...