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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 answers to chassis questions. Readers may submit questions by mail to: 155 Wankel Dr., Kannapolis, NC 28083; by phone at 704-933-8876; by e-mail to: markortiz@vnet.net. Topics are also drawn from my posts on the tech forums at www.racecartech.com and www.rpmnet.com. Readers are invited to check out these sites, and to subscribe to this newsletter by e-mail.

Mark Ortiz

REQUIRED FRAME STIFFNESS

Is there a way of calculating how much torsional stiffness a car's frame needs to have?

In road car engineering, it is customary to calculate a torsional natural frequency for the sprung structure, and compare this to the damped natural frequencies of the front and rear suspension in roll and warp. What this calculation tells you is whether you have enough stiffness to make the dampers (shocks) work as intended.

Any good race car should exceed this minimum by a substantial margin. I have never attempted to calculate or measure torsional natural frequency for a race car, and I doubt that anybody else does. Natural frequency depends not only on torsional stiffness, but also the mass of the sprung structure, and even the placement of major masses within the structure.

Measuring just the torsional stiffness of the frame is fairly common. This involves anchoring one end of the frame, typically at spring or rocker mounting points, and twisting the other end with a lever and a jack at the spring or rocker mounts. People don't try to reduce this measured stiffness to a calculated minimum; more is better.

There are some broad rules regarding how stiff is "stiff enough".

1) The stiffer the suspension's wheel rate in roll and warp, the stiffer the frame needs to be. Cars with beam axles at both ends typically have the softest wheel rates in roll and warp, and require the least torsional frame stiffness.
2) The stiffer the frame is, the more responsive the car is to tuning via roll resistance distribution. A flexible car does respond to roll resistance variation, but it takes a bigger change in roll resistance to get a given increment of cornering balance adjustment.
3) A car that relies on unequal front and rear roll resistance (one that corners on three wheels, or nearly so) needs a stiff structure more than one that has similar roll resistance front and rear.

4) A flexible car is more difficult to mess up with adjustments. It's also more difficult to fix with adjustments.
5) Stiff cars need smoother drivers. Jerky drivers often prefer more flexible cars.

Torsional stiffness of the whole frame, with loads applied at the spring or rocker mounts, isn't the only kind of rigidity that matters. All the load points that absorb forces from the suspension and steering need to be as rigid as possible. We can set forth a few general rules to help assure this:

1) Triangulate the frame as well as possible.
2) Feed loads, especially suspension loads, into the structure at tube junctions, not in the middle of a span.
3) Design brackets to minimize local torsion and bending loads. Make forces pass right through tube centerline intersections when possible.
4) When you cannot avoid feeding a load into a span, or when you are using stressed panels, design brackets so they spread the load so you minimize localized deflection.
5) Mount spherical joints and rod ends in double shear (plates on both sides) whenever possible.

MAKING BALLAST WEIGHTS

What does lead weigh per cubic inch? I want to make ballast weights using lead-filled 3"x3" or 4"x4" square tubing, weighing 25 and 50 pounds, and I need to know how long to make them.

Lead weighs about .41 lb./cu.in. in pure form – let's say about .40 if you're melting down wheel weights. If you use .125" wall tubing, 3"x3" weighs .39 lb./in. and 4"x4" weighs .53 lb./in. Internal cross-sectional areas are about 7.56 sq.in. for the 3"x3" and 14.06 sq.in. for the 4"x4".

So one inch of 3"x3" filled with lead weighs about 3.41 lb., and one inch of 4"x4" weighs about 6.15 lb.

Therefore, a 25 lb. weight using the 3"x3" would be 7.33" long, and a 50 lb. one would be 14.66". Using the 4"x4", you'd need about 4.07" for a 25 lb. or 8.13" for 50 lb.

Mounting holes, mounting hardware, voids in the lead fill, and using other wall thicknesses may cause minor variations from these theoretical numbers. If you make the weights a little on the large side, you can lighten them more easily than you can add material.

CAUTION: Lead is toxic. Any time you melt lead, be sure to provide good ventilation, and avoid inhaling fumes.