

Formulas for Vehicle Braking Dynamics

1. Torque created by the caliper on the rotor (at the wheel) = T_w

$$T_w = P_s \times A_p \times \mu \times 2 \times R_E$$

P_s = Pressure of system; A_p = Total Area of pistons in one half of caliper (one side of opposed type or active (piston) side of sliding or floater type); μ = Friction Coefficient; $\times 2$, since there are two sides of the rotor that the pads are exerting force against;

R_E = Effective Radius of clamping force.

IMPORTANT NOTE: Not all calipers are created equal. The equation above assumes a perfect embodiment of the caliper clamping function. In actual fact, the more compliant (or less stiff) a caliper is, the less efficient or able it is to maintain a 1:1 ratio of system pressure increase to increase in force applied perpendicular to the pad face. Other caliper functions can also affect the torque realized through losses that are the result of vibration, caliper and caliper mounting flex, and offset loads. Pad friction coefficient and caliper material strength are affected by temperature.

2. Weight transfer during braking = ΔW

$$\Delta W = M \times \gamma \times ht_{cg} / L_{WB} \lll W_{RStatic}$$

M = Mass of vehicle, γ = rate of velocity change (- since decelerating), $M\gamma$ is termed Force of Inertia, ht_{cg} = height of Center of Gravity, L_{WB} = Length of wheelbase

The amount of weight that is available to transfer is limited by the static weight on the rear wheels, in this example it would be called $W_{RStatic}$. In fact, the practical limit for weight that can transfer is much less than $W_{RStatic}$ and still see real work done by the rear brakes. Aerodynamic loading and cornering while braking will affect this limit dynamically, thereby changing the maximum rate of deceleration possible.