The Mark Ortiz Automotive

# CHASSIS NEWSLETTER

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## WELCOME

Mark Ortiz Automotive is a chassis consulting service primarily serving oval track and road racers. This newsletter is a free service intended to benefit racers and enthusiasts by offering useful insights into chassis engineering and answers to questions. Readers may mail questions to: 155 Wankel Dr., Kannapolis, NC 28083-8200; submit questions by phone at 704-933-8876; or submit questions by e-mail to: markortiz@vnet.net. Readers are invited to subscribe to this newsletter by e-mail. Just e-mail me and request to be added to the list.

## SPRINGS, BARS, AND LOAD TRANSFER

*I've been reading around and am having a hard time comprehending a spring's effects on load "change" and how they effect understeer/oversteer balance as stated in your April/May/June 2003 newsletter.*

*What I know (or think I know):*

*Longitudinal Load Transfer = acceleration x [(weight x cg height)/wheelbase]*

*Lateral Load Transfer = (Lateral Acceleration x weight x cg) / Track width*

*So, by looking at the equation, spring rates are not part of the formula, therefore they play no role in the amount of load transfer. However, I do know that sway bars DO affect load transfer by unloading the inside wheel and loading the outside wheel. In Carroll Smith's "Tune to Win," he states:*

*"The greater the resistance of the springs, the less roll will result - but there will be no significant effect on the amount of lateral load transfer because the roll couple has not been changed and there is no physical connection between the springs on opposite sides of the car. The same cannot be said of the resistance of the anti-roll bars. In this case, because the bar is a direct physical connection between the outside wheel and inside wheel, increasing stiffness of the anti-roll bar will both decrease roll angle and increase lateral load transfer."*

*By looking at the above information, we would assume springs are merely there to control body roll which affects camber, toe, etc.*

*And from your article, I gather that the amount of load transfer between the two front wheels vs the two rear wheels indicates how much oversteer/understeer a car will have. However, the above equations show that spring rates don't affect load transfer.*

*What I don't understand:*
*I realize that using higher spring rates in rear vs. spring rates in front will cause a car to oversteer - given a simplified car with equal motion ratios front/rear and without using sway bars. In the real world, it proves true. However, I'm having a hard time comprehending how spring rates can affect the balance of the car when they play no role in load transfer? What do you mean when you say stiffer springs cause more "load change"?*

The questioner is quite right that springs do affect car balance, and that this could not be so if they had no effect on load transfer.

With all due respect for Carroll Smith's memory and legacy, significant portions of the passage the questioner cites here are simply incorrect. Springs and anti-roll bars both affect load transfer – or more properly, load transfer distribution – in cornering or lateral acceleration, and they do so in essentially the same way. Indeed, anti-roll bars are springs, and the ride springs are connected side-to-side, by the car's frame.

The only difference between an anti-roll bar and a ride spring is that anti-roll bars act only in roll and warp, whereas ride springs act in all four modes of suspension movement: roll, pitch, heave, and warp. In the modes in which it is active, the bar is just another spring.

The equations cited are for total load transfer, in lateral or longitudinal acceleration. Taken as such, they are correct. The springs and the bars do not affect these total quantities, or at least not very much. However, the springs and bars affect the **apportionment** of that total, between the front and rear wheel pairs in lateral acceleration, or between the right and left wheel pairs in longitudinal acceleration.

Let's consider lateral acceleration first. The roll-resisting moments produced by the springs and bars are called the elastic component of roll resistance, and they produce the elastic component of load transfer at the tires. There is also a geometric component, at each end of the car, which comes from the forces in the (comparatively) rigid suspension components. These two components make up the total roll resistance for the front or rear suspension.

For purely lateral acceleration, in steady-state cornering, assuming equal track width at both ends, the total sprung mass load transfer at the front or rear is the total sprung mass load transfer for the whole car, times the percentage of the total roll resistance at that end. For example, if the front suspension's combined elastic and geometric roll resistance is twice as great as the rear suspension's combined elastic and geometric roll resistance, the front end then has 2/3 of the total roll resistance, and it will see 2/3 of the total sprung mass load transfer.

Increasing the front roll resistance or decreasing the rear will increase front sprung mass load transfer, and decrease the rear. Increasing front and rear roll resistance together, maintaining 2/3 of the total at the front, will result in no significant change in the wheel loads. It doesn't matter whether we change roll center heights (the measure of geometric roll resistance), springs, bars, or all three, as long as the totals front and rear are in the same ratio as before we made our changes.

In longitudinal acceleration, the same principles apply, except that the effects of the bars are negligible since we are dealing with pitch rather than roll, and we are concerned with the relative pitch resistances of the right and left wheel pairs, rather than the relative roll resistances of the front and rear wheel pairs.

In either case, the elastic component of the wheel pair load changes depends on the rate of both springs in the pair, and increasing the rate of either spring in the pair increases the average or total for the pair.

So, for the rear suspension in roll for example, stiffening either the inside or the outside spring adds roll resistance. On the outside wheel, a stiffer spring increases the **rate of force increase** with respect to suspension compression: more pounds of load change per inch of suspension movement. On the inside wheel, a stiffer spring increases the **rate of force decrease** with respect to suspension extension: again, more pounds of load change per inch of suspension movement.

Either way, we have more pounds-feet of roll-resisting moment per degree of sprung mass roll.

So in any situation that decreases the load on a spring, a stiffer spring gives less load on the wheel at a given suspension movement: more load change, implying less load, compared to same displacement with a softer spring.

More knowledgeable readers will note that this discussion is simplified somewhat compared to real life. Springs can somewhat affect total load transfer, chiefly because they can create ride height changes with roll and pitch. For example, if we put stiff springs in the rear and soft springs in the front, and the car has little anti-squat, then under forward acceleration the rear suspension will compress little and the front suspension will extend much. The car will therefore be sitting higher off the ground, c.g. height will be greater, and therefore rearward load transfer will be greater.

Thus, it is not strictly correct to say that springs do not affect overall total load transfer. However, for all but extreme cases, we can treat such effects as negligible.