

Impact of Quality of Brakes (Brake Bias) on Automobile Performance

Jha, U.C¹ and Saksham Gupta²

¹VSRD Research Mentor.

²Final Year ME Student, NIT Hamirpur.

Abstract

Brake Bias—Indicated as a percentage. This indicates the relative amount of brake pressure applied from the master cylinder(s) to the front brakes. This is an adjustment of the relative amount of hydraulic pressure applied to the front verses the rear brake calipers and pads. This is needed to optimize the braking power, as a car decelerates, load transfers to the front tires, which generally improves their grip, while decreasing the grip at the rear of the car.

In this paper various balancing of brakes in passenger car industry will be studied and there performance will be monitored. The paper is aimed to understand that brakes bias and its influence on the car performance.

Keywords: Quality, Brakes, Automobile, Performance.

1. Introduction

Brake bias—Indicated as a percentage. This indicates the relative amount of brake pressure applied from the master cylinder(s) to the front brakes. E.g. 52% would indicate that the front brakes were receiving 52% of the brake pressure and the rear brakes would be receiving 48%.

This is an adjustment of the relative amount of hydraulic pressure applied to the front verses the rear brake calipers and pads. This is needed to optimize the braking power, as a car decelerates, load transfers to the front tires, which generally improves their grip, while decreasing the grip at the rear of the car. In addition, the size of the front and rear brake rotors, pads, and piston area is often different requiring different amounts of pressure for the same braking power. The goal is to adjust the proportion of the braking forces between front and rear (brake bias) in order to maximize overall

braking efficiency. If the brakes are still applied as the car turns into the corner, the brake-bias setting will also have an effect on the car's turn-in balance.

Increasing Front bias: Shown as a larger number, increasing brake bias to the front will put more braking force into the front tires. This will stabilize the car in braking zones and increase under steer at corner entry. The compromise is that with too much front bias the rear tires are being under-utilized and overall braking efficiency will suffer. This can also cause rapid front tire wear due to front tire lockup, especially of the inside tire which is the first to lock up.

The brake bias settings have no influence on other garage settings. They will however influence tire wear (due to brake lockup) and stability and car balance under braking. In order to demonstrate the concept of proper brake balance, it is usually simpler to analyze a car's handling characteristics and then apply those principles back to the braking system.

1.1 So why is brake biasing necessary?

The maximum braking force that a particular tire can generate is theoretically equal to the coefficient of friction of the tire-road interface multiplied by the amount of weight being supported by that corner of the car. For example, a tire supporting 500 pounds of vehicle weight with a peak tire-road coefficient of 0.8 (a typical street tire value) could generate, in theory, 400 pounds of braking force. Throw on a good race tire with a peak coefficient of 1.5, and the maximum rises to 750 pounds of braking force. More braking force means higher deceleration, so we again see the mathematical benefits of a sticky race tire.

On the other hand, if our race tire was now only supporting 300 pounds, the maximum force would drop from 750 pounds of braking force to 450 pounds of braking force—a reduction of 40%.

Since the amount of braking force generated by the tire is directionally proportional to the torque generated by the calipers, pads, and rotors, one could also say that reducing the weight on the tire reduces the maximum brake torque sustainable by that corner before lock-up occurs. In the example above, if an assumed 700 ft-lb. of brake torque is required to lock up a wheel supporting 500 pounds, then only 420 ft-lb. (a 40% reduction) would be required to lock up a wheel supporting 300 pounds of vehicle weight.

At first glance, one could surmise that in order to achieve perfect brake bias you could just:

1. Weigh the four corners of the car
2. Design the front and rear brake components to deliver torque in the same ratio as the front-to-rear weight distribution
3. Win races

In other words, for a rear-wheel-drive race car with 50/50 front/rear weight distribution it would appear that the front and rear brakes would need to generate the same amount of torque. At the same time, it would look like a production-based front-wheel-drive car with a 60/40 front/rear weight distribution would need front brakes

with 50% more output (torque capability) than the rears because of the extra weight being supported by the nose of the car.

Like most things in life though, calculating brake bias is not as simple as it may appear at first glance. Designing a braking system to these static conditions would neglect the second most important factor in the brake bias equation—the effect of dynamic weight transfer during braking.

1.2 So what influences brake bias?

If we look at the equations we have developed, we see that all of the following factors will affect the weight on an axle for any given moment in time:

- Weight distribution of the vehicle at rest
- CG height—the higher it is, the more weight gets transferred during a stop
- Wheelbase—the shorter it is, the more weight gets transferred during a stop

We also know from fundamental brake design that the following factors will affect how much brake torque is developed at each corner of the vehicle, and how much of that torque is transferred to the tire contact patch and reacted against the ground:

- Rotor effective diameter
- Caliper piston diameter
- Lining friction coefficients
- Tire traction coefficient properties

It is the combination of these two functions—braking force at the tire versus weight on that tire—that determine our braking bias. Changing the CG height, wheelbase, or deceleration level will dictate a different force distribution, or bias, requirement for our brake system. Conversely, changing the effectiveness of the front brake components without changing the rear brake effectiveness can also cause our brake bias to change. The moral of the story

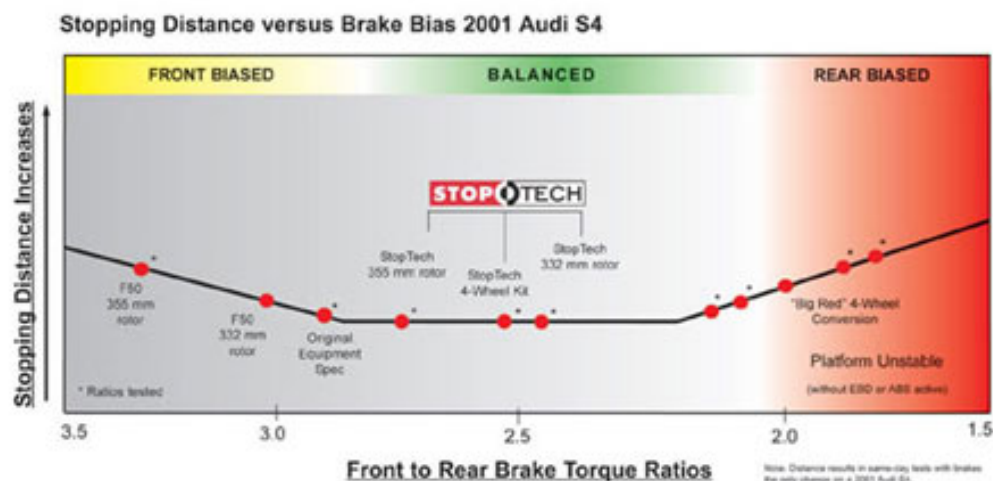


Fig. 1

As Fig. 1 illustrates, every car has a “sweet spot” for brake bias which will generate the shortest stopping distances possible. Typically, the auto manufacturers design their cars to be 5% to 10% more front-biased than optimum for maximum deceleration, but they provide enhanced brake stability in return. Not a bad trade-off for the public at large, and not necessarily a bad place for a race car in the heat of battle either.

As you go about modifying your car for the street or for the track, be aware that changes in the braking system as well as changes in the car’s ride height, weight distribution, or physical dimensions can swing brake bias all over the place. The only sure-fire way on knowing if your final bias has been optimized is to measure stopping distance both before and after your modification(s).

2. Conclusion

In summary, your tires certainly still stop the car, but if your bias is out in left field you might not be able to use everything they have to offer. Your braking system is just that—a system—and keeping an eye on brake bias effects during modification will go a long, long way toward bringing home the checkered flag. Of course, selecting the proper kit from a manufacturer who has already done the hard part for you can make the trip to victory lane that much easier.

References

- [1] Ginder, D.A. (1990), ‘The engineer and TQM’, Automotive Engineering, October, pp.18-19.
- [2] Research Results Digest (1994), no. 3, Transportation Research Board, National Research Council U.S.A.
- [3] Stone, Richard. And Jeffrey K. Bell. Automotive Engineering Fundamentals. Warrendale, Pa: Society of Automotive Engineers, Inc. 2004.
- [4] Limpert, Rudolf. Brake Design and Safety. Warrendale, Pa: Society of Automotive Engineers, Inc. 1999.
- [5] Walker, Jr., James. The Physics of Braking Systems StopTech LLC. 2005.