IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE)
e-ISSN: 2278-1684, p-ISSN: 2320-334X
PP 76-80
www.iosrjournals.org

Feasibility of hallow stability bar

Prof. Laxminarayan Sidram Kanna[1], Prof. S. V. Tare[2], Prof. A. M. Kalje[3]

ABSTRACT: *Stability bar also referred to as Anti-rolls bar or sway bar. The bar's torsional stiffness (resistance to twist) determines its ability to reduce body roll, and is named as "Roll Stiffness". A stability bar improves the handling of a vehicle by increasing stability during cornering or evasive maneuvers. Most vehicles have front anti-roll bar stability bar. Stability bar bars at both the front and the rear wheels can reduce roll further. Properly chosen (and installed), stability bar will reduce body roll, which in turns leads to better handling and increased driver confidence. Stability bar analyses in the past were performed using analytical methods, which required a number of assumptions and simplifications. In general, stability bar analyses are multidisciplinary, including calculations related to the stresses and to tribological failures such as like wear or shear, scoring. In this trying to design stability bar to resist bending, shear failure. As computers have become more and more powerful, people have tended to use numerical approaches to develop theoretical models to predict the effect of whatever is studied. This has improved stability bar analyses and computer simulations. Numerical methods can potentially provide more accurate solutions since they normally require much less restrictive assumptions. The model and the solution methods, however, must be chosen carefully to ensure that the results are accurate and that the computational time is reasonable*.

Keywords: Stability bar, torsional angle, stiffness etc.

I. INTRODUCTION

Stability bar, also referred to as Antiroll bar or sway bar, is a rod or tube, usually made of steel, that connects the right and left suspension members together to resist roll or swaying of the vehicle which occurs during cornering or due to road irregularities. The bar's torsional stiffness (resistance to twist) determines its ability to reduce body roll, and is named as "Roll Stiffness".

A stability bar improves the handling of a vehicle by increasing stability during cornering or evasive maneuvers. Most vehicles have front anti-roll bars. Anti-roll bars at both the front and the rear wheels can reduce roll further. Properly chosen (and installed), anti-roll bars will reduce body roll, which in turns leads to better handling and increased driver confidence. Thus, anti-roll bars are also used to improve directional control and stability. One more benefit of anti-roll bar is that, it improves traction by limiting the camber angle change caused by body roll. Anti-roll bars may have irregular shapes to get around chassis components, or may be much simpler depending on the car.

Ride comfort, handling and road holding are the three aspects that a vehicle suspension system has to provide compromise solutions. Ride comfort requires insulating the vehicle and its occupants from vibrations and shocks caused by the road surface. Handling requires providing safety in maneuvers and in ease in steering. For good road holding, the tires must be kept in contact with the road surface in order to ensure directional control and stability with adequate traction and braking capabilities. The anti-roll bar, as being a suspension component, is used to improve the vehicle performance with respect to these three aspects. The stability 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. A typical anti-roll bar is shown in Figure 2.1.

Figure 2.1 - A typical anti-roll bar

The main goal of using anti-roll bar is to reduce the body roll. Body roll occurs when a vehicle deviates from straight-line motion. The line connecting the roll centers of front and rear suspensions forms the roll axis roll axis of a vehicle. Center of gravity of a vehicle is normally above this roll axis. Thus, while cornering the centrifugal force creates a roll moment about the roll axis, which is equal to the product of centrifugal force with the distance between the roll axis and the center of gravity. This moment causes the inner suspension to extend and the outer suspension to compress, thus the body roll occurs

Stresses in Stability Bar

There are several failure mechanisms for stability bars. Shear failure of the bar is one of the main failure modes. The shear stresses in a stability bar are another interesting problem. When loads are too large, shear failure will occur. Shear failure in bars is predicted by comparing the calculated shear stress to experimentally-determined allowable fatigue values for the given material.

Different factors required for the calculation, can be obtained from the books on machine design. This analysis considers only the component of the tangential force acting on the bars, and does not consider effects of the radial force, which will cause a compressive stress over the cross section on the bars surface.

Fatigue or yielding of stability bars due to excessive shear stresses is one important in design considerations. In order to predict fatigue and yielding, the maximum stresses on the tensile and compressive sides of the bar respectively are required. In the past, the bending stress sensitivity of a gear tooth has been calculated using relatively coarse FEM meshes. However, with present computer developments we can make significant improvements for more accurate FEM simulations.

II. PROBLEM DEFINITION

The stress field at the stability bar will be analyzed using a three-dimensional finite element solid model. There are two important facts to be considered about the stability bar that first, the anti-roll stiffness of the bar has direct effect on the handling characteristics of a vehicle. And second, the geometry of the bar is dependent on the shape and location of other chassis components.

In addition to these two facts, considering that stability bar design is simpler than design of other chassis components, it is clear that in case of a problem about the handling of the vehicle or in case of a geometry change in one of the chassis components that leads to an interference with the stability bar geometry.
The first thing to be done is to change the design of the stability bar. Therefore, design changes of the anti-roll bars at various steps of the vehicle production are quite common. The phrase “various steps” includes design, testing and manufacturing phases of the vehicle production and furthermore, in some cases, it can occur after marketing according to the customer responses. The discussion on the availability and cost of FEA clarifies the fact that, it should be used more effectively. This necessity increases further as the number of analyses performed for a part increase. Methods that automate the design of such parts should be developed. Stability bar design can be a suitable objective for a study of automating the FEA.

Calculation of Shear Stress for Solid Stability Bar

Solid Bar Dia. 30	Solid Bar Dia. 31	Solid Bar Dia. 32
Load (L)= 30% of Weight L = 0.03x 7039N L = 2111.60 N	Load (L)= 30% of Weight L = 0.03x 7039N L = 2111.60 N	Load (L)= 30% of Weight L = 0.03x 7039N L = 2111.60 N
Moment (M)= Load x Distance M = 2111.60 X 1040 M = 219.60 Nm	Moment (M)= Load x Distance M = 2111.60 X 1040 M = 219.60 Nm	Moment (M)= Load x Distance M = 2111.60 X 1040 M = 219.60 Nm
Torque (T)= 2 x Load x Moment T = 2 x 2111.60 x 219.60 T= 927.41 Nm	Torque (T)= 2 x Load x Moment T = 2 x 2111.60 x 219.60 T= 927.41 Nm	Torque (T)= 2 x Load x Moment T = 2 x 2111.60 x 219.60 T= 927.41 Nm
Polar Moment of Inertia (J)= 3.14 x (r^4) / 2 J= 3.14 x $(30 / 2000)^4$ J = 7.95x 10^{-8}	Polar Moment of Inertia (J)= 3.14 x (r^4) / 2 J = 3.14 x $(31 / 2000)^4$ J = 9.06 x 10^{-8}	Polar Moment of Inertia (J)= 3.14 x (r^4) / 2 J =3.14 x $(32 / 2000)^4$ J = 1.02 x 10^{-7}

Torque (Z) = (Torque x Radius)/ Polar M.I Z= [927.41x (30 / 2000)] / [7.95 x $10^{-8]}$ Z= 174. 98 N/mm^2	Torque (Z) = (Torque x Radius)/ Polar M.I Z= [927.41x (31/ 2000)] / [9.06 x 10^{-8}] Z= 153.54 N/mm^2	Torque (Z) = (Torque x Radius)/ Polar M.I Z= [927.41x (32 / 2000)] / [1.02 x 10^{-7}] Z= 145.47 N/mm^2

Calculation of Shear Stress for Hallow Stability Bar

Hallow Bar Dia. 30 & 12	Hallow Bar Dia. 31 & 12	Hallow Bar Dia. 32 & 12
Load (L)= 30% of Weight L = 0.03x 7039N L = 2111.60 N	Load (L)= 30% of Weight L = 0.03x 7039N L = 2111.60 N	Load (L)= 30% of Weight L = 0.03x 7039N L = 2111.60 N
Hallow Bar Dia. (d)= 0.37 % of Outer Dia (D) d= 0.37 x 30 d= 11.10 mm	Hallow Bar Dia. (d)= 0.37 % of Outer Dia (D) d = 0.37 x 31 d = 11.47 mm	Hallow Bar Dia. (d)= 0.37 % of Outer Dia (D) d = 0.37 x 32 d = 11.84 mm
Moment (M)= Load x Distance M = 2111.60 X 1040 M = 219.60 Nm	Moment (M)= Load x Distance M = 2111.60 X 1040 M = 219.60 Nm	Moment (M)= Load x Distance M = 2111.60 X 1040 M = 219.60 Nm
Torque (T)= 2 x Load x Moment T = 2x 2111.60 x 219.60 T= 927.41 Nm	Torque (T)= 2 x Load x Moment T = 2 x 2111.60 x 219.60 T= 927.41 Nm	Torque (T)= 2 x Load x Moment T = 2 x 2111.60 x 219.60 T= 927.41 Nm
Polar Moment of Inertia (J)= 3.14 x (ro^4 – ri^4) / 2000 J= 3.14 x [(30 / 2000)^4 – (12/2000)^4] / 2 J = 7.74 x 10^{-8}	Polar Moment of Inertia (J)= 3.14 x (ro^4 – ri^4) / 2000 J= 3.14 x [(31 / 2000)^4 – (12/2000)^4] / 2 J = 8.85 x 10^{-8}	Polar Moment of Inertia (J)= 3.14 x (ro^4 – ri^4) / 2000 J= 3.14 x [(32 / 2000)^4 – (12/2000)^4] / 2 J = 1.00 x 10^{-8}
Torque (Z) = (Torque x Radius)/ Polar M.I Z= [927.41x (30 / 2000)] / [7.74 x 10^{-8}] Z= 179.73 N/mm^2	Torque (Z) = (Torque x Radius)/ Polar M.I Z= [927.41x (31/ 2000)] / [8.85 x 10^{-8}] Z= 162.42 N/mm^2	Torque (Z) = (Torque x Radius)/ Polar M.I Z= [927.41x (32 / 2000)] / [1.00 x 10^{-8}] Z= 147.20 N/mm^2

III. (FEM)DETAILS OF PREPROCESSING

(Solid Stability Bar with Diameter = 30 mm)

As two-dimensional model can satisfy our requirement, only two- dimensional model is drawn in ANSYS 13 as shown in figure below.

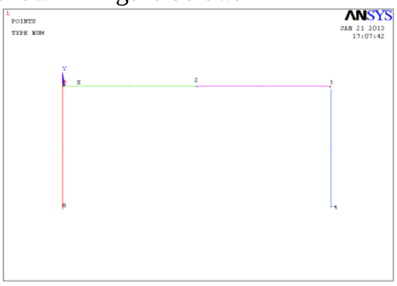

Fig: - Two dimensional model of stability bar

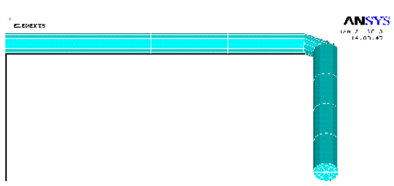

Fig: - Three-dimensional model

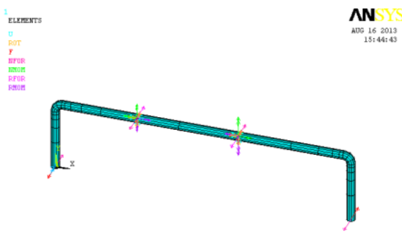

Fig: - Boundary Conditions applied to the mode

Meshing of Model: For meshing of the model, 8 Node Brick 45 (SOLID 189) elements are used. Solid 189 is used for the 3-D modeling of solid structures. The element is defined by eight nodes having three degrees of freedom at each node: translations in the nodal x, y, and z directions. The element has plasticity, creep, swelling, stress stiffening, large deflection, and large strain capabilities. Total 12407 elements are used for the analysis.

Boundary Condition: Considering the beam as cantilever, the displacement of the necessary part/surfaces is restricted. Following figure shows the boundary condition.

The small triangles on the surfaces show that the displacement of these surfaces is restricted.

Material properties: As the material of stability bar is (alloy) steel, the following material properties are used for analysis.

Material properties: As the material of stability bar is (alloy) Chromium-molybdenum steel, the following material properties are used for analysis.

Input properties

Young's Modulus	2.1 X 10 ^{5} Mpa
Poisson's ratio	0.3

8 Node Brick 45 (SOLID 189) elements were used for meshing. Figures show the meshed model along with boundary conditions & load conditions.

SOLVING (PROCESSING): The problem is then solved for static condition.

POST-PROCESSING: Post-processing is done to observe the results. Various results are obtained during post-processing.

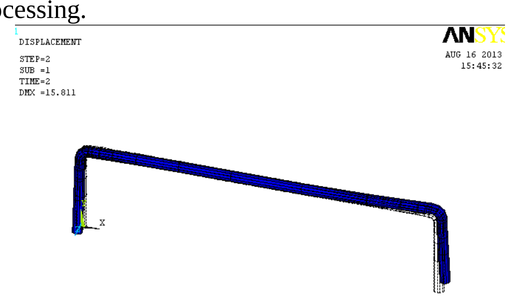

Fig: Deformed Shape & Original Shape

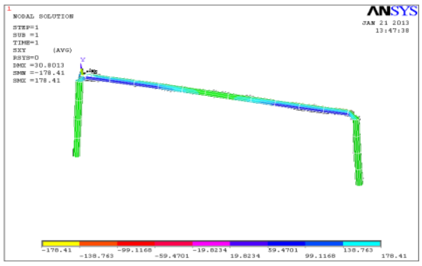

Fig: Maximum Shear Stress of 30 mm dia.

From the above figure, we can say that, deformation is more at the arm of stability bar which is far away from the clamping section of bar. The dotted lines indicate the deformed shape.

Shear Stresses:

Shear Stresses for Solid Stability Bar with Diameter = 30 mm

The following figure shows the shear stresses at the solid stability bar with diameter 30 mm. Load applied is equal to 4223.60 N. The load is applied at two different points.

The value is equal to 4223.60 / 2 = 2111.60 N.

Output: Maximum Stress : 178.41 MPa

From the above figure, it is clear that the stresses vary along the diameter of bar. i.e. They are not remaining

Stresses can be reduced by:

By changing material / properties of material (use of alloys) of Stability bar.

By changing the shape / size of stability bar.

By changing of the radius of curvatures of bar.

By changing of the deformation/ crack points etc.

Shear Stresses for Hallow Stability Bar with Diameter = 30 mm & 12 mm

Output: - Maximum Stress :183.097 MPa

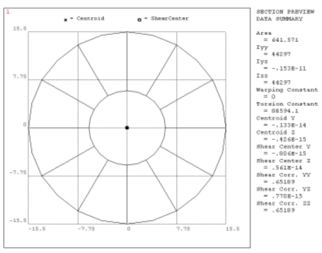

Fig: - Cross Section of Hallow Stability Bar

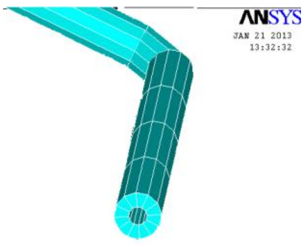

Fig: -Three-dimensional model

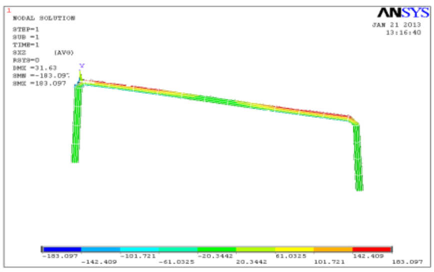

Fig: - Maximum Shear Stress of hallow bar

IV. RESULT ANALYSIS

Design Analysis Results Vs Analytical Results:

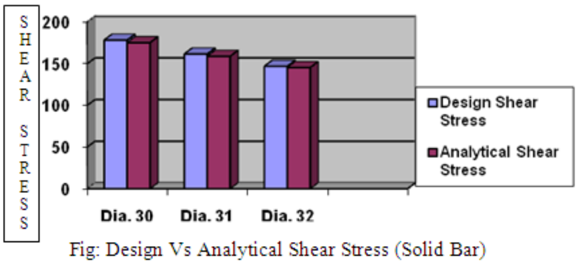

Fig: Design Vs Analytical Shear Stress (Solid Bar)

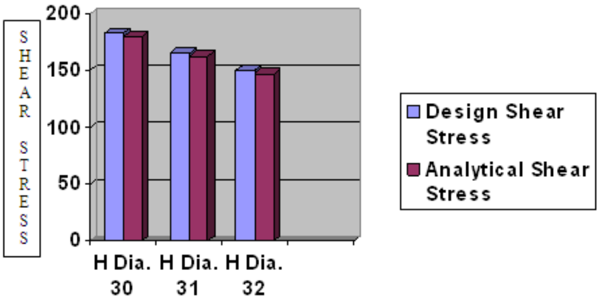

Fig: Design Vs Analytical Shear Stress (Hallow Bar)

IV. CONCLUSION

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/-

REFERENCES

1) John draper, safe technology limited, UK "Modern metal fatigue" Volume1, 2008.
2) Tirupati Chandrupatla, Ashok Belegundu, “Introduction to Finite Elements in Engineering”, Prentice Hall India, 2007.
3) V.B. Bhandari, “Design of Machine Elements”, Tata McGraw Hill Publishing Co. Ltd, New delhi, 2005
4) Fan, H. Cai, S. Lin, L. N. B. Gummadi and K. Cao, Visteon corporation, "Non-Linear Analysis of tunable Compression Bushing for Stabilizer Bars" ,SAE technical papers 2004-01-1548.
5) Rer. Nat. Lutz manke, Advanced Engineering Thyssen Krupp Federn, Hagen, "Weight saving through High stressed tubular stabilizer bars", techno forum December 2004.
6) E S Palma and E S dos Santos, "Fatigue damage analysis in an automobile stabilizer bar ", proceedings Instn Mech Engineers Volume 216 Part D: J Automobile Engineering, 2002.
7) ANSYS, Release 7.0, October 12, 2002, SAS IP
8) Comesky, J., “http://www.grmotorsports.com/swaybars.html”, 2002
9) Domingues, R., “http://www.tokicogasshocks.com/suspension/components.html”, 2002.
10) M. Barton, S. D. Rajan, “Finite Element Primer for Engineers”, 2000
11) Somnay, R., Shih, S., “Product Development Support with Integra Simulation Modeling”, SAE Technical Paper Series, Paper No: 1999-01-2812, 1999
12) Thi, T., V., “Automated Torsion Bar Design for Vehicle Suspension System”, MS Thesis, Department of Mechanical Engineering, University of Louisville, 1999
13) Orr, J., “Friendlier Finite Element Modeling”, Computer-Aided Engineering, v, 16, p 54, October 1994.