Structural Analysis of Front-End Cross Bar of a TATA407 Chassis Frame

A. Benjamin Asirdason and B. Stalin

Abstract--- *The automotive industries are advancing various systems of a vehicle with innovative technologies. It is more essential to improve the vehicle performance at low manufacturing cost. Reduction of weight of various parts of a vehicle can improve the performance and efficiency of the automobile. The composite materials provide a good strength-to-weight ratio, which could be replaced for the conventional materials. This paper deals with the structural analysis of a frontend cross bar which is replaced with Carbon Fiber Reinforced Polymer composite material. The front-end cross bar of a TATA407 vehicle frame is modelled using the CREO 2.0 modelling software and analysed through Ansys Workbench 14.5. the stress distribution and deflection results of the convetional steel and CFRP cross bars were compared. The strength-to-weight ratio has improved when CFRP is used.*

Keywords--- *Performance, Efficiency, Conventional, CFRP, TATA 407, Cross Bar, CREO, Ansys, Stres, Deflection.*

I. INTRODUCTION

THE chassis is the basic frame that supports the major components of the vehicle. The chassis frame is mounted with the Transmission system, Axles, Wheels and Tyres, Suspension etc. The reduction of the weight of vehicle frame improves the vehicle performance in many aspects. The carbon fibers are lower in cost wise than steel and much stronger. Hence, CFRP are more suitable and widely used alternate material for automotive.

In this paper the chassis type of TATA 407 is considered, which is of ladder type with diagonal cross member. The frame consists of two longitudinal members of C-cross section, two diagonal cross members of C-cross section in the middle, two transverse cross members of C-cross section at the rear end and one transverse cross member of box-cross section at the front end. The chassis was modelled in CREO using most of the actual dimensions. Finite element analysis was done usng ANSYS 14.5.

II. LITERATURE SURVEY

C.V. Babu et al. (2015) [1] have analysed the Eicher 11.10 chassis frame. The conventional steel frame is entirely replaced with CFRP to obtain better strength-to-weight ratio. The stress and deflection results are better in composite frame than the conventional steel frame.

Ms. Kshitija et al. (2014) [2] have conducted a failure analysis on the Tractor Trolley chassis using the Finite Element Method. The results have shown that the stresses get accumulated at a region where heavy loads are applied, which is also indirectly related to the self-weight of the frame. Thus it is required to redesign the chassis with respect to the stress strain analysis and thereby reducing the self-weight of the trolley.

H.B. Patil et al. (2013) [3] have analysed the stress of a ladder type low loader truck chassis structure. The objective of the work was to reduce the cost of the chassis frame by reducing the thickness of the side member and cross member, and changing the position of the cross member. It was concluded that, changing the thickness of the cross member gave better reduction in stress and deflection values than changing the thickness of cross member and the position of cross member.

J.S. Nagaraju and U.H. Babu (2012), [7] in their paper, have replaced the conventional materials of the chassis frame with Carbon Epoxy and E-Glass Epoxy composites. Structural and Modal Analyses are conducted by varying the layers and the reinforcement angles in the layers. Results have shown that the Carbon and E-Glass Epoxy have generated low stress values than the conventional steel material when subjected to vertical loads. The weight is reduced four times than the steel frame. It is also observed that using many layers of same thickness has given better strength than a single layer.

M.R. Chandra et al. (2012), [8] have described the design and analysis of a heavy vehicle chassis. The dimensions of a TATA 2515EX vehicle is taken for modeling and analysis with three different materials, Carbon/Epoxy, E-Glass/Epoxy and S-Glass/Epoxy, subjected to the same loading conditions as that of a Steel chassis. With similar design specifications, the composite frame has shown reduced stress and deflection values than the conventional steel, also reducing the weight of the chassis frame.

III. PROBLEM SPECIFICATION

The objective of the present work is to design and analyse the front end transverse cross member made from steel and also made from composite material like Carbon Fiber Reinforced Polymer (CFRP). The chassis frame is modelled in CREO and is imported to ANSYS 14.5 for analysis under normal loading conditions. The deflections and stress results of convetional steel chassis and CFRP is compared after analysis in order to choose the better material.

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IV. MODELLING AND STATIC ANALYSIS OF CHASSIS FRAME

A. Modelling

The chassis frame is model is created using CREO modelling software.

B. Analysis

The model created in CREO is imported to ANSYS. During the analysis, the following boundary conditions, element types and material properties are considered.

i. *Elements Considered:* Shell63 and Shell99 elements are considered for analysis. The Shell63 is a four noded element having six degree of freedom at each node. Whereas, the Shell99 is used in layered configuration and it is a eight noded element having six degrees of freedom at each node.
ii. *Material Properties:* The material properties considered for analysis are listed in table 3.1
iii. *Boundary Conditions:* Since we consider the front end transverse cross bar only, the ends of the cross bar are applied as boundary conditions.
iv. *Loading Condition:* The front end transverse cross bar is mounted with radiator fittings, engine bed and other minor accessories. Thus, the average load applied to the bar is taken as 20 kN.

V. DIMENSIONS OF CHASSIS FRAME

Vehicle Model: TATA407

The longitudinal cross members, diagonal cross members and transverse cross members are made from 'C' channels of dimension 125mm x 65mm x 8mm

The front-end transverse cross bar is made from box section of dimensions 65mm x 125mm x 8mm

Front Overhang = 710 mm

Rear Overhang = 840 mm

Wheel Base = 3200 mm

Front Wheel Track = 710 mm

Rear Wheel Track = 1016 mm

Angle of divergence at the

front-end near the cross bar = 20°

Table 1: Mechanical Properties of Materials

Material Properties	STEEL	CFRP
Young's Modulus (N/mm^2)	$2.1x10^5$	$17.5x10^3$
Density (kg/mm^3)	7850	1500
Poisson's Ratio	0.3	0.35

VI. RESULTS AND DISCUSSIONS

The deformation and von-mises stress distribution of both conventional steel and Carbon Fiber Reinforced Polymer is determined through analysis. The deformation of the frame is transferred from the front most end throughout the frame. The stress is distributed evenly on both the longitudinal cross bars.

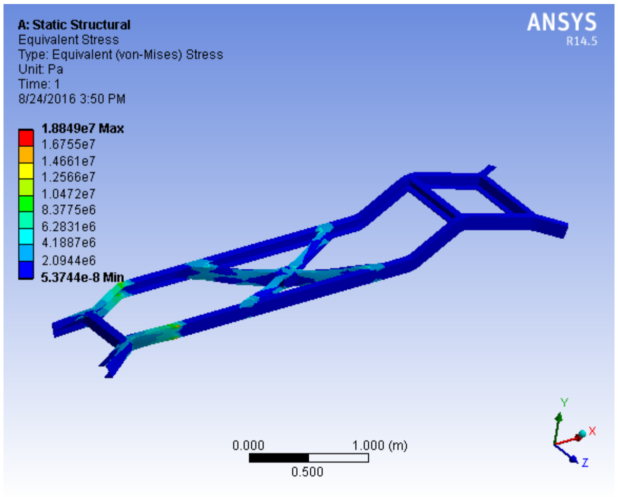

Figure 1: Von-mises Stress Distribution in CFRP

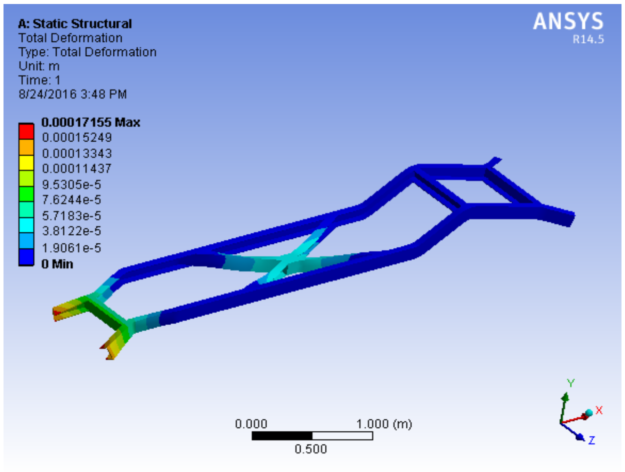

Figure 2: Deformation in CFRP

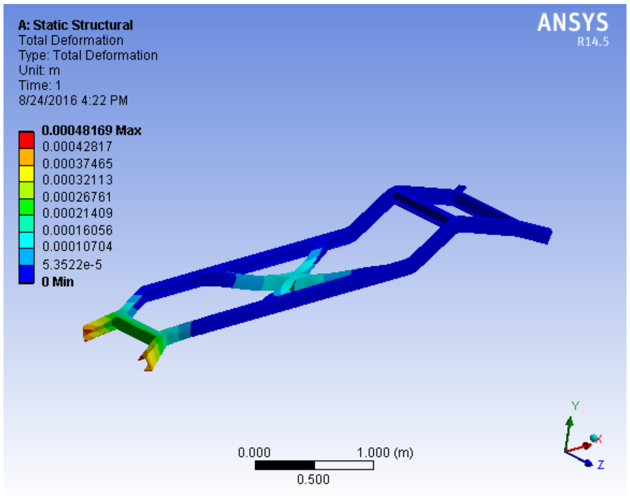

Figure 3: Deformation in Steel

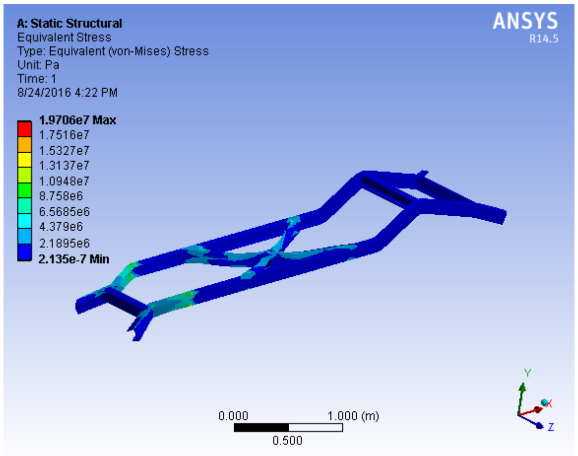

Figure 4: Von-mises Stress Distribution in Steel

The magnitude of deflection and stress of conventional Steel and Carbon Fiber Reinforced Polymer are tabulated in Table II. From the results it is clear that the CFRP is better than the steel.

Table 2: Deflection and Von-mises Stress Distribution in Static Analysis

	STEEL	CFRP
Deflection (mm)	48.169×10^{-5}	17.155×10^{-5}
Stress (N/mm^2)	1.9706×10^{7}	1.8849×10^{7}

VII. Conclusion

The carbon fibers are more suitable for ,most of the automotive applications. The replacement of the front-end cross bar only with CFRP has given better results than steel.

Thus when we replace the convetional steel with CFRP:

- the deflection of the cross bar is reduced by 64.38%
- the stress developed in the bar is reduced by 4.34%

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