

# AMZ Friction Ellipse

Degree programme : BSc in Automotive Engineering  
Specialisation : Dynamics and safety  
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AMZ, the Swiss Formula Student team, currently lacks a friction ellipse for its Hoosier R20 tire, as TTC data is insufficient. This project addresses the gap using the MoReLab mobile test bench to assess the tire under varied conditions. The result is a reliable and novel adhesion model, enabling accurate dynamic simulations for improved vehicle performance.

## Introduction

This project continues AMZ's efforts to model the friction ellipse of the Hoosier R20 tire. By leveraging the MoReLab test bench (picture 1) and a crosstalk compensation method, reliable data were obtained to support the optimization of the Formula Student vehicle's dynamic performance.

## Goals

The goal of this project was to conduct a series of tests specifically designed to generate a friction ellipse. This will enable AMZ to quantify the tire's grip performance for any combination of longitudinal and lateral slip under varying normal forces. The project also aims to reformat the data to closely match the structure of Tire Test Consortium (TTC) data and to develop a Pacejka mathematical model for use in simulation software such as Simulink or IPG CarMaker.

## Methods

The tests were conducted using the MoReLab mobile lab on Hoosier R20 tires, in a campaign of about 950 measurements. Parameters such as vertical force, slip angle, camber, and drive mode (acceleration/braking) were varied to cover the full adhesion domain needed to build a complete friction ellipse. Though some external factors may have influenced results, high repeatability was targeted. Road and tire temperatures and tread depth were strictly controlled. The data were then integrated and processed in MATLAB. Initial steps included cleaning, filtering, and formatting the data to match the Tire Test Consortium (TTC) structure, enabling reuse of existing tools and avoiding confusion over units and definitions.

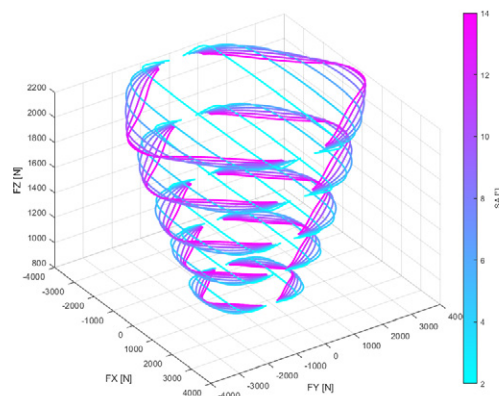


1. MoReLab

This allowed the friction ellipse to be built and the effects of load and temperature on grip to be analyzed. A Magic Formula 6.1 model was then developed to describe this behavior through mathematical equations under various load conditions.

## Results

The data collected during testing enabled the construction of a reliable friction ellipse (picture 2). At a vertical load of 1500 N, a lateral adhesion coefficient of 1.6 and a longitudinal adhesion coefficient of 1.5 (in both acceleration and braking) were achieved. These values were correlated with acceleration data recorded from a Formula Student race car equipped with the same Hoosier R20 tires. When aerodynamic effects were considered, the tire performance demonstrated a strong match with the test results. In addition, the dataset provides valuable insights into the tire's sensitivity to camber, load, and temperature, factors that were not fully characterized in the TTC data. The results show good agreement with the available Tire Test Consortium data. Based on the experimental measurements, a Pacejka model was developed, validating the shape of the derived friction ellipse and supporting its integration into simulation tools.



2. Hoosier R20 friction ellipse



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