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Understanding spring rates and damper settings of sports 2000 car using driver in the loop simulator

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Introduction

This project is a study into evaluating the current spring rate and damper settings of the MCR from track data and damper dynamometer testing which will then be imported into the simulator model to show the effects on handling. The damper settings that will be investigated will be low/ high speed compression/rebound and what affect they have on the force vs velocity graph, histograms and handling and what is the relationship between the three. These will then be compared to new "ideal" coefficients implemented into the simulator

Aims and objectives

What affect does spring rate have on handling and how does spring rate relate to damper coefficients?

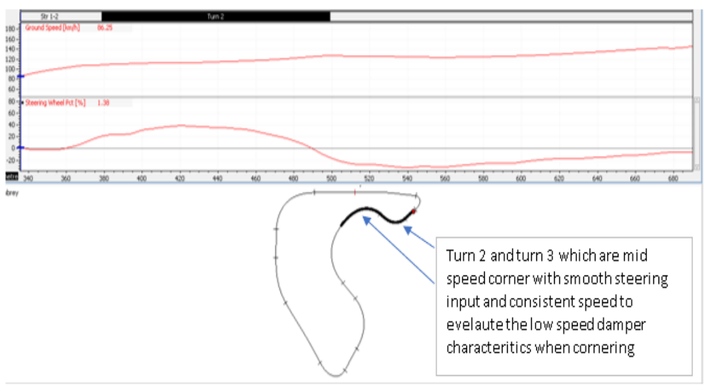
What affect does low/high compression/rebound have on histograms and handling?

Produce a set up guide for the sports 2000 for the damper and spring rates depending on the desirable handling balance.

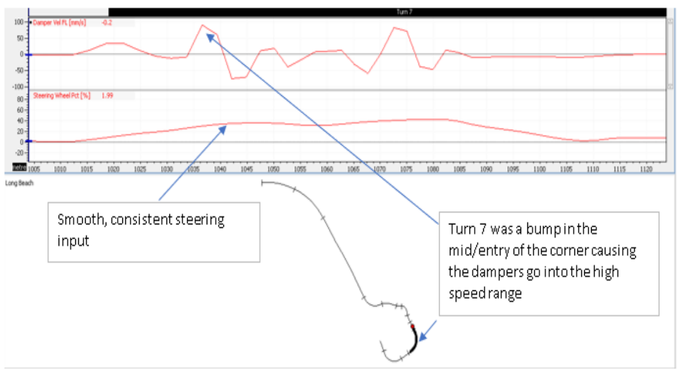
Methodology

The testing will all be conducted in the simulator with 1 lap with each setting adjusting low/high compression rebound separately to avoid correlation errors.

Low speed testing comparing maximum to minimum compression/rebound



High speed testing would be conducted at Long beach in a bump mid corner



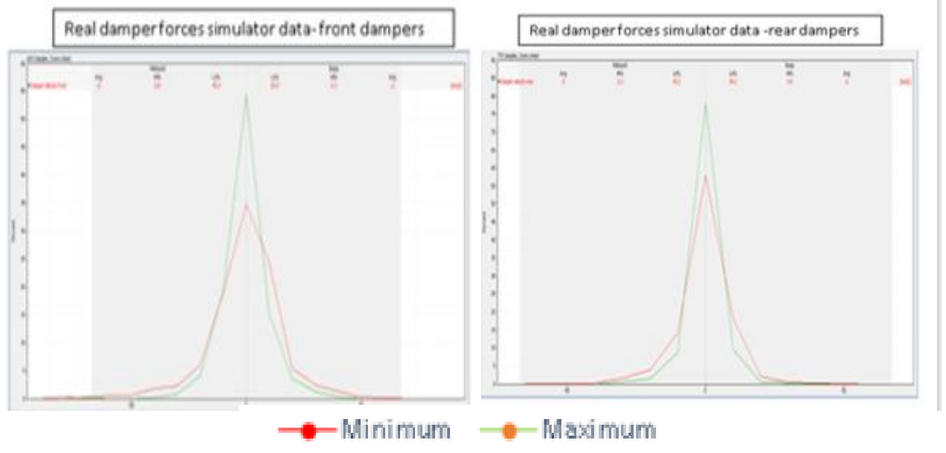
Testing the spring rates would include track testing at Pembrey and long beach just like the damper testing and comparing the sprung frequency to other race cars.

Table showing typical sprung frequency values

car	sprung frequency (hz)
passenger car	0.5-1
modified springs	1-1.5
rally car	1.5-2
low downforce car	1.5-2.5
FSAE car	3.2-3.5
mid downforce car	2.5-3.5
high downforce car	3.5-5.0

Results

The compression was over critically damped with a damping ratio of 1.7-1.5 with not enough rebound force with a damping ratio ranging from 0.3-1.1.



The histograms responding correctly with the softer setting spend more time at low velocity damper range (10-50 mm/s)

Summarised handling guide of different damper settings

Compression		
Low speed	Too much	Chassis **roll slow** to develop **Reduces understeer** on initial **turn in**
	Too little	**Dives** and **squats** excessively Roll velocity increases
High speed	Too much	**Doesn't absorb** impacts from kerbs and bumps **Instability** over bumps
	Too little	**Plush** feeling Car could **ground** over bumps and compressions
Rebound		
Low speed	Too much	**Wheels don't return** to ground quickly after displacement. **Overload** outside tyre and **underload** inside tyre
	Too little	Difficult to **gain traction** at the rear **Faster roll** velocity
High speed	Too much	Damper packs, **doesn't return to full stroke** to absorb next impact **Firm** ride
	Too little	**Excessive oscillation** over bumps and kerbs **Instability over bumps** on corner entry, mid corner.

Table of the different spring rate settings to be tested

setting	front spring rate (n/m)	Rear spring rate (n/m)	front sprung frequency (hz)	rear sprung frequency (hz)	average frequency (hz)
1	130000	260000	3.8	4.2	4.0
2	100000	200000	3.3	3.7	3.5
3	75000	150000	2.9	3.2	3.0
4	50000	100000	2.4	2.6	2.5
5	35000	70000	2.0	2.2	2.1

The table shows the spring rates corresponding to the chosen sprung frequency. 60% of the mass is over the rear axle meaning a stiffer spring at the rear.

Conclusions

The spring rate would need to be in an "ideal" range of a sprung frequency for the MCR between 2-2.5 hz as anything above or below would be excessive.

The relationship the spring rate has to damper settings is that the spring has a larger impact on handling compared to the dampers.

You want the low speed rebound to be stiffer than compression with a damping ratio ranging from 0.5-0.6 to provide more stability and softer compression of a damping ratio of 0.3-0.4 to provide more grip by increasing tyre force.

You want high speed to be softer than low speed to absorb the bump/kerbs with a damping ratio ranging from 0.25-4

References

Carroll Smith, tune to win, 1978, aero books publishers

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