MODELING AND OPTIMIZATION OF HEAVY VEHICLE CHASSIS FRAME

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ABSTRACT

Composite material is a material composed of two or more distinct phases (matrix phase and dispersed phase) and having bulk properties significantly different from those of any of the constituents. Different types of composite material are available and one of it is Polymer matrix composite. In my thesis, designing and modeling the heavy vehicle chassis is done using Pro/Engineer software, taking the data from the Larsen & Toubro (L&T) Heavy vehicle model by reverse engineering processes. The present shape of the chassis is C – Channel, the shape is optimized by taking C – Channel. And also optimization is done to reduce the weight of frame on the chassis. Present used material for chassis is Structural Steel; it is replaced with Carbon Epoxy, E Glass Epoxy. By using steel, the weight of the chassis is more compared with composite materials, since its density is more. FEA analysis is done on chassis for optimizing above parameters by applying the load of 10 tons.

Key Words: Chassis, Composite Material, Optimizing

I. INTRODUCTION

Automotive chassis is a French word that was initially used to represent the basic structure. It is a skeletal frame on which various mechanical parts like engine, tires, axle assemblies, brakes, steering etc. are bolted. It gives strength and stability to the vehicle under different conditions.

II. FRAME

Automobile chassis without the wheels and other engine parts is called frame. Automobile frames provide strength and flexibility to the automobile. The backbone of any automobile, it is the supporting frame to which the body of an engine, axle assemblies are affixed. Tie bars that are essential parts of automotive frames are fasteners that bind different auto parts together. Automotive frames are basically manufactured from steel. Aluminum is another raw material that has increasingly become popular for manufacturing these auto frames. In an automobile, front frame is a set of metal parts that forms the framework which also supports the front wheels.

III. FUNCTIONS OF THE FRAME

1. To carry load of the passengers or goods carried in the body.
2. To support the load of the body, engine, gear box etc.
3. To with stand the forces caused due to the sudden braking or acceleration.
4. To with stand the stresses caused due to the bad road condition.

3.1 Various Loads Acting On the Frame

1. Short duration Load –While crossing a broken patch.
2. Momentary duration Load –While taking a curve.
3. Impact Loads –Due to the collision of the vehicle.
4. Inertia Load –While applying brakes.
5. Static Loads –Loads due to chassis parts.
6. Over Loads –Beyond Design capacity.

3.1.1 Problem Specification

Weight reduction is now the main issue in automobile industries. Because if the weight of the vehicle increases the fuel consumption increases. At the same time as the weight of the vehicle increases the cost also increases which becomes a major issue while purchasing an automobile. For example if we take frame of L & T heavy vehicle frame. It is manufactured with Structural Steel. Steel structures exposed to air and water, such as bridges are susceptible to corrosion. In conditions of repeated stress and more temperatures it can suffer fatigue and cracks. These are the main problems of steel and these are compensated by inducing composite materials.

Fig.3.1.1 Fatigue crack of the sub-frame

Table 3.1.1. Specifications of Existing Larsen & Toubro (L&T) Heavy Vehicle Frame

SL. NO.	DESCRIPTION	DIMENSION (MM)
1	Wheel base	3600
2	Front track	1800
3	Rear track	1690
4	Overall length of vehicle with load body	6600
5	Max. width	2270
6	Frame length	5620

3.1.2 Introduction to CAD

Computer-aided design (**CAD**), also known as **computer-aided design and drafting** (**CADD**), is the use of computer technology for the process of design and design-documentation. Computer Aided Drafting describes the process of drafting with a computerTo increase the productivity

- To improve the quality of the design
- To uniform design standards
- To create a manufacturing data base
- To eliminate inaccuracies caused by hand-copying of drawings and inconsistency between Drawings

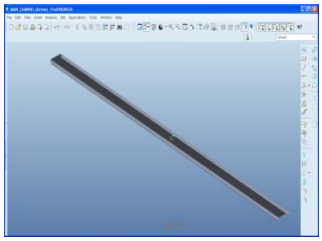
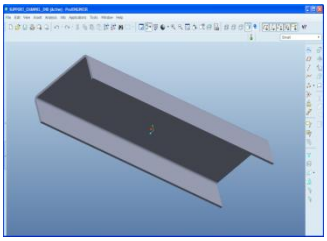
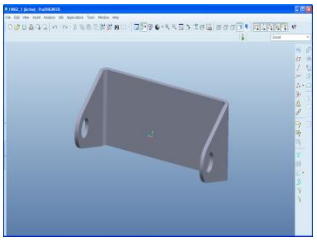
3.1.3 Introduction to PRO/Engineer

Pro/ENGINEER is the industry's standard 3D mechanical design suit. It is the world's leading **CAD/CAM /CAE** software,

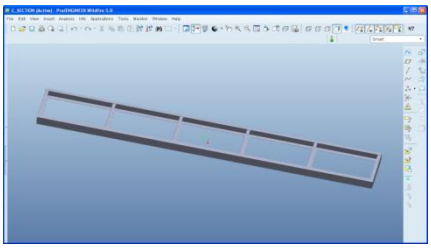
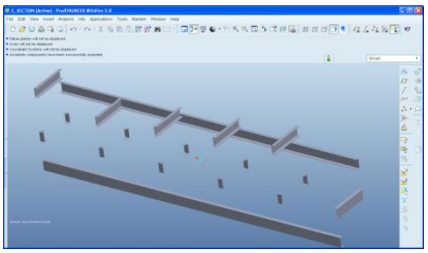
MODELLING SCREEN

C-Section

Main Channel **Support Channel** **Hinge**

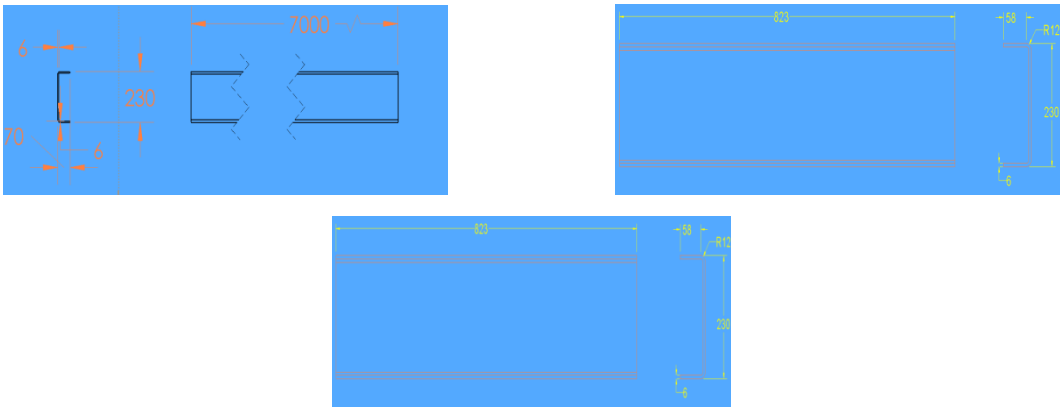




ASSEMBLY

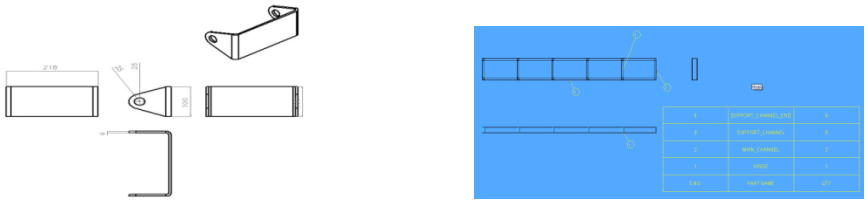



2D DRAWINGS

Main Channel **Support Channel**



Hinge **Assembly**



IV. INTRODUCTION TO CAE

Computer-aided engineering (CAE) is the broad usage of computer software to aid in engineering analysis tasks. It includes Finite Element Analysis (FEA), Computational Fluid Dynamics (CFD), Multibody dynamics (MBD), and optimization.

4.1 LOAD CALCULATIONS

The load application is the major part in the analysis of a component. There may be different types of loads like Uniformly Distributed Load, Uniformly Varying Load and Point Load.

The present frame carries the UDL throughout its length.

From the vehicle specifications

FAW= 7000 Kg

RAW = 3000 Kg

Total GVW = 10000 Kg

As the frame supports the bodt by its two side frames, the load on each side member

= 10000/2 = 5000 kg

The total area on which the UDL is placed = 1081587.65 mm^2Total pressure applied = Total load /Total area = 10000/1081587.65 = 0.0907 N/mm^2 = 0.0907 MPa

V. MATERIAL PROPERTIES

A. Composite Materials

A composite material is defined as a material composed of two or more materials combined on a macroscopic scale by mechanical and chemical bonds. Unique characteristic of many fiber reinforced composites is their high internal damping capacity.

B. Carbon Steel

It is steel construction material, a profile, formed with a specific shape or cross section and certain standards of chemical compositionand mechanical properties. Structural steel shape, size, composition, strength, storage, etc., is regulated in most industrialized countries.

Composition:

0.565%C, 1.8% Si, 0.7%Mn, 0.045%P and 0.045% S

C. Mass of Frame

The mass of an object is a fundamental property of the object, a numerical measure of its inertia, a fundamental measure of the amount of matter in the object.

Mathematical equation for mass is

Mass = Volume × Density

We know, Density of steel = 7850kg/m3

Volume of frame = 4.1×10-2m³

Total mass of frame = 7850 × 0.041

= 321.85 kg

D. Carbon Epoxy

Carbon-Fiber-Reinforced Polymer, Carbon-Fiber-Reinforced Plastic or Carbon-Fiber- Reinforced Thermo Plastic (CFRP, CRP, CFRTP or often simply carbon fiber, or even carbon) is an extremely strong and light Fiber-Reinforced Polymer which contains carbon fibers.

Composition:

Bisphenol-based epoxy 60-90%, Amine-based curing agent 1-30%,Imidazole-based curing catalyst 0.1-3% and Carbon Black 1-10%.

E. Mass of Frame

Mathematical equation for mass is

Mass = Volume × Density

We know Density of Carbon/Epoxy = 1600 kg/m^3

Volume of frame = $4.1\times10^{-2}m^3$

Total mass of frame = 1600 × 0.041 = 65.6 kg (Approx.)

F. E-glass/ Epoxy

An individual structural glass fiber is both stiff and strong in tension and compression that is, along its axis. Although it might be assumed that the fiber is weak in compression, it is actually only the long aspect ratio of

the fiber which makes it seem so i.e., because a typical fiber is long and narrow, it buckles easily. On theother hand, the glass fiber is weak in shear that is, across its axis.

Composition: 54% SiO2 - 15% Al2O3 - 12% CaO

G. Mass of frame

Mathematical equation for mass is

Mass = Volume × Density

We know Density of E-glass/Epoxy = 2600 kg/m^3

Volume of Frame = 4. $1\times10^{-2}m^3$

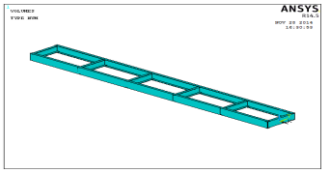
Total mass of Frame = 2600 × 0.041 = 106.6 kg

VI. STATIC AND MODAL ANALYSIS OF CHASSIS WITH C – SECTION

6.1 Carbon Steel

Static Analysis

Imported Model from Pro/Engineer



Element Type: solid 20 nodes 95

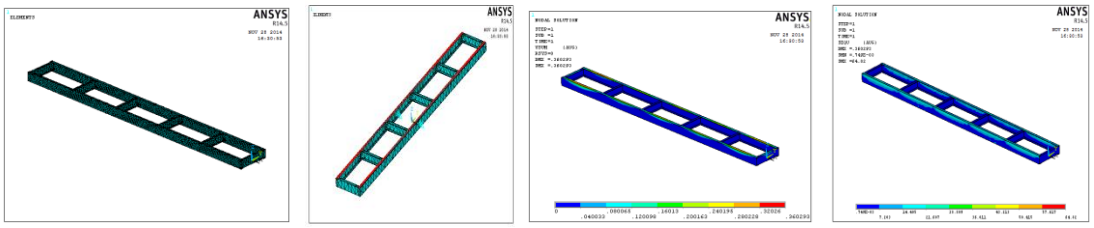
Material Properties :

Youngs Modulus (EX) : 205000N/mm^2

Poissons Ratio (PRXY) : 0.29

Density : 0.000007850 kg/mm^3

6.2 Meshed Model



Load

Pressure – 0.0907 N/mm^2

Solution

Solution – Solve – Current LS – ok

6.3 Carbon Epoxy

Static Analysis

Element Type **:** Solid 20 node 95

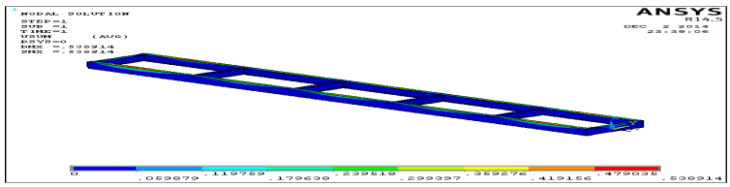
Material Properties **:** Youngs Modulus (EX) : 135000N/mm^2

Poissons Ratio (PRXY) : 0.3

Density : 0.0000016 kg/mm^3

Solution

Solution – Solve – Current LS – ok



E Glass Epoxy

Static Analysis

Element Type **:** solid 20 nodes 95

Material Properties **:** Youngs Modulus (EX) : 50000N/mm^2

Poissons Ratio (PRXY) : 0.3

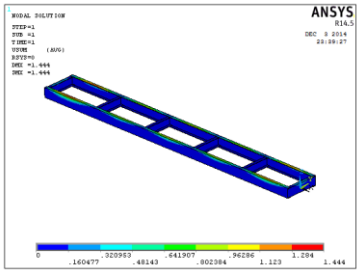
Density : 0.000002 kg/mm^3

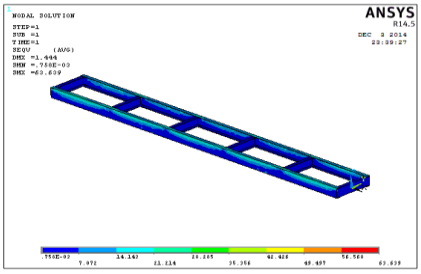
Solution

Solution – Solve – Current LS – ok

6.4 General Post Processor

Displacement Vector Sum





VII. RESULTS TABLE FOR C- SECTION

7.1 Static Analysis

	Carbon Steel	Carbon Epoxy	E Glass Epoxy
STRESS(N/mm^2)	64.82	63.631	63.639
DISPLACEMENT(mm)	0.360293	0.538914	1.444

STRAIN	$0.324e^{-3}$	$0.478e^{-3}$	0.00128

7.2 Modal Analysis

		Carbon Steel	Carbon Epoxy	E Glass Epoxy
Mode 1	Frequency (Hz)	4.711	8.515	4.652
	Displacement (mm)	0.196239	0.434159	0.388324
Mode 2	Frequency (Hz)	4.997	9.031	4.934
	Displacement (mm)	0.216162	0.478329	0.42783
Mode 3	Frequency (Hz)	5.148	9.306	5.084
	Displacement (mm)	0.211655	0.468338	0.418894

VIII. CONCLUSION

In this paper, I have designed a chassis used in heavy vehicles. Present used material for chassis is steel with C-Channel. I am replacing this material with composite materials Carbon Epoxy, E Glass Epoxy and S2 Glass Epoxy with Box Section. Since the density of composite materials is less than that of steel, the weight of chassis reduces using composite materials than steel. And also the strength of the composites is more than that of steel.

The weight of the chassis assembly by using steel is 321.85Kg, using Carbon Epoxy is 65.6, using E Glass Epoxy is 106 Kg.

Static and Modal analyses are done on the chassis for all the four materials. By observing the analysis results, the stress values are less than their respective permissible values. So using all three materials is safe under the given load condition.

When, I compare the results for all four materials, the stress value is less for Carbon Epoxy and also its weight is less compared with other three materials.

Finally, I can conclude that **Carbon Epoxy** is better for both models.

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