



Programme:	HND Motorsport Engineering HND Automotive Engineering		
Module/Unit:	Vehicle Technology B / Motorsport Technology B		
Assignment No:	2	Lecturer: R Dowden	Internal Verifier: A Gibson
Assignment Title:	Vehicle Testing		

Hand Out Date:	Wednesday 25 th January	Return Date:	Wednesday 22 nd February	Contribution to Overall Module/Unit Assessment (%):	40%
-----------------------	------------------------------------	---------------------	-------------------------------------	--	-----

Penalties for late submission: Up to one week late, maximum grade of Pass. Over one week late, Fail.

Outcomes being Assessed (from Module Syllabus):	
Number	Description
1	Analyse weight transfer and tyre behaviour
Aim	
To determine roll stiffness of a vehicle practically and compare with calculated results	
Procedure	

Brief

The aim of this assignment is compare the roll stiffness results obtained from practical measurement with that from calculation.

Note

The moment produced by the lever attached to the chassis in the workshop test is intended to approximate to the overturning moment produced as the car experiences a lateral acceleration. The overturning moment for the cornering car is:-

$$\text{Lateral acceleration} \times \text{Sprung Mass} \times \text{Moment arm of sprung mass about roll axis} \quad [Nm]$$

When the car corners both front and rear suspensions react the overturning moment in parallel and to a degree determined by their relative roll stiffness, but because of the way the load is applied in the workshop test and the chassis flexibility we have to measure the effect of the moment on each end of the car in turn.



Procedure for workshop test

Initial Measurements

Collect the required data to carry out the calculations including:

1. Front and rear tracks
2. Front and rear spring rates
3. Front motion ratio
4. Front suspension points to calculate motion ratio
5. Rear suspension pickup points to develop improved calculation method.

Front Roll Stiffness

1. With the car mounted on the chassis pivots ensure the front wheels are pre-loaded to around 30 kg on the front scales by winding the scale mounts up .
2. Zero the scales
3. Apply a load to the lever at the rear of the car and note the load on each front scale.
4. Add the two values ignoring the sign of the value (one will be +ve and the other –ve.
5. Divide by 2 to find average wheel load
6. Multiply this average load by track to find moment being reacted by the front wheels.
7. Note and record the angle of the chassis at the front suspension and rear bulkhead
8. Divide roll angle by the calculated moment to give the roll stiffness of the front suspension
9. Calculate the theoretical roll stiffness of the front suspension using the equation developed in class:

$$\text{eg } K_{\phi f} = \frac{(T_f^2 \times K_{wff})}{2}$$

10. Repeat the exercise for a number of loadings (but stop before you either destroy the chassis or ruin the scales!) Look for consistent results over a number of readings rather than an average value across the whole range of loads. The final value of roll stiffness should be consistent for a number of readings. Low load values are likely to vary significantly as friction and clearances create larger errors.

Rather than doing the calculation for each result you will find it much easier to create a spreadsheet to work out the results required. An example layout can be found in Moodle. Plotting the results is an even better way to get a consistent result.



Front Wheel Rate

11. Lock the front right chassis twist lever by putting a jack or stand under it and then find the front left wheel rate by measuring and plotting in Excel wheel travel vs load change and finding the gradient. This will be the rate in N/mm (remember to convert the scale reading in kg to N !)
12. Calculate the motion ratio from suspension point measurements and use this to calculate the wheel rate.
13. Compare the measured and calculated wheel rates
14. Demonstrate the effect of any differences in calculated and theoretical wheel rate on the theoretical roll stiffness calculated in 9) above.

Rear Roll Stiffness

15. Repeat the exercise for the rear suspension remembering to use the correct equation for a live axle rather than the independent suspension.:-

$$K_{\phi r} = \frac{(T_{sr})^2 \times K_{ser}}{2}$$

Where

T_{sr} = rear spring track

K_{ser} = effective rear spring rate which is $K_{sr} * MR^2$

$MR = \cos \Theta$ where Θ = the angle of the spring to the vertical.

For the LocoBlade assume this angle is 16°

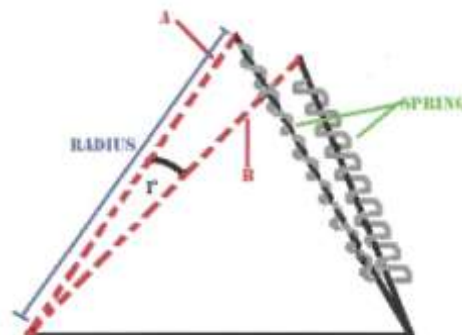
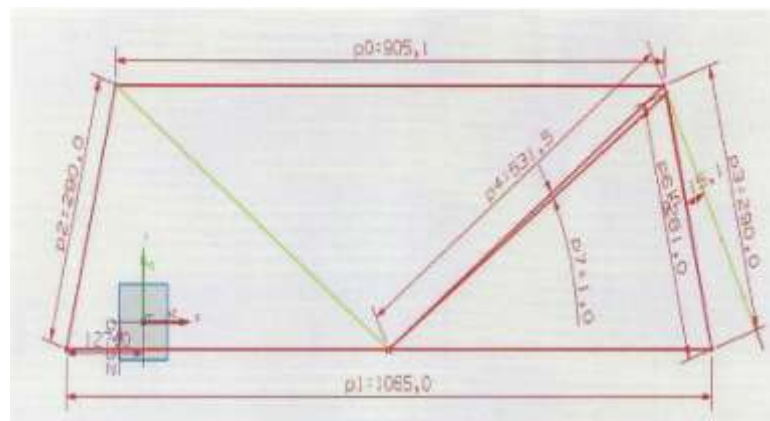
16. As the car rolls each trailing link has to twist. There is no play in the joints and the poly buses used have an extremely high rate in twist so the only way roll can occur is by twisting of the trailing arms. To determine the effect of this remove the rear road springs and repeat the rear suspension twist test. This will yield a roll stiffness. If this value is added to the calculated roll stiffness of the rear suspension it **should** give the same result as the measured roll stiffness for the rear suspension with the springs installed. Comment on any difference that is actually produced .

17. We usually get very good correlation of results at the front but less so on the rear. See if you can refine the rear calculation bearing in mind the following .

The rear suspension is a 'de Dion' arrangement, the rear springs are at an angle θ to the vertical and so also at an angle to the line joining the upper spring mount to roll centre axis ie the radius of rotation of the upper spring mount

Measure the suspension geometry and then try to work out what the theoretical roll stiffness of the chassis on the springs will be. The diagrams below illustrate a possible procedure:-

- Use either trigonometry, CAD or use of a WinGeo3 model to find out how far the spring compresses when the chassis rolls through 1 degree.
- Multiply this deflection by K_s - that will be the increased spring load.
- The moment produced will be the increased spring load x spring track/Cos α (where α is the angle of the spring axis to the upper spring mount to roll centre axis)
- Roll stiffness = moment / 1° which will be the same numerical value as the moment calculated.



Diagrams - Ceri Thomas 2011



Loco Blade Data

Rear

Rear track (plate to plate)

1520 mm

Angle of spring to vertical

13.5 degrees

Spring track measured at axle level

1063mm

Rear Spring rate = 169.5lb/in 29.795 N/mm

Front

Front Track Measured to ball joint centres 1315 mm

Front Spring rate 252lb/inch or 44.2398 N/mm

Front Motion ratio 0.48

Track = 1.49 m

Chassis Stiffness

18. The chassis stiffness can be determined by looking at the results obtained in Task 7. Take the rear chassis angle from the front chassis angle at each load setting. This is the chassis twist. The moment created at each load setting divided by the chassis twist is the torsional stiffness of the chassis. As before average the results obtained when relatively stable results are being achieved to determine a chassis stiffness value. Compare this with the front and rear roll stiffnesses.

Once the test has been undertaken and the results obtained you, as an individual, need to decide on the best way of demonstrating the results obtained. Your report should contain the following:

Introduction – What the aim of the assignment is

Methodology – The test procedure used and how the measurements were taken and any changes to the procedure used

Results - Summary tables of all the results obtained

Analysis –

- Calculation of roll stiffnesses and comparison with measured value,
- Calculation of wheel rate and comparison with measured value
- Development of improved method of calculation for rear roll stiffness.

Evaluation How the methodology of the test could be improved next time, further investigations possible to improve the accuracy of results

**Marking Scheme**

	No	Proportion of overall grade of this element
Completion of practical test and quality of experimental test results recorded (<i>Group</i>)	1	30%
Analysis of data and comparison of 'measured' and calculated results for stiffness and wheel rates, development of improvements to rear roll stiffness measurement.	2	60%
Production of well structured report (<i>Individual</i>)	3	10%



School of Automotive Engineering

Student Name:	
Assessor :	Roger Dowden
Assignment Title:	Twist Rig Test
Programme:	HND Automotive Engineering HND Motorsport Engineering
Module:	Motorsport /Vehicle Technology B
Submission Date:	
Grade Awarded:	
Completion of practical test and quality of experimental test results recorded (<i>Group</i>) 30%	
Analysis of data and comparison of 'measured' and calculated results for stiffness and wheel rates, development of improvements to rear roll stiffness measurement 60%	
Production of well structured report 10%	

The mark awarded for this work is provisional. It will not be used for determining the final mark for the module until it has been agreed by the Examinations Board in June 2011.