Measuring sway bar wheel rate in situ on a formula car

James Hakewill, 4th July 2006

Wheel rate for a one corner of a race car can be calculated from two numbers – the rate of the road spring and the motion ratio of the suspension.

The 'rate' of a spring indicates how much the spring will deflect when a load is applied. Spring rate is measured either in pounds per inch (lb/in), or in Newtons per millimeter (N/mm). Race springs are usually marked with their nominal spring rate in lb/in - if not the rate can be measured with a spring testing machine.

A 5" x 550 lb/in race spring.

Motion ratio indicates how much the road spring will be moved for a given amount of wheel movement. For example, if the wheel moves 1" into bump and the spring is compressed by 0.5", the motion ratio is 0.5 / 1 = 0.5. Wheel movement is measured at the centerline of the contact patch.

A suspension can be designed to incorporate varying motion ratios depending on the position of the suspension. For example cars generating large amounts of downforce have incorporated rising-rate suspension to make the wheel rate progressively stiffer as more force is applied – thus allowing for a certain ride height to be maintained as speed (and thus downforce) increases.

Most suspensions are designed to have a fixed (or linear) rate, at least for the majority of the range.

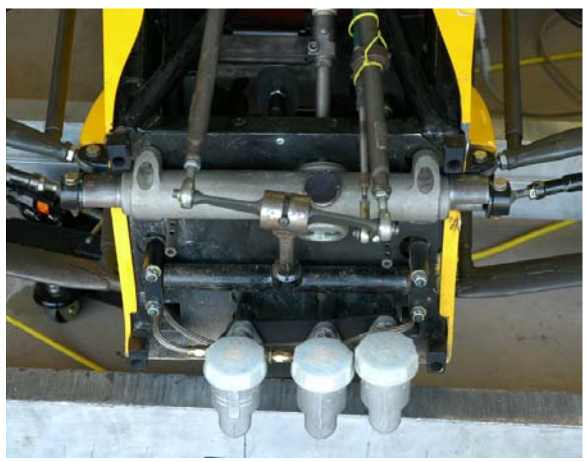
The equation for wheel rate is:

$$WheelRate = MotionRatio^2 \times SpringRate$$

So far so good – however the situation for sway bars is not quite so simple. A sway bar (or anti-roll bar) is a spring connected between the left and right side of the car, whose role (as suggested by its name) is to resist rolling of the suspension. The sway bar must move freely with the suspension in pitch - the road springs alone support the weight of the car, and the sway bar provides additional roll stiffness when required.

Sway bars come in many forms - usually involving a twisting motion (torsion), as opposed to a linear motion used to operate the road springs and shocks.

The object being twisted might be a solid bar, a tube, a flat beam or 'blade' or a combination of the above. Often an adjustment scheme is incorporated – where the motion ratio of linkages or the effective spring rate is altered to change the sway bar wheel rate.



The picture above shows a cockpit-adjustable front sway bar on a modern Van Diemen Formula Ford. The bar consists of a T-shaped combination of a ½" torsion bar (the upright of the T) plus adjustable blades (the crosspiece of the T). The bar is actuated by links from the suspension, and attached to the frame using bearingequipped mounting blocks. A cable from the cockpit adjuster (shown below) changes the position of the flat blades in order to change the spring rate of the sway bar assembly.

Whilst it would in theory be possible to calculate the torsional stiffness of the sway bar for each position of the adjuster, it is much easier to measure it!

The first idea that comes to mind when thinking of measuring sway bar rate might involve constructing a jig to hold the bar, applying known weights and measuring deflection with a dial gage.

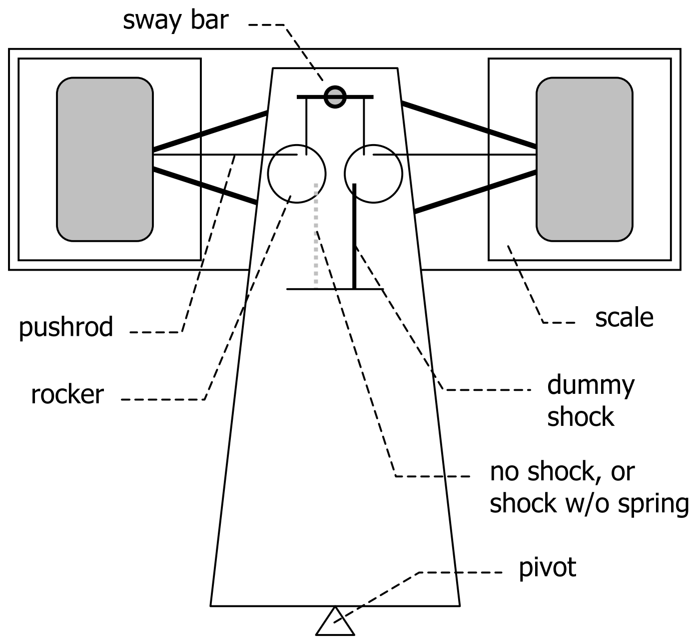
However – if some assumptions are made, it is possible to measure the sway bar rate whilst it is fitted to the car – thus taking into account the effect of the adjustment schemes, angle of linkages etc.

For this scheme to work, we must be sure:

1. The suspension has a linear motion ratio through its range
2. The sway bar wheel rate is around the same order of magnitude as the road spring wheel rate

To measure the sway bar rate, it is necessary to apply a force (or a torque) and measure deflection. This can be done quickly using commonly available setup equipment to get an idea of sway bar wheel rate.

The scheme described here is to apply a force only in roll, and at only one end of the car. The following assumes a formula car with coil-over-shocks, but can be applied also to other types of vehicle.



The car is placed on scales on a setup pad, with the driver or equivalent ballast installed. At the end of the car where the measurement is to take place, springs and shocks are removed from both sides, and dummy shocks installed. A dummy shock is a plain bar arranged to be the same length as the usual spring/shock combination at the normal ride height. If the front end is being measured, steering blocks are put in place to prevent the rack from moving.

A pivot at the centerline supports the other end of the car at normal ride height, and the wheels are removed. This ensures that the only roll resistance comes from the end being measured.

At this point, the weights measured by the two scales are noted, as are the lengths of the dummy shocks.

The car is jacked up and one dummy shock removed – replaced by a shock (no spring) set to full soft.

When the car is dropped back onto the scales, the weight of the corner without the dummy shock will be supported only by the sway bar, and will go into bump – the other side is supported by the dummy shock and will not move.

Now, the force measured by the scale pad is being applied at the wheel, and a deflection takes place, which can be measured at the shock. The deflection of the wheel can be calculated using the motion ratio. Hence we can work out the anti-roll bar wheel rate!

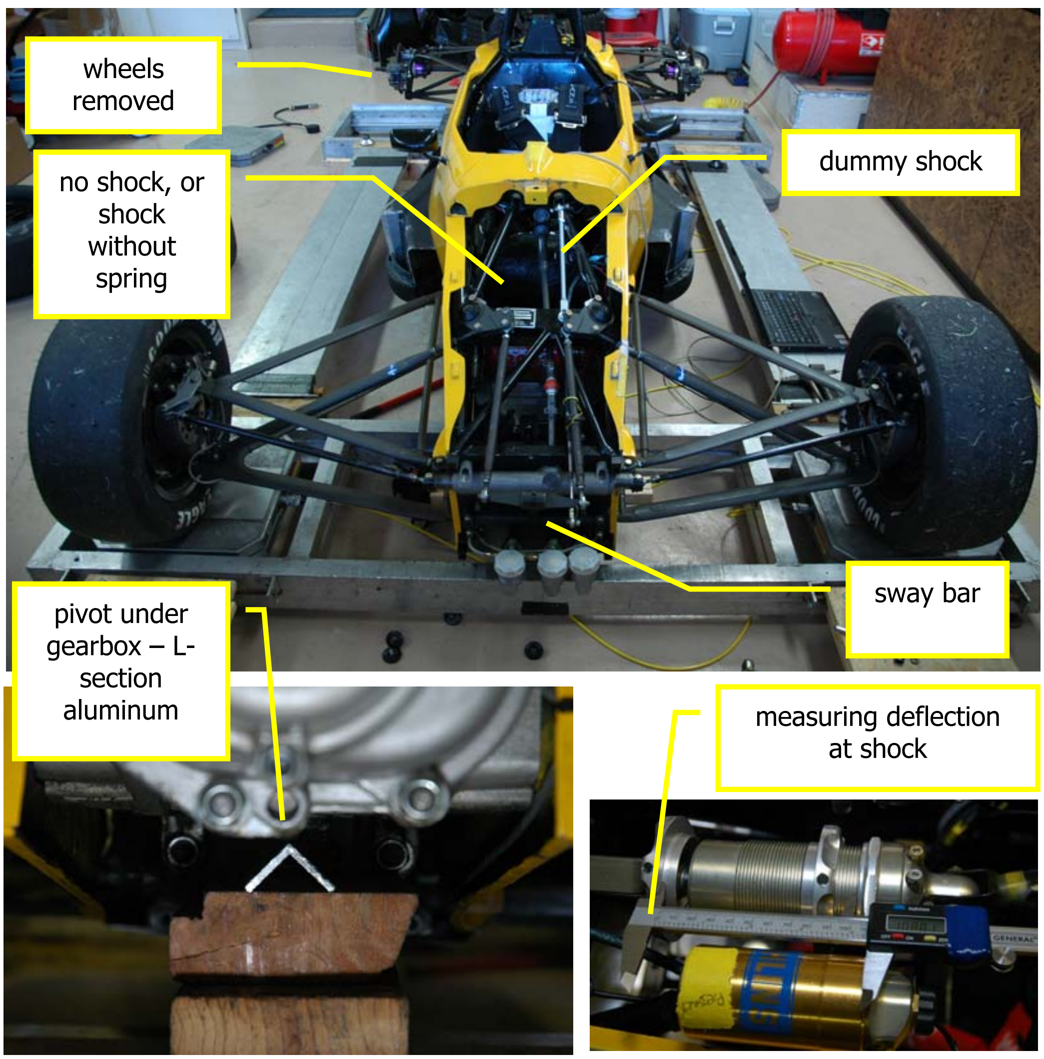
The deflection at the shock is noted along with the measurements from both scales. When this scheme was tried with a Formula Ford, the weights measured at each scale did not change. Since the cornerweights are equal and unchanging, the effect of the tire spring rate is also equal on both sides and can be ignored.

If the car has suspension measurement pots, these can be used without needing to refit a shock in order to take measurements.

Some jiggling will almost certainly be required to overcome friction in the suspension.

Sandwich plates under the wheels will also help – a pair of metal plates with either oil or grease making the sandwich filling. These help when dropping the car down from the jack – allowing the suspension to take its proper position without being resisted by sideways loads from the tires.

Given the friction in the suspension, and the



possibility of human error, it's a good idea to take more than one set of measurements.

For example:

1. Set adjuster to position number 1
2. Raise car on jack
3. Drop car + jiggle
4. Measure deflection at shock, and note scale readings
5. Repeat 2-4, twice
6. Set adjuster to position number 2
7. etc..

Then repeat for all the available sway bars, and then go again at the other end of the car.

Taking the average of figures for each adjuster position, the sway bar wheel rate can be calculated using this formula:

$$BarWheelRate = \frac{Scale}{WheelDeflection}$$

Given that

$$WheelDeflection = \frac{ShockDeflection}{MotionRatio}$$

We can say

$$BarWheelRate = \frac{Scale \times MotionRatio}{ShockDeflection}$$

Once all the measurements have been taken, a spreadsheet can be used to produce the desired result – a graph showing sway bar wheel rate for a number of different sway bars at each adjuster setting.

The chart below shows this information for the front suspension of a narrow-track Van Diemen RF99 Formula Ford/Formula Continental.

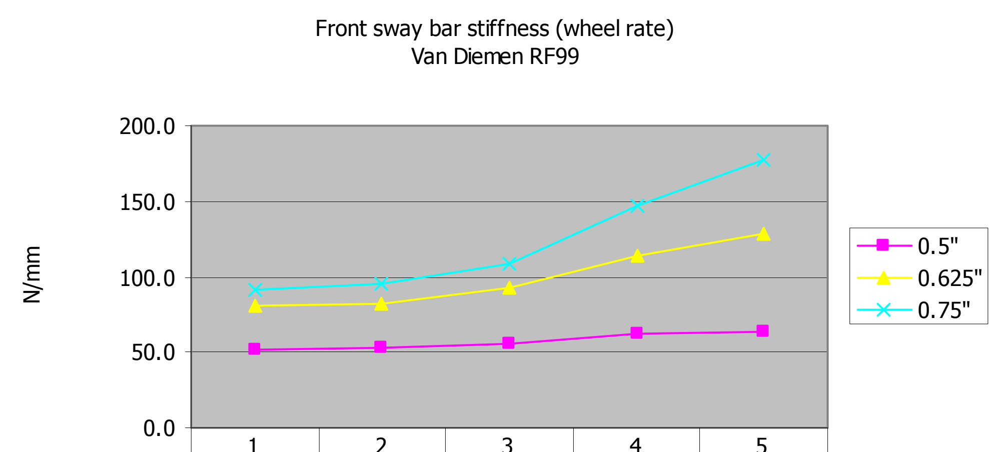
Why might the scheme not work for you?

1. If the suspension does not have a linear spring/shock motion ratio throughout its range, the measured deflection at the shock would need to be adjusted to get the proper wheel deflection.

2. If the sway bar cannot support the weight of one corner of the car, the chassis may touch the ground or damage the sway bar.

This is a description of one way to measure sway bar wheel rate in situ – there are surely others, perhaps easier. By all means think about and try this scheme, but you do so at your own risk.

Thanks for reading!



	1	2	3	4	5
0.5"	51.2	52.5	55.3	62.4	63.2
0.625"	81.3	81.9	93.1	114.4	128.0
0.75"	91.8	95.2	108.9	147.3	178.1

Adjuster setting from soft