© 2018 IJRTI | Volume 3, Issue 4 | ISSN: 2456-3315

Numerical Analysis for a Bicycle Frame made of Mild Steel and Composite

[1]Mr. Mahanthesh.M.R., [2]Mr. Prashanth.R.Kubasad, [3]Mr. Kirankumar N.A.

[1,2,3]Assistant Professor
Department of Mechanical Engineering, PESITM
Shivamogga, India

***ABSTRACT*- Frame is very important part of bicycle as all the important accessories are mounted on the frame. The frame need to be very strong, stiff and light in weight, which is obtained by combining different materials and optimizing its shapes. The strength of frame construction is correct design of a frame because it is the most important part that ensures safe riding. This paper deals with the two different materials of bicycle frame. The modeling of bicycle frame is done in CATIA V5R21 and analysis of frame is done using the analysis software ANSYS. This analysis is done for static and modal which are important for dynamic behaviour to find deformation, stress, strain, natural frequencies and modal shapes for Mild steel and Carbon/Epoxy bicycle frame. This paper provides us the deformation, stress, strain, natural frequencies of particular bicycle frame.**

***Keywords*: Modal shapes, composite, Bicycle frame.**

I. INTRODUCTION

A bicycle frame plays an important role in a two wheeler and it carries the load acting on the vehicle. Therefore, it must be a strong to resist twist, shock, vibration, not buckle on uneven road surface and other effective stresses. Also, it should not be transmitted distortion to the body. Bicycle frames can be made of steel, aluminium or an alloy. For the purpose of reducing weight, the carbon/epoxy composite materials are now widely used for the manufacture of bicycle frames. Mostly the frame is consisting of hollow tube. If the natural frequency of bicycle frame is coincides with excitation frequency then the resonance will occur. Due to resonance the frame will undergo dangerously large oscillation, which may lead excessive deflection and failure. To solve these problems, modal analysis is very essential. In the design process of the bicycle, structural analysis of the bicycle frame is a very important stage. Before the manufacture of bicycle prototype and commercial products, the strength and stiffness of the bicycle structures can be predicted and modified to an optimal design with the aid of theoretical and numerical calculations. Bicycle frame modelling was done in CATIA V5 R21 software. Finite element analysis was done using ANSYS 14 software. Shell element is used to model the bicycle frame. In vehicle frame different types of failure occurs due to static and dynamic loading actions. Its inherent structural properties are natural frequency, damping and mode shapes, these properties can be found experimentally by modal analysis. The main purpose of this paper is to find out maximum stress and maximum deformation induced by static analysis and natural frequencies, modal shape of bicycle frame using experimental modal analysis.
.

II.LITERATURE SURVEY

Bharati A. Tayadea[1], T.R.Deshmukhb[2] analysed the static analysis to find stress, strain, factor of safety of a particular bicycle frame by considering conditions like static start up, steady state paddling, vertical impact, horizontal impact, rear wheel braking. They conclude that the stresses induced in the bicycle frame is least and the factor of safety is also well above the limit. Also, the Von Mises stresses are less than ultimate strength for the mild steel material. Thus, the design of bicycle frame is sturdy.

Arun Sam Varghese [1], Sreejith N.K.[2] analysed the structural analysis of bicycle frame made of carbon/epoxy composite materials. On the basis of Maximum stress criterion, an optimal ply design for different loading conditions has been suggested in this work. Two testing methods for the bicycle frame, i.e. frontal and vertical loads are adopted in the analysis. From the finite element analysis results, weak regions, that is regions with higher stress concentration are identified on the bicycle frame

Rahul J. Pawar[1] Dr. Kishor P. Kolhe[2] conducted an experiment on vibrational analysis of bicycle chassis. In this paper they find out experimental modal analysis to validate FE models. i.e. dynamic characteristics of bicycle chassis such as the natural frequency and mode shape were determined by using finite element (FE) method. Both mild steel and aluminium 6063 alloy are used here. They concluded that aluminum frame shows the better results and is fabricated.

III. OBJECTIVES:

To determine the maximum stress and deformation region, natural frequencies and different modal shapes in bicycle frames made of mild steel and carbon/epoxy composite materials.

IV. BICYLE FRAME MODELLING:

The Bicycle frame modelling was done in CATIA V5 R21 software as shown in the fig 1 below. The main dimensions of the bicycle frame are shown in the table 1 given below. Fig 2 shows the dimensions of bicycle frame.

After modelling the analysis of frame is done in ANSYS Software. For that purpose, after preparing the model in CATIA it is imported to ANSYS, the file is imported from CATIA by file>import>IGES. Meshing is done in ANSYS Workbench. The mesh created is as shown in the fig 3. After constructing finite element model of bicycle frame and appropriate meshing of elements, model has been done modal analysis to find out first 6 natural frequencies that play important role in dynamic behaviour of bicycle frame. Also, in static analysis the maximum stress, strain and deformation are found out for two different materials.

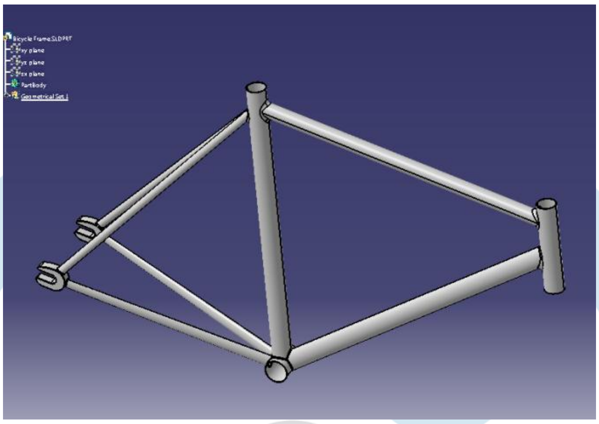


Fig 1: CATIA Model of Bicycle Frame

Fig 2: Dimensions of Bicycle Frame

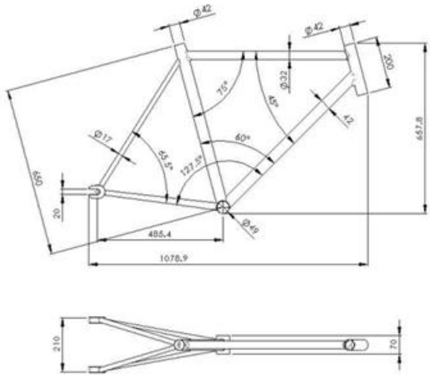


Table 1: Dimensions of Bicycle Frame

Part	Length (mm)	Diameter (mm)
Top Tube	593	32
Seat Tube	650	42
Down Tube	758	42
Head Tube	200	42
Chain stays	485	17
Seat stays	633	17
Bottom Bracket	70	49

The properties for mild steel and Carbon/epoxy are given in the table 2 and table 3 respectively.

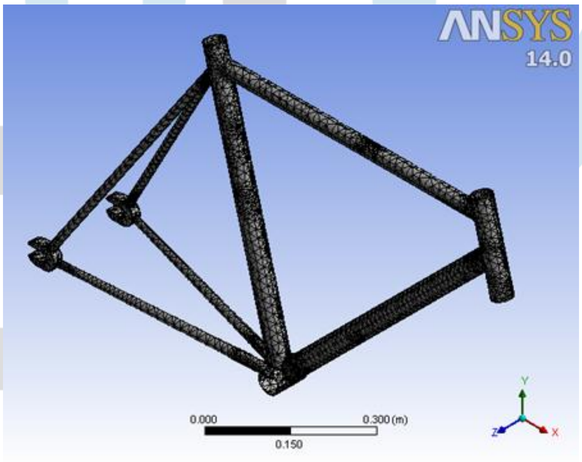
Table 2: Properties of Mild Steel

Material: Mild Steel	
Properties	**Values**
Young's Modulus	200 GPa
Poission's ratio	0.31
Density	7750 Kg/m^3
Tensile Yield Strength	320 MPa
Tensile Ultimate Strength	400 MPa

Table 3: Properties of Carbon/Epoxy

Material: Carbon/epoxy Composite	
Properties	**Values**
E1 (Young's Modulus)	162 GPa
E2	14.9 GPa
E3	14.9 GPa
Density	1600 Kg/m^3
υ12 (Poisson's Ratio)	0.283
υ_{13}	0.283
υ_{23}	0.283
G12 (Shear Modulus)	5.7 GPa
G_{13}	5.7 GPa
G_{23}	5.4 GPa

Fig 3: Meshed model of Bicycle Frame.



V. RESULT AND DISCUSSIONS

i) Modal Analysis.

Table 4: Natural frequencies for MS and Carbon/Epoxy

Mode No.	**Natural Frequencies (Hz)**	
	Mild Steel	Carbon/Epoxy
1	5.336	111.36
2	6.35	137.17
3	6.9083	159.09
4	7.3013	162.65
5	8.222	171.42
6	8.5183	193.65

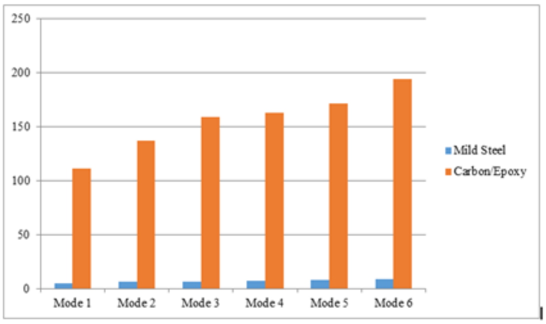


Fig. 4: Comparison between natural frequencies of Ms and Carbon/Epoxy

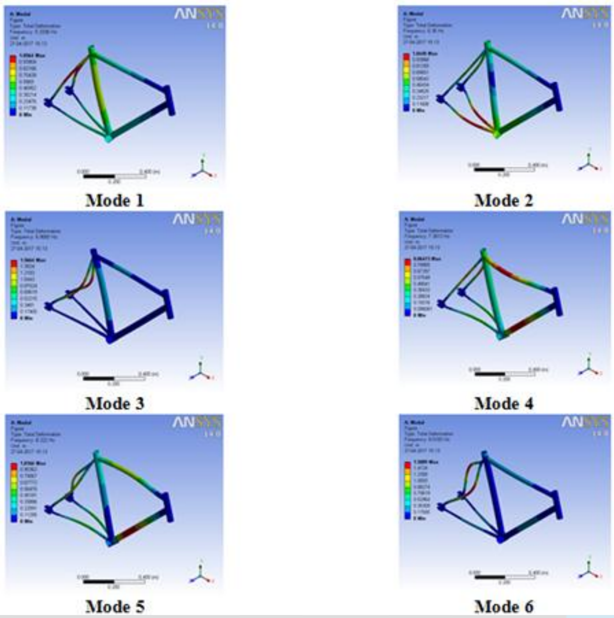


Fig. 5: Modal Shapes for MS bicycle frame

The above table 4 shows the comparison between natural frequencies of mild steel and carbon/epoxy material and fig. 4 shows the graph of natural frequencies two materials. The natural frequencies for mild steel is much lesser compared to carbon/epoxy. But the mass of carbon/epoxy is much lower. The fig. 5 and 6 shows the different modal shapes of MS and carbon/epoxy cycle frames respectively.

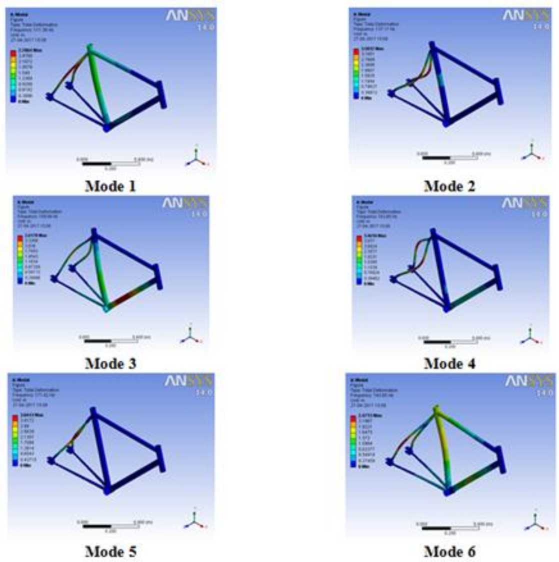


Fig. 6: Modal Shapes for Carbon/Epoxy bicycle frame

ii) Static Analysis.

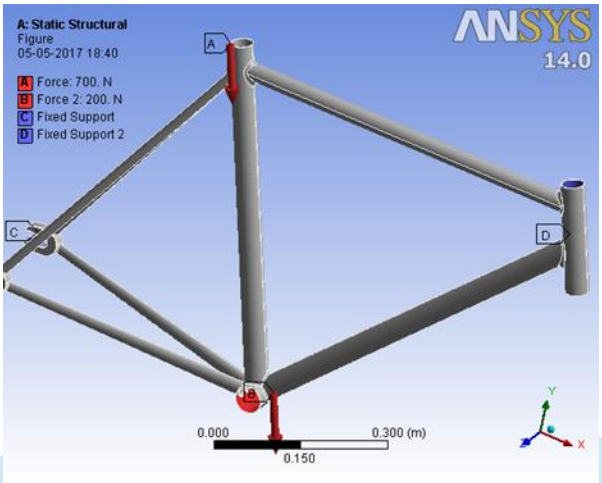


Fig. 7: Boundary Condition and Loading on Bicycle Frame

The fig 7 shows the boundary condition and loading condition for both MS and Carbon/Epoxy bicycle frames. The table 5 shows the comparison of deformation, strain and stress for both MS and Carbon/epoxy bicycle frames. Both the deformation and strain are less for Carbon/Epoxy frames compared to MS frame. But the Von-Mises stress for Carbon/Epoxy frame is almost two times that of MS frame. Fig. 8 and 9 shows the deformation, strain and stress of MS and Carbon/Epoxy bicycle frames respectively.

Table 5: Deformation, Strain and Stress for MS and Carbon/Epoxy

	Mild Steel	**Carbon/Epoxy**
Deformation (m)	0.036107	0.00029667
Strain	0.30081	0.0033676
Von-Mises Stress (MPa)	48.404	88.727

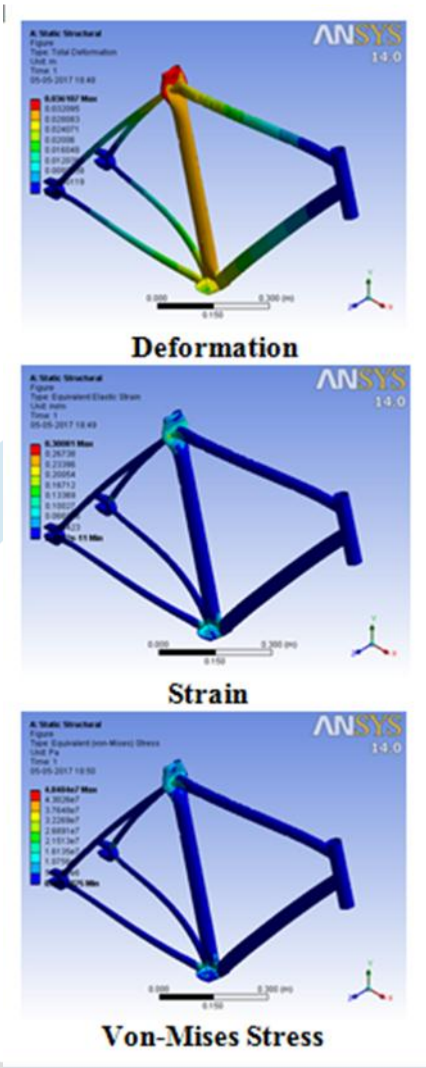


Fig. 8: Deformation, Strain and Von-Mises Stress for Mild Steel

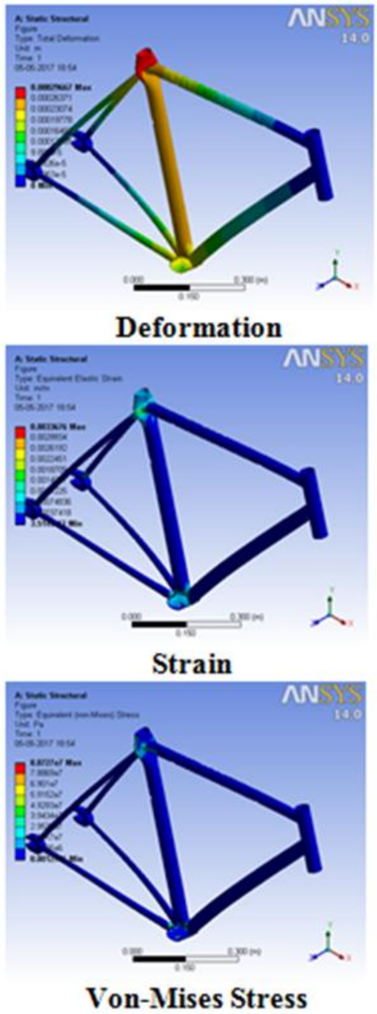


Fig. 9: Deformation, Strain and Von-Mises Stress for Carbon/Epoxy

VI. CONCLUSION

From the results of FEA, in modal analysis natural frequencies for bicycle frame made of mild steel is much lower than carbon/epoxy composite due to high density. In static analysis the deformation and strain are much lesser for carbon/epoxy compared to mild steel, but Von-Mises stress is higher for carbon/epoxy composite. The results show that bicycle frame made of carbon/epoxy composite can be considered for alternative for conventional materials.

REFERENCES

[1] **A study on structural health of bicycle frame using Finite Element Analysis,** Bharati A[1]. Tayadea[2], T.R.Deshmukhb[3] International Journal of Innovative and Emerging Research in Engineering *Volume 2, Issue 4, 2015*

[2**] Structural Analysis of Bicycle Frame Using Composite Laminate**, Arun Sam Varghese[1], Sreejith N.K.[2] *International Journal of Engineering Trends and Technology (IJETT) – Volume 28 Number 7 - October 2015*

[3] **Vibrational Analysis of Bicycle Chassis,** Rahul J. Pawar[1], Dr. Kishor P. Kolhe[2] IJIRST –International Journal for Innovative Research in Science & Technology| Volume 3
| Issue 02 | July 2016