Case Study: **Vellore Institute of Technology**

Improving Ride and Handling of Formula Student Car Using Adams Car

By Sudeep Kumar and Santosh Maharana of Zuura Formula Racing

Industry Challenge

Zuura Formula Racing is a student team from the Vellore Institute of Technology in Chennai, India that participates regularly in the Formula SAE student competition organized across the globe by SAE Interna-tional.

For participating teams, the task at hand is to develop a small formula-style race car. Each student team designs, builds and tests a prototype based on a series of rules, aimed at ensuring on-track safety and promoting clever problem solving. The prototype is evaluated for its potential as a production item.

During the course of this project, one of the focus areas for the Zuura Formula Racing team was to ensure good suspension for their vehicle. To achieve this, they needed to ensure that the tires were as perpendicu-lar to the ground as possible to achieve maximum traction. The front geometry had to be designed such that it had a negative camber in jounce. This was an important factor in keeping the wheels perpendicular to the ground, and also to resist body roll.

The main target before the vehicle dynamics simulation engineer at Zuura Formula Racing was to improve the ride and handling of the vehicle by reducing yaw, pitch and roll rates.

With Adams Car, FSAE teams can quickly build and test their functional virtual prototypes of complete vehicles and vehicle subsystems. FSAE engineering teams can exercise their vehicle designs under various road conditions, performing the same tests they normally run in a test lab or on a test track, but in a fraction of time.

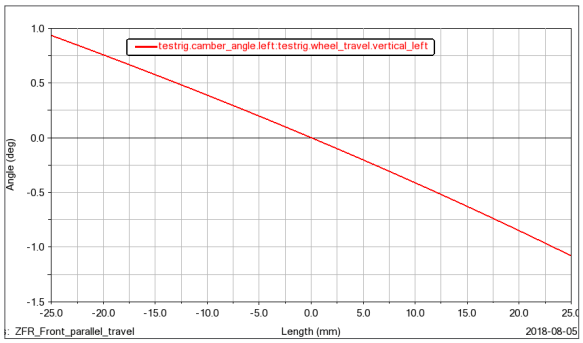
MSC Solution

The Zuura Formula Racing team used the Adams Car software from MSC Software. Adams Car allows students to design and simulate their FSAE vehicles to maximize their vehicle performance. With Adams Car, FSAE teams can quickly build and test their functional virtual prototypes of complete vehicles and vehicle subsystems. FSAE engineering teams can exercise their vehicle designs under various road condi-tions, performing the same tests they normally run in a test lab or on a test track, but in a fraction of time.

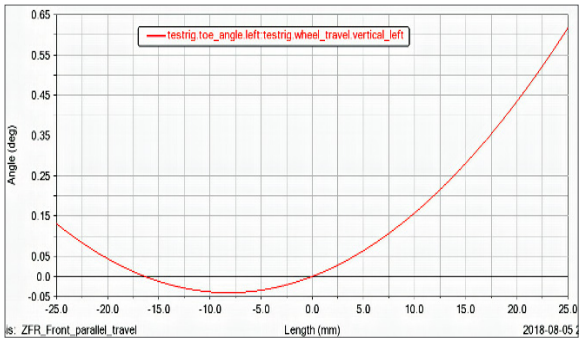
Kinematic Analysis

The team first modelled their suspension geometry in Adams Car to do the Kinematic analysis for adjusting parameters like camber, caster, toe & roll center. To counter the large roll moment, the team designed enough camber gain into the suspension by iterating the geometry in Adams Car to compensate for body roll with anti-roll bar. By optimization of the hardpoints in the geometry, we also incorporated better camber and roll center control. This was done through parallel wheel travel and opposite wheel travel analysis in Adams Car. The toe change and bump steer were also reduced during the analysis.

To achieve good suspension in the car, the team needed to ensure that tire remains perpendicular to the ground. The Zuura Formula Racing team modelled the car's suspension geometry in the Adams Car in order to ensure perpendicular tires.



Camber vs wheel travel



Toe change vs wheel travel

Key Highlights:

Product: Adams

Industry: Automotive

Challenge: To improve ride and handling of car for Zuura Formula Racing's entry into FSAE challenge

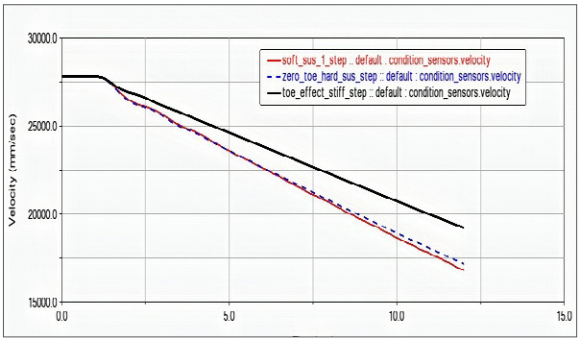
Solution: Simulation with Adams Car helped in doing Kinematic & Dynamic analysis for improving car's dynamics

Dynamic Analysis

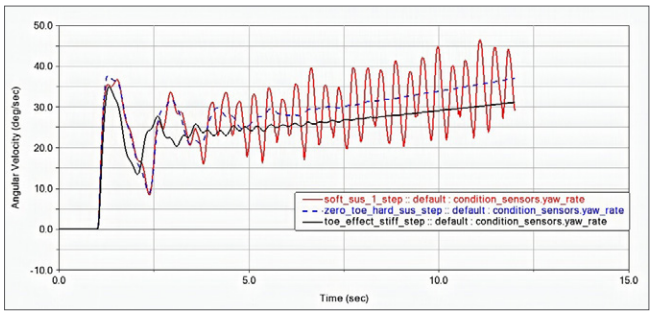
An important focus area for the team was to improve the ride and handling characteristics of the vehicle by performing dynamics simulation. This could be done by reducing the vehicle's yaw, pitch and roll rates. The team used Adams Car to help visualize the vehicle Dynamics and bring appropriate design changes to obtain optimal results.

The team also performed some turning tests such as skid pad and step steer using Adams Car to measure yaw, pitch, roll and lateral acceleration. By analysing yaw, pitch and roll obtained during simulation, the team was able to decide on the stiffness of the spring used in the car's front and rear suspensions. Adams Car was also used to analyse the toe effect with respect to the cornering capability of the car.

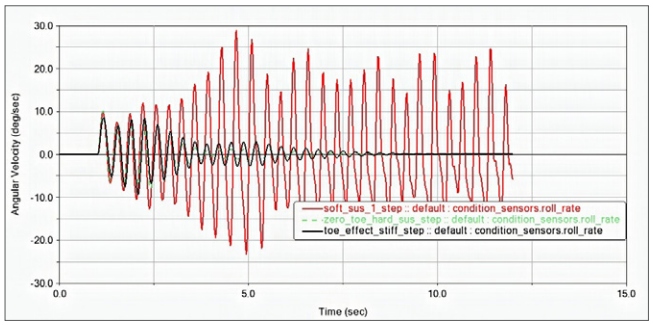
The dynamic analysis enabled the team to accurately predict the loads on each of the components. Based on this, they were able to design the components such that they had lowest mass possible. The team also exported dynamics loads to do FEA & stress analysis of the components.



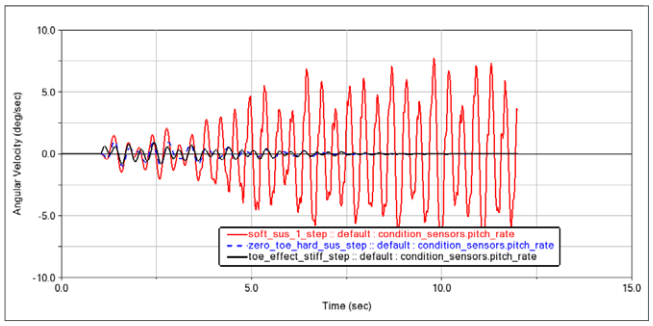
Velocity vs time



Yaw rate vs time



Roll rate vs time

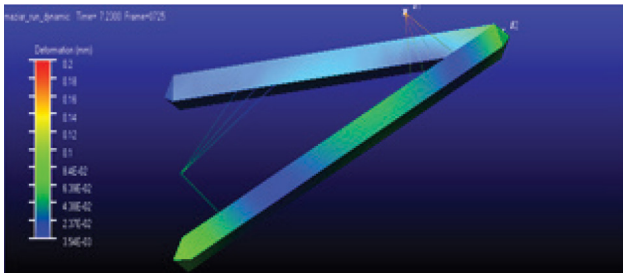


Pitch rate vs time

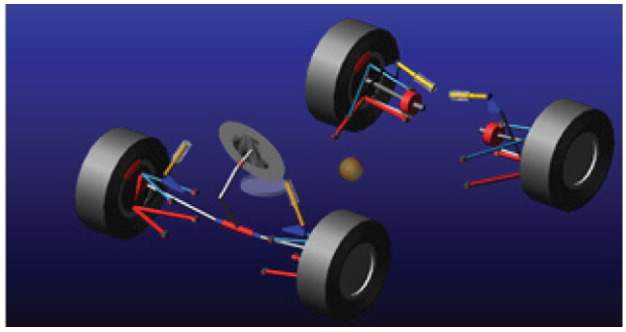
Optimal Design

The team needed to determine the optimal stiffness of the spring in order to ensure yaw, pitch and roll moment. The different scenarios were plotted as per the graph above. The red curve represents the softer spring and black one is the stiffer spring. By observing the dynamics curve of yaw, pitch and roll analysis, the team found that a stiffer spring could help reduce yaw, pitch and roll moment. Softer springs had a large yaw, pitch & roll rate, which didn't stabilize over time. The velocity curve also showed that the stiffer spring helps the vehicle to turn faster during cornering.

This study also enabled the team to decide the stiffness of the car and further incorporating some toe in the vehicle helps the yaw rate to get stabilizes with time. This also improves the cornering capability of the car during turning. The team also performed flex analysis to study the deformation and stress analysis of the vehicle's control arms.



Deformation after dynamic suspension analysis



Full Vehicle Assembly in Adams Car

Through the use of MSC Adams Car Software, the Zuura Formula Racing team was able to effectively tackle its objective to improve the riding and handling experience.

About Zuura Formula Racing

Zuura Formula Racing is an FSAE team from VIT Chennai, India. The team competes at national and inter-national level FSAE competitions held across the globe by applying engineering principles to build one of the most advanced formula student cars. Zuura is Sanskrit for "warrior of good" - a brave fighter who represents virtue against all odds. The team has won several awards at international competitions.

ZFR-06 Race Car

For more information on Adams and for additional Case Studies, please visit: **www.mscsoftware.com/adams**

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