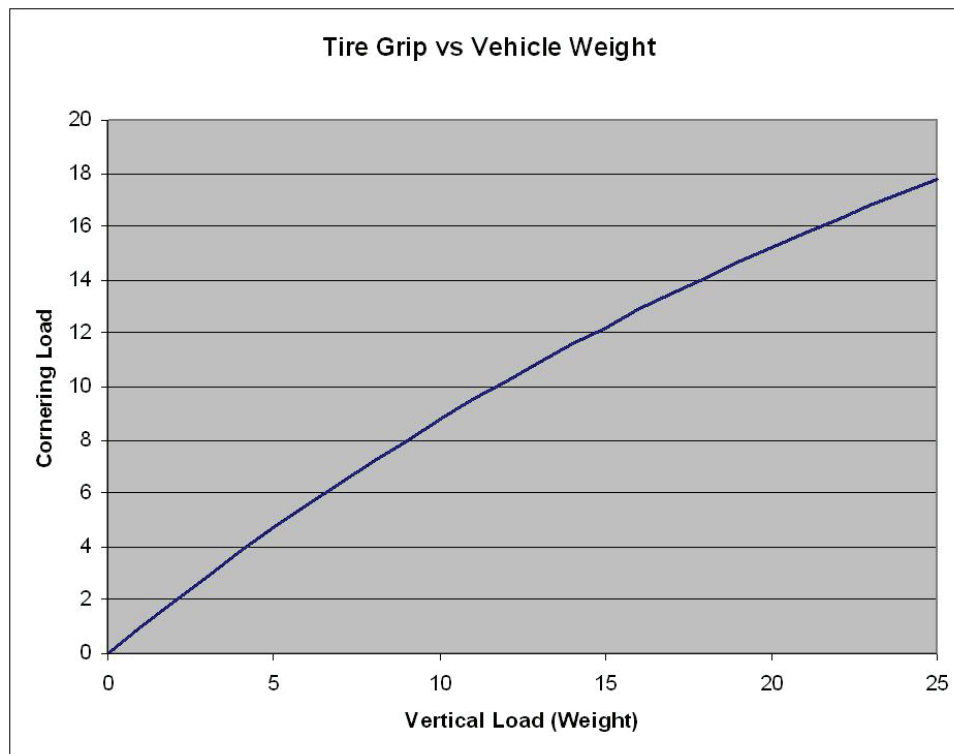


Tire Grip & Car Balance

By Larry Herman

One of the biggest difficulties in understanding how to improve or adjust the handling of one's car is the comprehension of grip: what it is, how it works and how to work with it. Grip is derived by placing weight (or load) on the tire in a vertical direction, which will produce cornering ability in the horizontal direction. When I talk about balancing the car to a group of advanced drivers, I like to present the basic premise, devoid of aerodynamics, tire loading or other influences, that a car on street tires has the most grip when it is sitting in the paddock! Pretty profound huh? Each axle has fairly even weight on both sides; therefore the tires have the same pressure against the tarmac, so they are both contributing equally, providing maximum grip. Why is this so? Because of the fact that as you increase the weight (downward loading) on a tire, its grip (ability to resist sideways loading) will increase as well but not quite as much in relation to the load. Here is a graph to illustrate what I am talking about. The numbers are purely for demonstrative purposes.



This phenomenon of diminishing returns is why a car when cornering hard, transferring much of its weight onto the outside tires, actually has less overall grip. It is also the biggest reason that light cars, which by definition transfer less weight to their outside tires, generally handle better than heavy cars.

This single most fact is what balance is all about, and why a change in roll rate, either accomplished through springs, sway bars or even through shock dampening can make a profound difference in the understeer/oversteer characteristics of a car. As the car accelerates, brakes and corners, it is constantly transferring weight from back to front, and from side to side. This changes the respective balance of grip from front to rear, and creates the tendency for over or understeer. And depending on the car's front and rear roll rates, and the amount of weight being transferred, the change in grip can be pretty dramatic.

Let's take a simplistic example to illustrate what I am trying to explain. A Boxster or Cayman is a fairly neutral car with about a 50/50 weight distribution and similar sized front & rear tires. If we were to drive this car around a skid pad, as our speed is slowly increased, more weight will be transferred from each inside tire, to each outside tire until they get to maximum grip. If we continue to feed in a little more speed, the slight shift of weight on the back tires should provide enough extra grip so that the front will start to slide (understeer). If we lift off even infinitesimally, the weight will shift back towards the front and the rear will begin to slide (oversteer). Most drivers have a pretty good grasp of this. But now how do we tune this so that we can still have a little oversteer as we are adding throttle? By adding roll stiffness to the rear, or reducing it at the front. I am a big believer of adjusting the end of the car that I want to control, so if I want to add oversteer while the car is accelerating, I will stiffen the back end.

Why does increasing the rear roll rate do this? In my classrooms many hands get raised; "because it transfers more weight to the outside tires" is the typical answer. And that would be incorrect. Remember that there are only 3 things that affect the total amount of weight transfer in a car: #1 vehicle weight, #2 center of gravity and #3 track width. So what is going on here?

Let's take our Cayman example whose corner weights are:

800 800

800 800

Imagine that we are in a right hand corner that transfers 1000 lbs total, with equally stiff front and rear springs, the corner weights would be:

1300 300

1300 300

Now if we change the rear roll stiffness either through sway-bar adjustment or spring rate such that 70% of the total weight transfer (or 700 lbs) happens at the rear, the corner weights would be:

1100 500

1500 100

See how the balance has changed from front to rear, and the weight differential across the front has become more even than across the back? It is pretty clear that the front now has a lot more grip and the rear a lot less. This car is going to oversteer bigtime!

How does this rear to front weight shift occur? Increasing the roll stiffness at the back of the car will help keep the overall platform more level, rather than having it "sit down" on the outside rear tire. This keeps more weight on the inside front tire, thereby increasing the grip at the front of the car. You can try it yourself with a simple test. Take your iPhone (or something similar) and pretend it is the car. With the phone long ways, hold each end with your thumb and forefinger on each corner. Lift up your thumbs, tilting it up on one side slightly to simulate a car leaning. Now gently lift the fore-finger that you imagine is outside rear corner. See how it immediately pressures the inside front, across the diagonal? This "leveling of the car" is what transfers load from the inside rear to the inside front, reducing grip in the back and increasing grip at the front. It is important to remember that we have not changed the total amount of weight transferred, we have just shifted it forwards.

Keep in mind that what I am explaining here is not the definitive word on all of the forces in play, but a primer to help with getting a grasp of the basics. I hope that this provides a little clearer idea of what is happening with grip and balance.