

Measurement of forces and moments of bicycle tyres

G. Mastinu, M. Gobbi, G. Previati, F. Ballo

Dipartimento di Meccanica

Politecnico di Milano

Via La Masa 1, 20156 Milano

e-mail: gianpiero.mastinu@polimi.it, massimiliano.gobbi@polimi.it

G. Magnani

Dipartimento di Elettronica, Informazione e Bioingegneria

Politecnico di Milano

Via Ponzio 34/5, 20133 Milano, Italy

e-mail: gianantonio.magnani@polimi.it

Tyre parameters affect the stability and handling properties of bicycles, and their knowledge is required in analytical and simulation studies [1], [2], [3]. The influence of tyre parameters specifically on weave and wobble modes of a race bicycle is discussed in [4]. Two test rigs are proposed and measurement results are given in [5], [6].

A new test rig for measuring the characteristics of bicycle tyres is presented in this paper (Fig.1). Its first goal is to measure the parameters of the race bicycle tyres used in the on-road experiments that triggered the nonlinear dynamics analysis published in [4] and [7], and validate the results therein.

The test rig consists of a frame that allows a single wheel to be cambered and steered. A braking system can be added to produce longitudinal slip. The test rig is conceived to be employed either on a drum or on a flat surface, after proper arrangement of the fixtures. The drum that is currently employed has a diameter of 2.6 m and an extremely smooth surface (± 0.03 mm). The friction on the drum or on the flat surface can be varied in a relatively easy way.

The test rig can measure the vertical force, the lateral force, the self-aligning torque, the moment around the longitudinal axis, and, after proper arrangement, the longitudinal force.

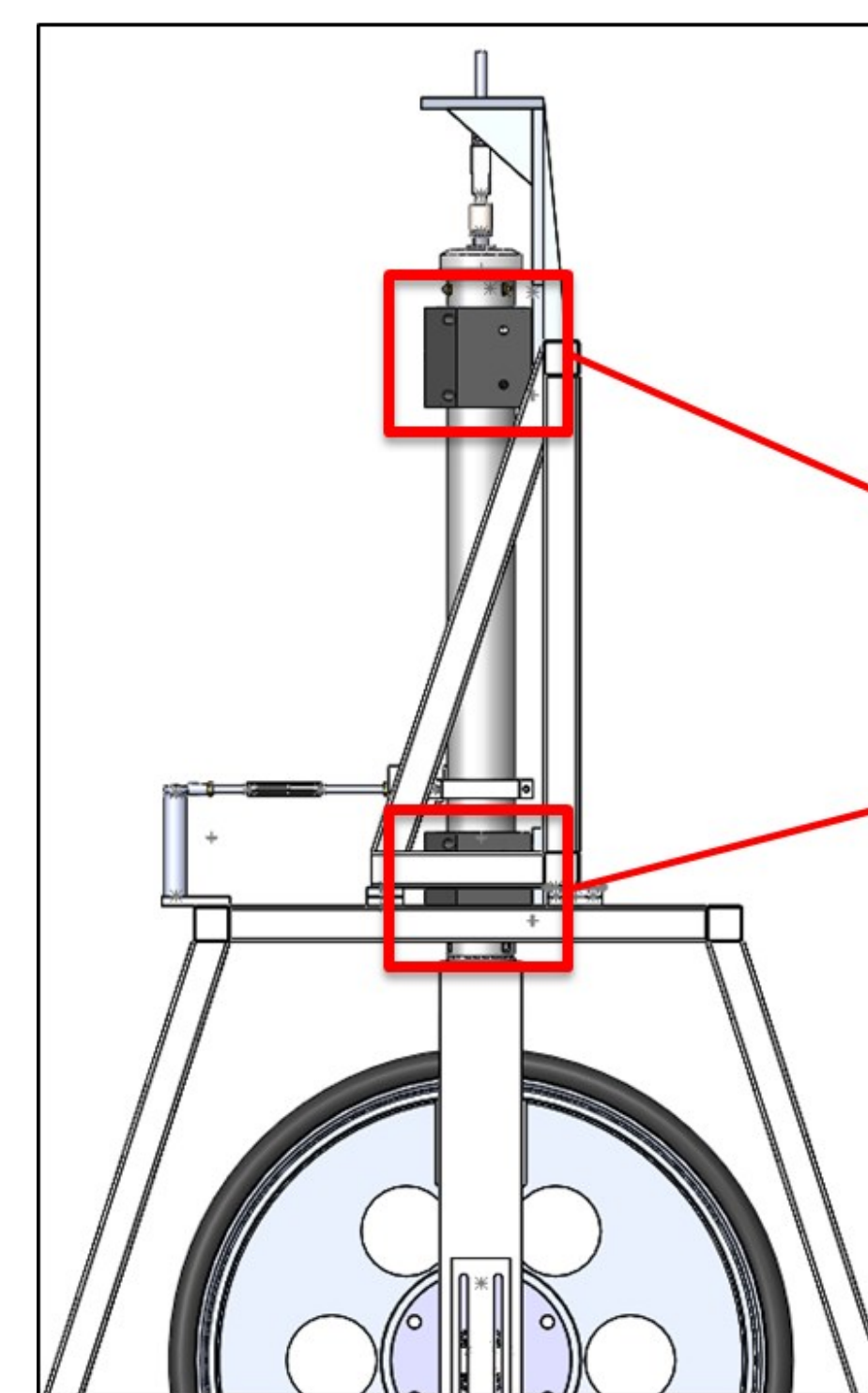
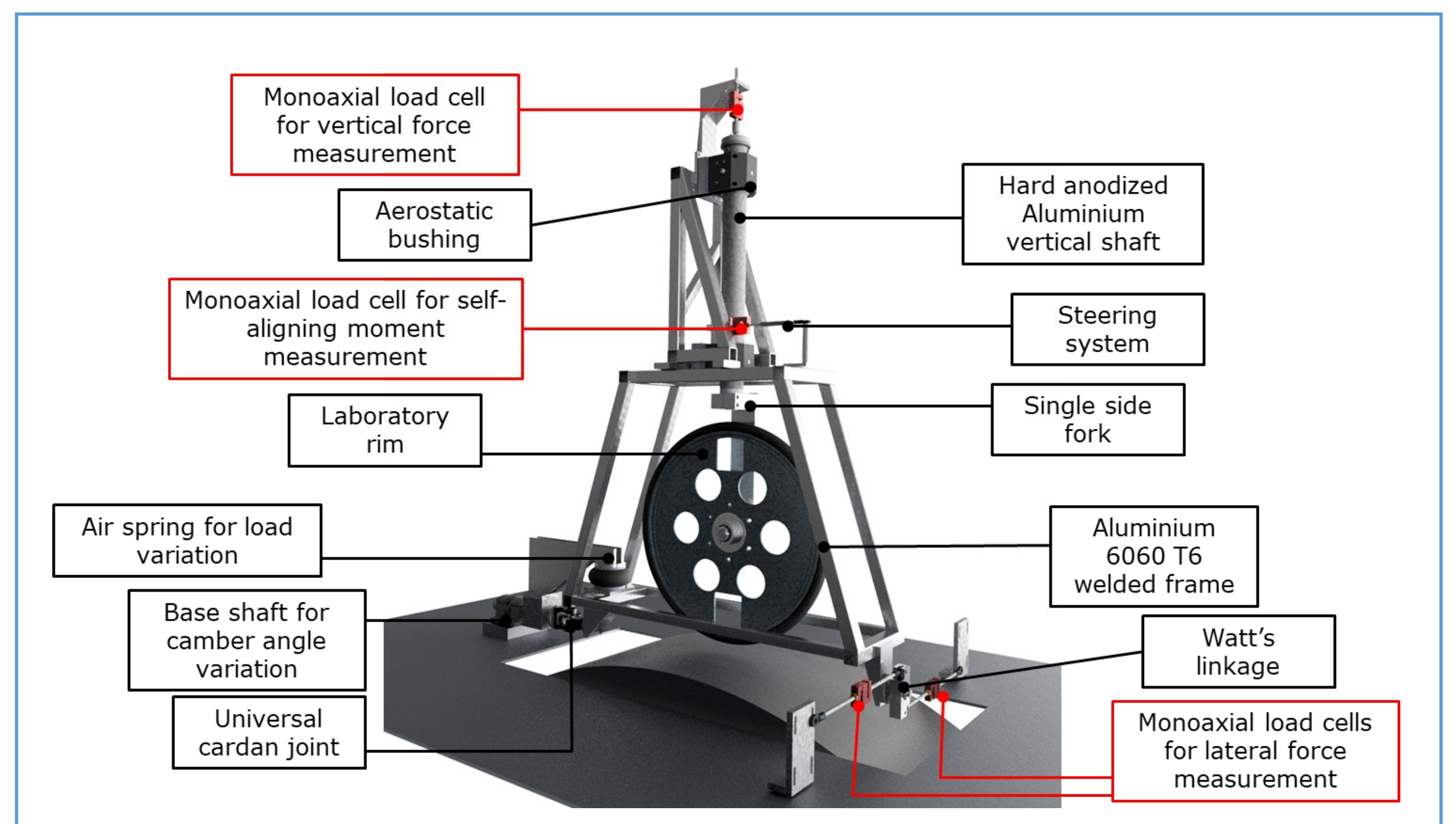
When the test rig is positioned on a drum, the frame can be tilted around a longitudinal axis that passes by the contact point of the wheel. The frame can be rotated in the vertical plane around an axis that is parallel to the drum axis and lies on the horizontal plane tangent to the drum at the centre of the tyre contact patch. In this way the vertical vibrations of the wheel are forced to occur in such a way that the wheel/drum centre contact point is displaced in the vertical direction, i.e. without longitudinal velocity. The frame can rotate around a vertical axis, but the rotation is counteracted by a Watt's linkage with two load cells capturing the lateral force at the horizontal plane tangent to the drum at the centre of the tyre contact patch.

The vertical arm carrying the wheel is connected to the frame by means of two pneumostatic bearings. This allows a vanishing moment applied at the arm. The vertical force on the arm is obtained by another pneumostatic bearing which applies the load at a vanishing moment applied around the arm's axis. Thus, an accurate measurement of the self-aligning torque can be obtained. A simple longitudinal arm applies the steering torque that is measured by a single-axis load cell. The pneumostatic bearings can be substituted by conventional roller bearings if the test rig is employed outdoor.

A pneumatic spring with very low stiffness adjusts the vertical load to the required value.

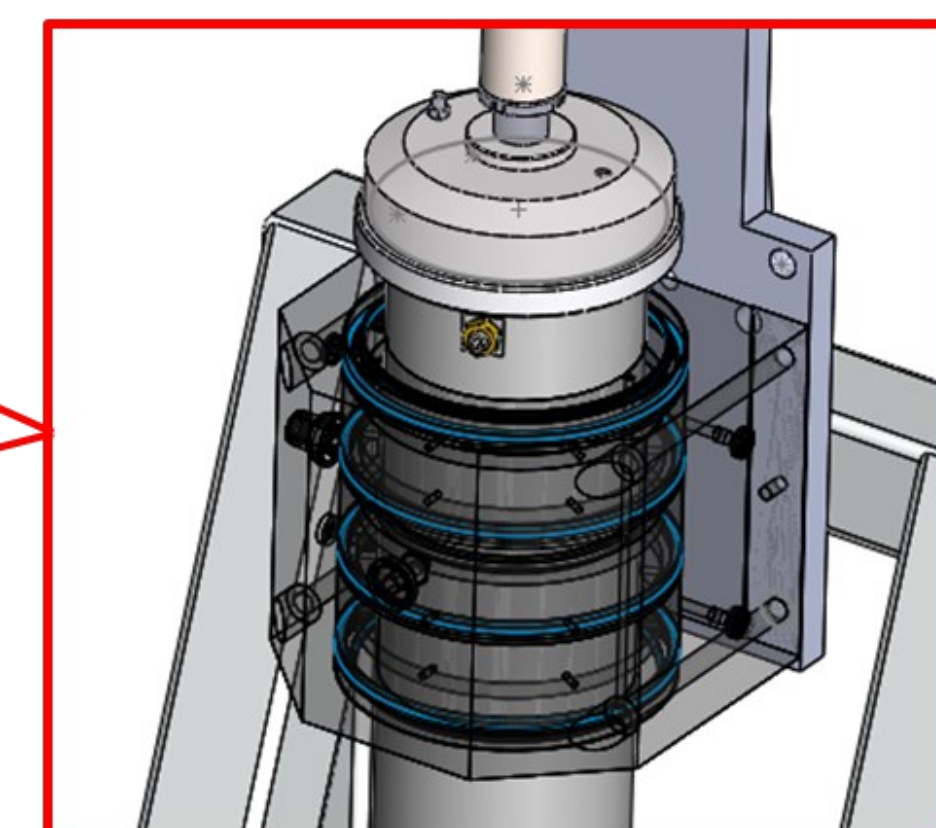
The design of the test rig has been made focusing on the modal vibrations and on safety issues.

The first measurements refer to a race bicycle tyre [8].



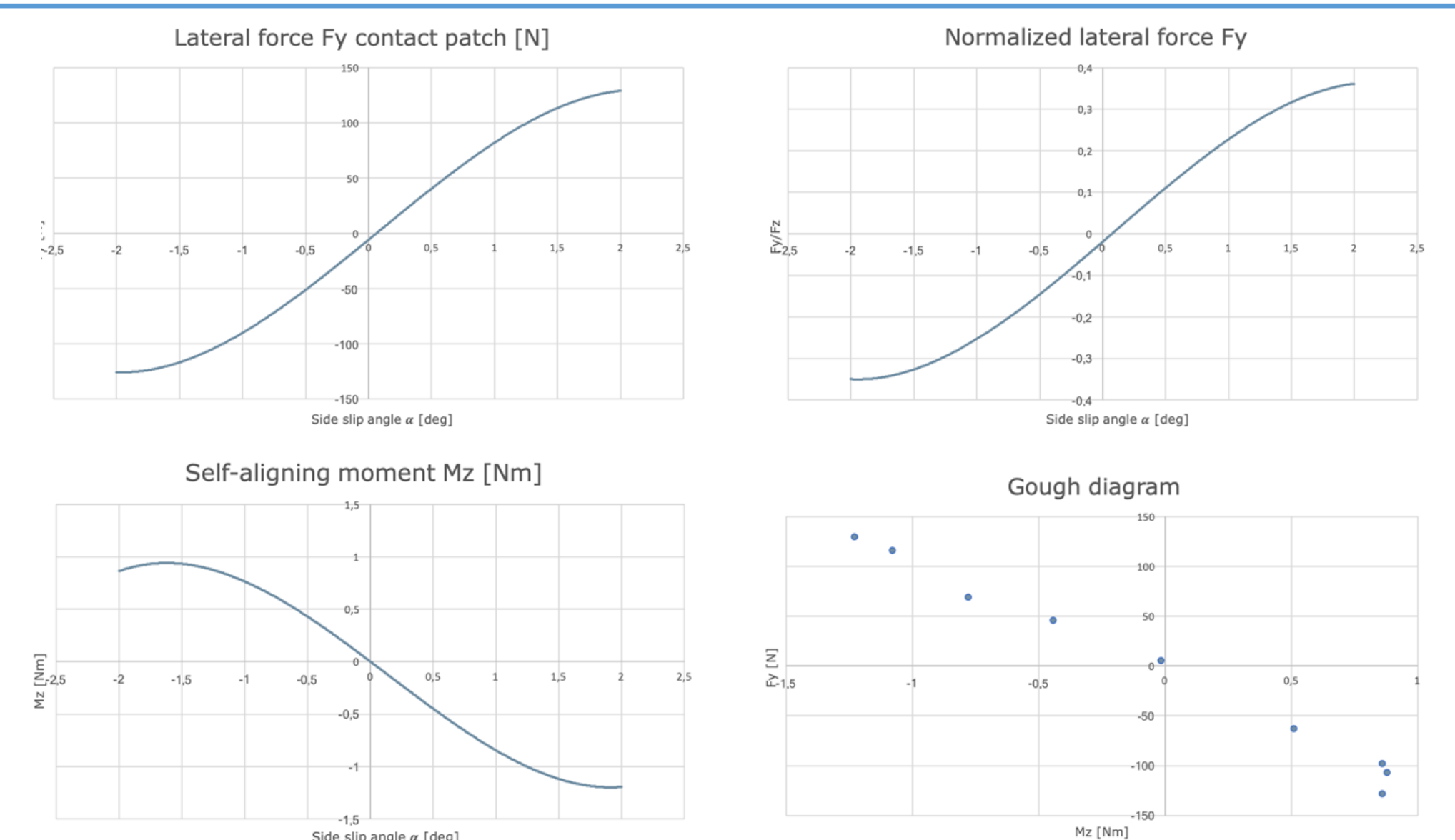
ADVANTAGES:

- Bearing spheres substituted by a pressurized air film
- NON contact between surfaces -> zero friction



- No side effect on self-aligning moment

- Tyre: Pirelli P Zero Velo 25-622
- Pressure: 7.1 bar
- Tyre speed: 5 m/s
- Camber angle: 0°
- Sideslip angle: -2°, 2°
- Vertical load: 358 N
- Tyre mounted on a Fulcrum Racing Zero 25-622 C rim



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