# REVIEW WORK ON DESIGN & OPTIMIZATION OF ANTIROLL BAR & DEVELOPMENT OF TEST RIG FOR PERFORMANCE MEASUREMENT

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## ABSTRACT

*An anti-roll bar which is also called as stabilizer bar & sway bar is a part of suspension that helps reduce the body roll of a vehicle during fast cornering or over road irregularities. It connects opposite (left/right) wheels together through short lever arms linked by a torsion spring. Optimization is an act, process, or methodology of making something (as a design, system, or decision) as fully perfect, functional, or effective as possible. In a typical optimization problem, the goal is to find the values of controllable factors determining the behavior of a system that maximize productivity or minimize waste. The aim of this paper is to investigate possibilities of optimization of Antiroll bar & to study related research papers to validate design of Antiroll Bar.*

***Keywords: Antiroll bar, Design of Experiments Method, FEA, Parametric optimization, Suspension system.***

## I. INTRODUCTION

The anti-roll bar, as being a suspension component, is used to improve the vehicle performance with respect to Ride comfort, handling and road holding. The anti-roll bar is a rod or tube that connects the right and left suspension members. It can be used in front suspension, rear suspension or in both suspensions, no matter the suspensions are rigid axle type or independent type. The main goal of using anti-roll bar is to reduce the body roll.

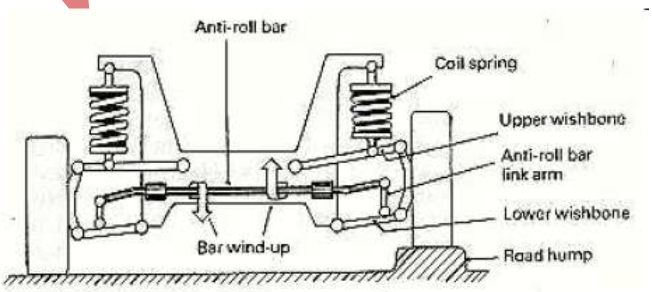


**Figure1: Vehicle Experiencing Body Roll During Cornering.**

The following paragraph show the relevant result and the studies conducted on the performance and analysis done by them are describe in below paragraph of the literature.

**S. B. Tuljapure, Laxminarayan Sidram Kanna** [1] They analysed the Stability Bar & derived the following conclusions about Antiroll Bar design parameters:-

- Increasing the cross-sectional diameter of an anti-roll bar will increase its roll stiffness. But larger stresses occur on the bar for the same bar end deflection. The size factor used for endurance limit modification is also affected from the diameter of the bar.
- The weight of the hollow anti-roll bar is less than the solid bar having the same roll stiffness. However, the stresses on the hollow bar are higher. The size factor is also adversely affected from the outer diameter of the anti-roll bar.
- Increasing the bushing stiffness increases the anti-roll stiffness. The stresses are again increased.
- Constraining the x movement of the within the bushing increases the roll stiffness if the amount of this displacement is high in the unconstrained case.
- Locating the bushings closer to the centre of the bar increases the stresses at the bushing locations while roll stiffness of the bar decreases.
- The roll stiffness of the bar is increased while the maximum stresses are decreased due to distribution of the stresses along the length of the bar.
- Required roll stiffness can be obtained with a lower weighting bar by changing the bar by changing the bar material.

They have suggested some recommendations for Future Work:

- In order to obtain desired anti-roll bar properties, the automated design software must be run with trial parameters. Optimization can be utilized for finding the value of input parameter (bar diameter) to obtain a specified property (roll stiffness) while keeping the other input parameters same.
- In some situations zooming may be very useful in post processing the results. Thus, zooming capability can be made available in the post-processor.
- Although their use is not common, the analysis of bars with variable cross-section can be added to program capability.
- A database of bushing materials with material properties can be made available to user.
- Fatigue analysis can be performed by using real road data.
- Automated design software can be developed for other machine components.

**Yogesh Sharma**[2] He analysed Antiroll bar by the Finite Element Technique. His project helps us to understand the vital role of anti-roll bar or torsion bar and it's designing. As mentioned in his project the yield strength of the material which they are using is 850 MPa. The maximum value of stress calculated for 1000 Nm torque while frontal portion of vehicle rolls down is 208.8 MPa which is well within the limits. And therefore, the factor of safety of theoretical calculations is 4.07; whereas for the FE simulations the stress developed are 390.752 MPa, so again the factor of safety in this case is 2.175. Safety is of utmost concern in every respect. Considerable factor of safety (FOS) or design factors is applied to the anti-roll bar design to minimize the risk of failure & possible resulting injury. This FOS value implies the safe value of applied loads and deformations.

**M. Murat TOPAÇ, H. Eren ENGİNAR, N. Sefa KURALAY**[3] They have carried out study on Stress concentration at the corner bends of an anti-roll bar & have reduce stress concentration at corner bends of Antiroll Bar by Parametric optimization.

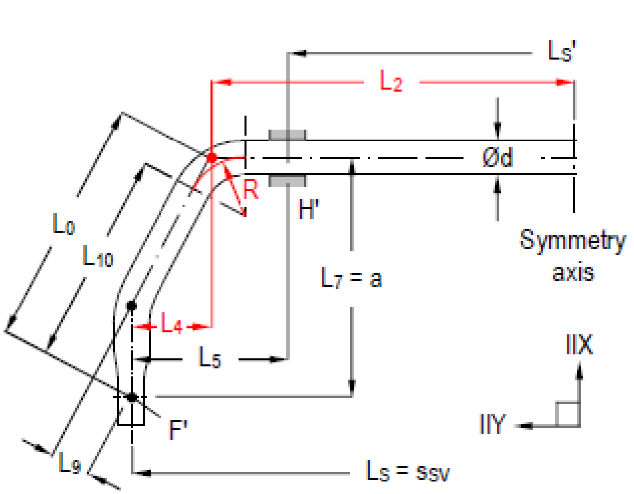


**Figure2:Basic Dimensions of Antiroll Bar**

The effects of two design parameters; the transition length L2 and the transition radius R that constitute the geometry of the critical regions were studied.

- An increase of the transition length L2 decreases the equivalent von Mises stress at the corner bends, however raises the anti-roll bar mass.
- Increasing the transition radius R raises the equivalent stress and also the notch effect at the critical regions over an optimum R value.
- Increasing the transition radius R also decreases the anti-roll bar mass.

**Prof. Laxminarayan Sidram Kanna, Prof. S. V. Tare, Prof. A. M. Kalje**[4] Authors have discussed Feasibility of hollow shaft in this project. The Stability bars are analyzed for shear stress. The conclusions are as below:

The shear stress is not constant throughout the length of stability bar.

The hallow stability bar contain large amount of shear stress than solid stability bar.

The (Mostly) maximum stress is in the bend location, middle zone of the stability bar whereas on the sides of the bar, the stresses are lesser.

The shear stress concentration is maximum at internal side of bend location.

The variation in the shear stress is considerable. If load per unit diameter is kept constant, the maximum deformation & Maximum Stress are nearly same for all diameter of bar.

In Hallow Stability bar we can the hydraulic incompressible oil for breaking system. So that the Storage tank (by conventional method) required for hydraulic oil is remove here. Approximately the we can save the 140-150 kg of material and as per the Rupees we can save Rs. 3000-Rs.4000/-

**Keerti Sharma1, P. M. Bora2, Dr.Pushpendra Kumar Sharma3**[5] They have worked on Hollow Cross-Section vs. Solid Cross-Section & Increasing Diameter of Solid Cross-Section by using Finite Element Analysis of Anti roll Bar & concluded below points:

1. Increasing the cross-sectional diameter of an anti- roll bar will increase its roll stiffness. But larger stresses occur on the bar for the same bar end deflection.

2. The weight of the hollow anti-roll bar is less than the solid bar having the same roll stiffness. However, the stresses on the hollow bar are higher.

3. Locating the bushings closer to the centre of the bar increases the stresses at the bushing locations while roll stiffness of the bar decreases.

4. If the pin joints are used at the bar ends, the Stresses near the ends are increased. The roll stiffness of the bar is increased while the maximum stresses are decreased due to distribution of the stresses along the length of the bar.

**P. M. Bora1, Dr. P. K. Sharma2**[6] They have analyzed Anti-roll Bar using FEA tool ANSYS & Following conclusions are derived about anti-roll bar design parameters from FEA: -

1. As the load on bar increases, deflection, stresses and strain on the bar increases correspondingly.

2. Increasing the cross-sectional diameter of an anti-roll bar will increase its roll stiffness and decreases deflection and stress.

3. The weight of the hollow anti-roll bar is less than the solid bar, while the stresses on the hollow bar are higher for the same load conditions.

4. In Hollow bar, as the thickness increases, stress, strain and deflection decreases while weight of bar increases. (Here for 2mm thickness bar fails).

**J. Marzbanrad, A. Yadollahi**[7] They have studied Fatigue Life of an Anti-roll Bar of passenger vehicle. In the present paper, as a first stage, some modifications are proposed to some existing fatigue failure models. Many hints that may be considered to develop general fatigue failure models for three-dimensional stress fields with random, no proportional loadings are mentioned. Then, fatigue life of an anti-roll bar component of a passenger vehicle, is investigated by numerical method and finally comparison is made among

the results of the FEM analysis, results of the existing theories, results of the modified versions of the theories, as well as the experimental results. The presented results confirm the accuracy of numerical fatigue analysis.

**Preetam Shinde1, M.M.M. Patnaik2** [8] They have discussed Parametric Optimization to Reduce Stress Concentration at Corner Bends of solid & Hollow Stabilizer Bar.

A stabilizer bar that will be used in the front axle suspension of the vehicles is redesigned to minimize the stress concentration at the corner bends for given structural limits. For this purpose, the effects of two design parameters; the transition length (L2) and the transition radius (R) that constitute the geometry of the critical regions are studied for solid as well as hollow stabilizer bar. Locating the bushings closer to the centre of the bar increases the stresses at the bushing locations. Also the weight of the hollow anti-roll bar is less than the solid bar but the stresses on the hollow bar are higher.

The parametric optimization is applied via ANSYS Workbench V13.0 commercial finite element software by using Design of Experiments (DoE) approach. FE analyses showed that it is possible to decrease the maximum equivalent stress at the critical regions for solid and hollow stabilizer bar to 11% and 12% with a mass increase of 3.75% and 3.45% respectively.

The results obtained can be summarized as: An increase of the transition length (L2) decreases the equivalent Von misses stress at the corner bends, however raises the anti-roll bar mass. Also the effect of increasing the transition radius R raises the equivalent stress and also the notch effect at the critical regions over an optimum R value. Increasing the transition radius R also decreases the anti-roll bar mass.

(see figure2)

**Tim Webb and Karen Curtis** [9] They have studied tubular stabilizer bars with varying levels of shot peening induced residual stress to maximum load during accelerated fatigue testing & found that fatigue test life, without considering shot peening effects, was 11,000-20,000 cycles; life with shot peening was 60,000- 78,000 cycles. Failure locations were detected in the vicinity of one of the rubber bushes.

**Mohamed Krid and Faiz Benamar** [10] They have studied on Design and control of an active anti-roll system for a fast rover. In this paper they have an integrated approach of an active anti-roll system has been presented. An innovative kinematics which can be easily added on existent off-road chassis is proposed. A model predictive controller based on minimization of load transfer and energy consumption is designed. Simulation results show that this system improves the performance and the stability of the robot when cornering. An important advantage of the proposed solution is its easy integration as new part, without any transformation of the original chassis. This system can be controlled independently and is demonstrated to have no effect on the dynamics of path controller. A new rover based on an existent commercial chassis is currently under construction to equip it with electric actuators, sensors, and the active anti-roll system detailed in this paper. The next steps, will focus on the experimental validation of this promising new system. Another challenge for increasing off- road performance, would be the design and development of innovative systems for preventing tip-over instability along both roll and pitch axes.

**Pravin Bharane, Kshitijit Tanpure, Amit Patil, Ganesh Kerkal** [11] They have studied Design, Analysis and Optimization of Anti-Roll Bar & concluded below points:

- Anti-roll bars are tunable vehicle components which have direct effect on the vehicle's performances.
- By changing the parameters of the bar, bar properties can be improved.
- The time required for analysis of Anti-roll bar using APDL (Ansys Parametric Design Language) is very short and can be repeated simply after changing any of the input parameters which provides an easy way to find an optimum solution for anti-roll bar design.
- The most obvious effect of using hollow section is the reduction in mass of the bar.
- Locating the bushings closer to the centre of the bar increases the stresses at the bushing locations which results in roll stiffness of the bar decreases and the max Von-mises stresses increases
- By Increasing the bushing stiffness of Anti-roll bar, increases Anti- roll stiffness, also increasing the stresses induce in the bar.

**H. Bayrakceken, S. Tasgetiren , K. AslantaS** [12] They have explained Fracture of an automobile anti-roll bar. A failed anti-roll bar is analysed in this study. The bar is produced from plastically deformed smooth bar of AISI 9260 spring steel. The plastic deformation is localized at the bent locations. Mechanical properties, microstructural properties, chemical compositions, fractographic and stress analyses are carried out to determine the possible fracture reasons of the component. As a conclusion, the following statements can be drawn:

- The fracture is taken place after a fatigue procedure under a combined bending and torsional stresses having highly reversible nature.
- The crack of the fracture is initiated at the highly stressed region of the bar.
- The fracture is taken place in a ductile manner.
- The production process could have affected the initiation region of the failure.

**A.-M. Wittek, H.-Ch. Richter, B. Łazarz** [13] The article outlines the calculation methods for stabilizer bars. Modern technological and structural solutions in contemporary cars are reflected also in the construction and manufacturing of stabilizer bars. A proper construction and the selection of parameters influence the strength properties, the weight, durability and reliability as well as the selection of an appropriate production method.

**M. Cerit , E. Nart, K. Genel,** [14] Scholars Investigated effect of rubber bushing on stress distribution and fatigue behaviour of anti-roll bar. Stress distribution of an anti-roll bar has been investigated by using FE method for various polyurethane rubber material type and wall thickness under 7_ rotational loading. Structural analyses and experimental results indicated that the inner surface of the corner bend is critical from point of fatigue failure. Regardless of rubber hardness and wall thickness, the maximum stress takes place at the same location. It was concluded that the reduction of equivalent stress in anti-roll bar could be realised by modifying the bushing provided a significant improvement in the fatigue life. Approximately 9% improvement with respect to base bushing can be obtained by selecting relatively soft rubber material. Changing in only wall thickness for 75 Shore A from 7 mm to 8.75 provides 11% improvement. Total improvement from the proof tests reached up to approximately 21% in the fatigue life. Although no structural failure was detected in polyurethane bushing in proof test, wear and creep should be examined for long term running in service condition.

**P.H. Cronje, P.S. Els** [15] They have discussed off-road vehicle handling using an active anti-roll bar. The present study successfully implemented an active anti-roll bar to improve the handling of an off-road vehicle without a detrimental effect on ride comfort. It is concluded that the active anti-roll bar system can dramatically improve the handling of an off-road vehicle without sacrificing ride comfort.

## II. CONCLUSION

There is much software on which we can work and design the model such as UG, solid works, catia, pro-e, etc can use for modeling of Antiroll Bar and finite element analysis can be done by Ansys software.
From the above study we can conclude that Antiroll Bar is smallest component in suspension system for roll prevention, Hence is feasible for study & test purpose.
It can be made cost effective by proper study of parametric optimization.
Test Rig (Performance measurement instrument for Mechanical or Electrical component) can be developed for performance measurement of Antiroll Bar.

## III. OTHER RECOMMENDATIONS

We can also investigate methods of validating Antiroll bar by different type of experimental setups.
We can further study on different type of materials for Anti roll bar & software used to improve productivity, efficiency & minimizing waste.

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