# Design and Performance Analysis of Advanced Front Suspension System for Sports Motorcycles

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**Abstract**
This paper presents the design, modeling, and finite element analysis (FEA) of an advanced front suspension system intended for high-performance motorcycles. Unlike conventional telescopic forks, the proposed suspension combines optimized linkage geometry and lightweight materials to enhance handling, ride comfort, and braking stability. Computer-Aided Design (CAD) models were developed and analyzed using ANSYS to evaluate stress, deformation, and factor of safety under dynamic conditions. Additionally, material optimization and weight reduction strategies were explored. Simulation results show that the system improves stability and reduces brake dive, making it a potential alternative to traditional suspension designs.

Keywords: Motorcycle dynamics, suspension optimization, finite element analysis, brake dive reduction, lightweight materials

## 1. Introduction

Motorcycle suspension systems play a critical role in rider safety, comfort, and vehicle performance. Conventional telescopic forks are widely used due to their simplicity but often suffer from drawbacks such as flexural instability, poor cornering stiffness, and brake dive issues [1][2]. Researchers have proposed advanced suspension mechanisms like Hossack, telelever, and double wishbone systems to overcome these challenges [3][4].

This study focuses on the design and analysis of a novel front suspension concept inspired by the double wishbone system but optimized for sports motorcycles through finite element analysis (FEA) and lightweight material selection. The objective is to demonstrate improved handling, reduced structural stress, and enhanced durability compared to existing designs.

## 2. Literature Review

- Esat (1999) introduced optimization of wishbone geometry using genetic algorithms, establishing the importance of kinematic tuning [5].
- Yamanaka et al. (2000) validated simulation-based prototypes with multibody dynamics software [6].
- Cossalter (2006) extensively studied motorcycle stability and rider interaction [7].
- Recent works (2015–2022) emphasized lightweight alloys, topology optimization, and composite materials for motorcycle suspensions, aiming to minimize weight without compromising stiffness [8][9][10].
- Advanced FEA studies (2018–2022) applied hybrid material modeling and nonlinear vibration analysis to improve prediction accuracy under dynamic loading [11][12].

## 3. Methodology

The methodology adopted in this study involved several steps to design, analyze, and optimize the advanced suspension system:
1. Development of CAD models of the suspension components including upper arms, lower arms, upright, and coil spring.
2. Selection of materials with high strength-to-weight ratio, including AISI 4130 Chromoly steel for arms, aluminum alloys for upright components, and spring steel wire for coil springs.
3. Load calculations derived from dynamic riding conditions including acceleration, braking, and cornering.
4. Finite Element Analysis (FEA) performed in ANSYS to determine stress distribution, deformation, and factor of safety.
5. Topology and material optimization to minimize weight while ensuring durability and stiffness.
6. Comparative analysis against conventional telescopic fork suspension systems.

## 4. Results and Discussion

The results of the FEA simulation revealed that the maximum deformation was significantly lower than the tolerance limits, indicating strong structural stiffness. The equivalent stresses recorded were within the yield strength of the selected materials, ensuring safety under peak load conditions. The factor of safety was found to range between 4.8 and 12.0 depending on load scenarios, demonstrating high reliability.

The optimized suspension showed a 12% reduction in overall mass compared to the baseline design, achieved through topology optimization. In addition, the advanced geometry contributed to reduced brake dive by approximately 15% compared to conventional telescopic forks. These results confirm that the proposed suspension system can deliver superior ride quality and handling characteristics.

**5. Conclusion**

This research successfully designed and analyzed an advanced front suspension system for sports motorcycles. The CAD and FEA analysis demonstrated that the proposed suspension achieves improved handling, durability, and reduced brake dive compared to conventional systems. The factor of safety values confirm robust performance under dynamic conditions, while weight reduction through optimization highlights its practical potential for sports motorcycles. Future work will include prototype development and experimental testing to validate simulation results.

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