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.

EFFECTS OF SPRING RATES AND DAMPER SETTINGS DURING CORNERING

I would be interested to hear your comments about the effects of relative spring rates (front/rear) and damper settings on steady-state cornering characteristics. I do not race, but I am interested in the effects of suspension settings on the relative under/over-steer characteristics.

I presume that (all other things being equal) any increase in spring rate at the front will increase the apparent roll stiffness and therefore make the car trend towards an increase in understeer (which I presume is the same as an increase in static directional stability) – and an increase in the rear will cause the reverse. And an increase in damper rate at one end would seem to have a similar dynamic effect during turn-in, while the load transfer is actually taking place.

I own a Morgan – which as you are aware does not have any anti-roll bars – and I am about to change the front springs to a higher rate (140 lb/in vs. 105 lb/in) and I presume that this is going to cause some change in behavior. It would be interesting to know what order of magnitude of change I could expect, though, and whether it would be worth experimenting with the (adjustable) damper rates to try to modify turn-in behavior.

If I had more extensive experience with Morgans, perhaps I could predict the change with more confidence. As things stand, I can say that you have correctly understood the effect that spring rates have on steady-state handling balance in most cases: stiffen one end, and you get more load transfer at that end and less at the other, so you reduce grip at the end you stiffened and add grip at the other end.

However, in certain cases we can add roll resistance at the front and reduce understeer! This is most often seen in cars with beam axles in back, and independent suspension with poor camber recovery in roll in front – most commonly small rear-drive sedans that roll a lot and have lowered MacPherson strut suspension in front. What's going on in these cases is that although the front tires are less equally loaded, the reduction in roll improves their camber so much that the camber improvement more than makes up for the more unequal loading. At the rear, the beam axle gives 100% camber recovery at any roll angle, so rear camber is unaffected.

The Morgan is a similar case in some respects. It rolls a lot less than a tall, narrow sedan, but it has no camber recovery in roll at all with that sliding-pillar front suspension. The front wheels lean the same amount as the body. So when you add roll resistance at the front, you are hurting the load distribution at the front but helping the camber. At the rear, you are helping the load distribution and leaving the camber largely unchanged.

Also complicating prediction in the case of the Morgan is that the frame is unusually flexible in torsion. That mutes the effect of relative roll stiffness changes.

Actually, all cars with independent suspension in front and beam axles in back have poor camber recovery in front compared to the rear, so they all are subject to the same conflicting effects when we add front roll stiffness. Interestingly, when we change rear roll resistance the effects on front load distribution and front camber are additive rather than subtractive, and we can predict the effect on car behavior with much better certainty. Reducing rear roll stiffness will hurt both camber and load distribution at the front, while helping load distribution and not affecting camber at the rear. We know that will add understeer. Conversely, adding rear roll stiffness will help both camber and load distribution at the front, while hurting load distribution and not affecting camber at the rear. We know that will add oversteer.

As to the effect of shocks, yes stiffening the fronts will add understeer during entry and stiffening the rears will add oversteer, provided that the road surface is smooth. This effect requires that the car have a roll velocity outward, and that this be the main source of suspension movement. When the car is cornering steady-state on a smooth surface, the roll velocity should be zero, the suspension should have displacement from static but not velocity, and shocks shouldn't matter. During exit, the car has a roll velocity inward (it's de-rolling). In this situation, the effect of the shocks reverses. Stiffening the fronts adds oversteer; stiffening the rears adds understeer.

So to add understeer or oversteer overall, we use the relative stiffness of the front and rear springs (and/or bars, if present). To change entry and exit properties in opposite directions, we use the relative stiffness of the front and rear shocks (remember, only on smooth surfaces).

I sometimes refer to damper forces as creating frictional anti-roll or pro-roll (anti-de-roll). Even forces generated purely by a liquid may be termed a form of friction if they act in opposition to motion. Speaking of friction, I believe I have observed a phenomenon watching Morgans run that may be of interest here. I think that these cars can easily experience excessive friction in the sliding pillar mechanism when subjected to the forces modern racing tires can generate. This causes understeer until the driver finally gets the car rotating, gets on the power, and starts unwinding the steering. Then the car snaps into oversteer as the front end suddenly frees up and can roll. I therefore always tell people running these cars to keep the pillars in good condition and well lubed.

Readers may be a bit baffled by the questioner's reference to "static directional stability". After all, aren't a car's static properties the ones it has when it's motionless? And any car is directionally stable when it's sitting still, right?

The questioner is in fact using terminology that is familiar to engineers. It has been traditional to analogize a car's directional stability to a statically stable stationary object, i.e. one which rights itself when disturbed a moderate amount by an outside influence or force, rather than tipping over. A directionally stable car tends to "right itself" similarly in yaw. If the car is disturbed in yaw while running straight, say by one wheel hitting a piece of debris, it will then travel down the road in a yawed condition, with all tires running at a slip angle. The car's inertia then has a car-lateral component, as in cornering. If the car understeers in gentle cornering, it is said to have greater cornering stiffness at the rear than at the front. If that is the case, it will also tend to straighten itself out when disturbed; it will tend to rotate in the direction of its own inertia rather than the other way, absent any steering input from the driver.

Usually, discussion related to this ignores aerodynamic factors in directional stability, but actually the analogy applies, and its relation to under/over-steer applies, when aerodynamic yaw moments and downforce/lift are present.