iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 11 Issue: VI Month of publication: June 2023

DOI: https://doi.org/10.22214/ijraset.2023.53792

www.ijraset.com

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 11 Issue VI Jun 2023- Available at www.ijraset.com

Analysis of Heavy Motor Vehicle Chassis Frame with Different Materials Equipped with CNG Cylinders of Composite Materials Using CAE Tools

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Abstract: The transport sector now has a significant impact on both the economies of developed and developing nations The frame, also known as the chassis, is the main part of the vehicle because it has the highest design stress. This is vehicle support as all components are only supported on the chassis. Using the chassis as a platform, the front and rear suspensions are connected without dropping.

At the same time, it can also be used for sudden stops, bumpy roads, and high-speed driving. It has sufficient rigidity to withstand impact, deflection, bending, vibration and shape deformation caused by causes. Scientific data obtained from various studies to date, weight, stress and strength, deformation, etc. have proven to be ideal for many factors. This can be done by changing the section and material of the chassis frame.

The material chosen for this project is AISI4130 for LPO 1613 CNG BS-IV OBDII Front Engine Bus for Delhi Integrated Intermodal Transport System (DIMTS). Create 3D models in CAE Solid-works and analyze them with ANSYS 19.2. Automotive composite CNG cylinders are the best combination of the latest technology using carbon fiber reinforced seamless aluminum inner liner.

Often found in airplanes, space shuttles, and bulletproof vests, this material is known for its durability; These special features and safety are due to its lightness and durability, beyond automobile with large CNG cylinders.

Keywords: Bus Chassis Frame, SOLIDWORKS, ANSYS 19.2, Stress Distribution, Total Deformation, CNG cylinder.

I. INTRODUCTION

The chassis is one of the key components in the automotive industry. The model is the largest of all auto and the auto is favourable on this frame.

It is also called the "backbone" of the automobile because all the important parts of the auto rest on it. The main role of the chassis is not only to support the equipment and load, including the engine, body, passengers and luggage, but also to maintain the suspension and steering link The more energy absorbed by the chassis during a crash, the lower the energy transferred to vehicle occupants and the surrounding environment, and the fewer injuries. Due to the bumpy road, the weather and the materials attached to it, the chassis is subject to stress, bending moments and vibrations.

When the car or bus moves along the road, the stress of the different chassis changes with all aspects of the automobile skeleton. The main challenge in the land vehicle industry today is to overcome the growing demand for higher performance, lighter weight and longer product life to meet fuel economy demands while delivering new safety in a short time at an affordable price. At the time, further revision analysis is highly needed for this chassis and there will be modal analysis, finite element analysis for torsion and bending.

A. Aim of Project

1) Literature review of various published academic studie
2) Select business items such as choosing business models and matching items
3) Draw chassis frame in CAD model software (Creo Parametric)
4) Examine and compare statistical data for two types of dat
5) Improve platform design for efficiency and productivity.
6) Design a chassis frame with different sections to increase strength, rigidity and weight.

II. LITERATURE REVIEW

[1] Mr. Rahul L. Patel, Mr. Divyesh B. Morabiya and Mr. Anil N. Rathour, "Design and analysis of ladder frame chassis considering support at contact region of leaf spring and chassis frame(2015)" Investigated and optimized a chassis design for Weight reduction of TATA 2516TC chassis frame using Pro- Mechanics. Thy first find out the assembly weight, maximum stress, strain and displacement for the existing section of chassis by using ANSYS Software after then they modified the dimensions of existing C-sections and again, find all and concluded that the existing "C" sections is better than all the sections with respect to the Stress, Displacement, Strain and Shear stress except the weight. For the weight consideration modified "C" section has less weight than the all sections which are studying in this paper. [2] Bhat KA, Untawale SP, Katore HV, "Failure Analysis And optimization of Tractor Trolley Chassis: An Approach Using Finite Element Analysis (2014)" Redesigned the chassis for tractor trolley. The existing trolley chassis uses "C" cross section and material used is mild steel. The total capacity of the trolley is 60KN but the self-weight of trolley and other accessories is 13 KN. Redesign is done by changing cross section from "C" to "I" by without change in material and dimension. The change in cross section resulted in more safer stresses than previous cross section and 31.79kg reduction in weight, so cost of chassis ultimately reduced. [3] Ketan Gajanan Nalawade, Ashish Sabu and Baskar P," Dynamic (Vibrational) and Static Structural Analysis of Ladder Frame (2014)" Did the static structural analysis and modal analysis of a TATA 407 truck chassis. Modelling is done in CATIA and finite element analysis is done using ANSYS workbench. After carrying out the analysis on the ladder frame with structural steel and E-Glass composite the results are obtained that maximum shear stress and equivalent stress generated in E-glass is under acceptable limit and total deformation is also within the limit. It also shows that for the same load carrying capacity E- glass is more suitable than steel and thereby able to reduce the weight by 60-68%and increase in stiffness. [4] Sandip Godse and D.A.Patel ," Static Load Analysis Of Tata Ace Ex Chassis and Stress Optimisation Using Reinforcement Technique (2013)", Presents the paper on static load analysis of the chassis of TATA ace ex using ANSYS workbench and stress optimization using reinforcement technique of optimization. This has been carried out with limited modifications by adding stiffeners. They analysed the existing chassis by the finite element analysis, the stress levels are found to be 37.04 N/mm 2. After modifications, the chassis with suitable reinforcement, increase in thickness, addition of stiffeners, the finite element analysis was carried out, and the stress levels of chassis are found as 22.97 N/mm2 which demonstrates that the modified chassis is capable to carry the loads beyond the previous payload. [5] K Chinnaraj, M Sathya Prasad, and C Lakshmana Rao, Experimental Analysis and Quasi-Static Numerical Idealization of Dynamic Stresses on a Heavy Truck Chassis Frame Assembly (2013)", Explained current trend in automotive design to optimize components for weight reduction. To achieve this, the chassis frame body of a heavy truck used for long distance goods hauling application was chosen for investigation. Aquatic-static access that approximates the dynamic manoeuvres into a number of small processes having static equilibriums was followed to bear out the numerical simulation, approximating the dynamic behaviour of frame assembly. With the help of economical finite element package ANSYS, the quasi-static numerical simulations were carried out and compared with experimental results.

A. Methodology/Procedure Planned to Be Implemented

We are contented to consider the LPO 1613 CNG BS-IV OBDII front engine bus for Delhi Integrated Intermodal Transport System (DIMTS). Exclusive to this bus is the 5.7 SGI CNG NA engine with rail and fuel injection for low emissions according to BS IV OBDII.

In this study, the chassis size of TATA LPO 1613 was used to analyse the design of a heavy-duty vehicle chassis considering two different products, since metal structures are a frequently used material for vehicle chassis structures steel. The structures steel is easy to obtain and the machines that control them are also simple. Second, we chose AISI4130 alloy, which has excellent atmospheric corrosion resistance and reasonable durability.

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III. COMPOSITE CNG CYLINDERS

Composite CNG (Compressed Natural Gas) Cylinders are becoming increasingly popular in the automotive industry due to their lightweight, high-strength, and low-cost features. These cylinders are mainly used for storing and transporting CNG in vehicles, which provides a cleaner and more efficient fuel source than traditional gasoline. Automotive composite CNG cylinders are a perfect integration of the innovative technologies, using Seamless Aluminium Liners reinforced with carbon fiber. A material known for its durability commonly found in planes, space shuttles, and bullet proof vests; theses distinctive features and safety owe to its lightweight and strength, which exceeds that of normal automotive CNG cylinder.

Comparison Table

Type	Pressure	Capacity	Weight	Average Speed	Mileage Performance
Steel	200	100	110	100-120	220
Composite	200	100	33	100-120	250

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A. *Types Of Chassis Frames Are*

1) Ladder Frame Chassis.
2) Backbone Chassis.
3) Monocoque Chassis.
4) Tubular Chassis.

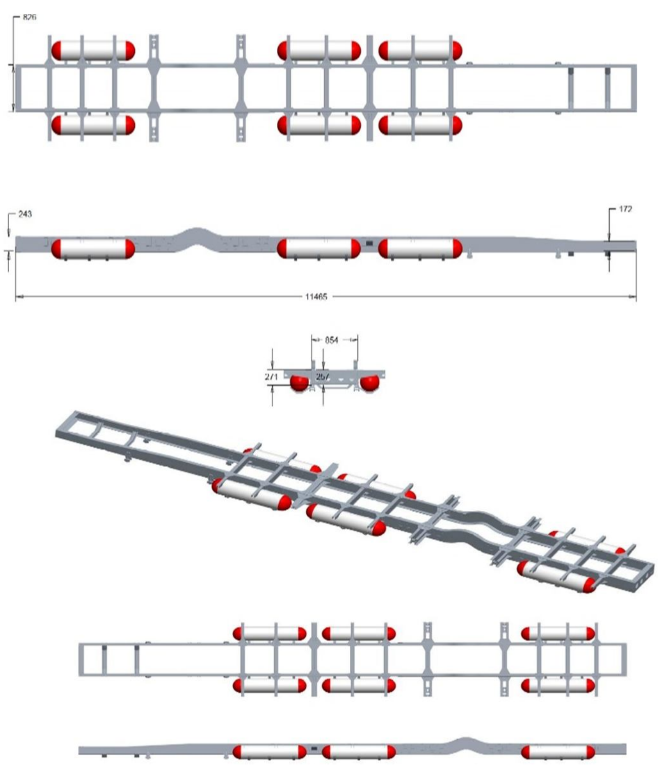
B. *Chassis Frame Material*

1) Structural Steel Currently the material used for the chassis (TATA LPO 1613) is as per IS standard is structural steel with St 37. Structural steel in simple words with the varying chemical composition leading to changes in names. The typical chemical composition of the material is: 0.565%C, 1.8% Si, 0.7%Mn, 0.045%P and 0.045%S.
2) 4130 STEEL is a chromium-molybdenum alloy steel and is considered a low carbon steel. It has a density of 7.85 g/cm3 (0.284 lb/in3) and benefits from heat-treatment hardening. It is an exceptional welding steel, being wieldable in all commercial methods, and is readily machined in its normalized/tempered condition. The typical chemical composition of the material is: 0.28 - 0.33% Carbon, 0.8 - 1.1% Chromium, 0.7 - 0.9% Manganese, 0.15 - 0.25% Molybdenum, ≤ 0.035% Phosphorus, 0.15 - 0.35%, Silicon, ≤ 0.04% Sulphur.

C. *Mechanical Properties*

Mechanical Properties	ST37	AISI 4130
Density	7850 kg/m3	7850 kg/m3
Modulus of Elasticity	210 GPa	205 GPa
Ultimate Tensile Strength	460 MPa	670 MPa
Tensile Yield Strength	260 MPa	435 MPa
Poisson Ratio	0.29	0.27 – 0.30

D. *Creo Parametric Modelling*



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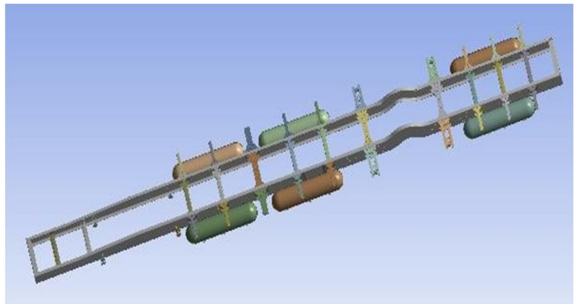
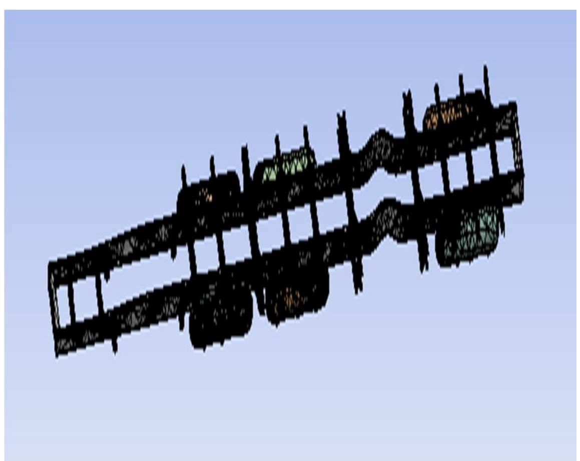
E. Static Structural



Object Name	Geometry
State	Fully Defined
Bounding Box	
Length X	11465 mm
Length Y	580.09 mm
Length Z	1871.1 mm
Properties	
Volume	1.6978e+008 mm^3
Mass	1332.8 kg
Scale Factor Value	1.
Statistics	
Connections	116
Active Connections	116

F. Meshing



Object Name	Mesh
State	Solved
Nodes	509713
Elements	254399

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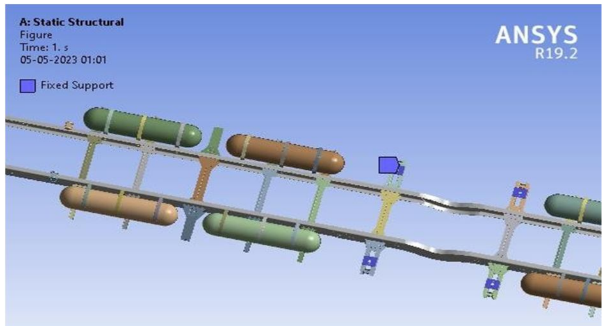
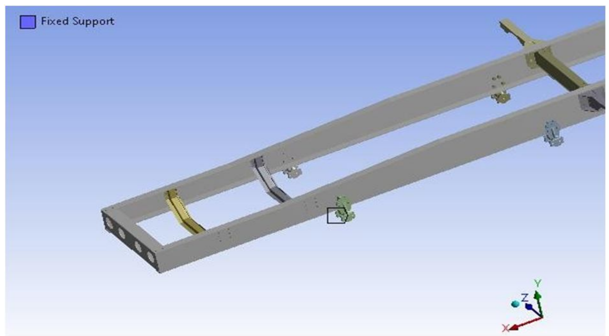
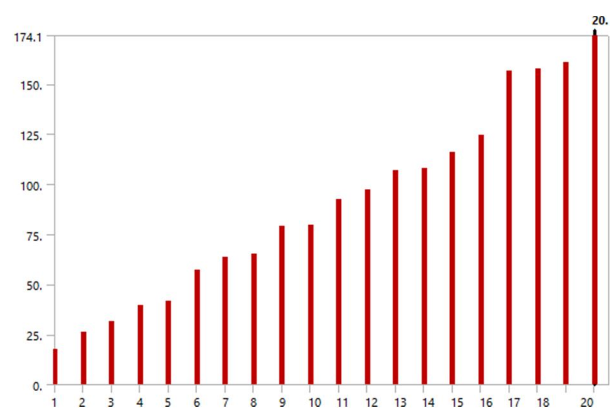
1) *Fixed Support I*



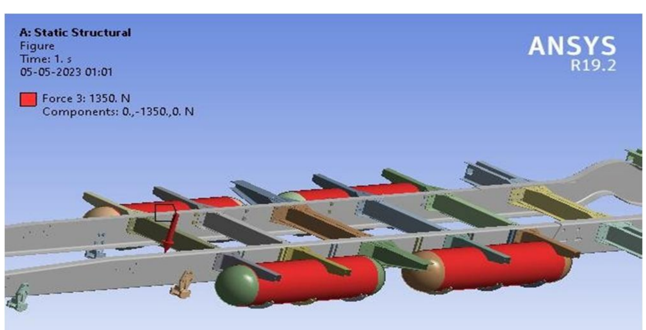
2) *Fixed Support II*



G. *Bar Chart Indicating Frequency At Each Calculated Mode*



1) *Applied Force I*



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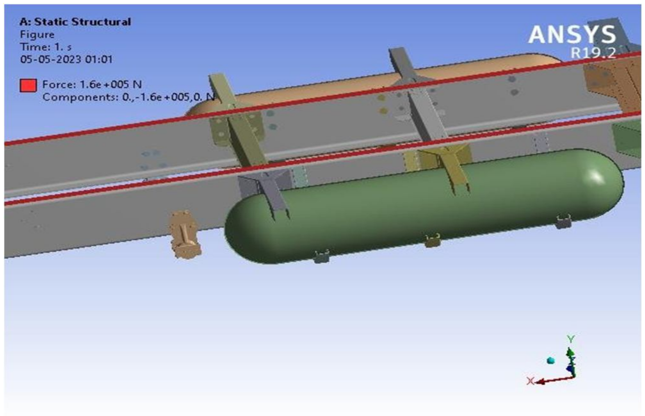
2) Applied Force II

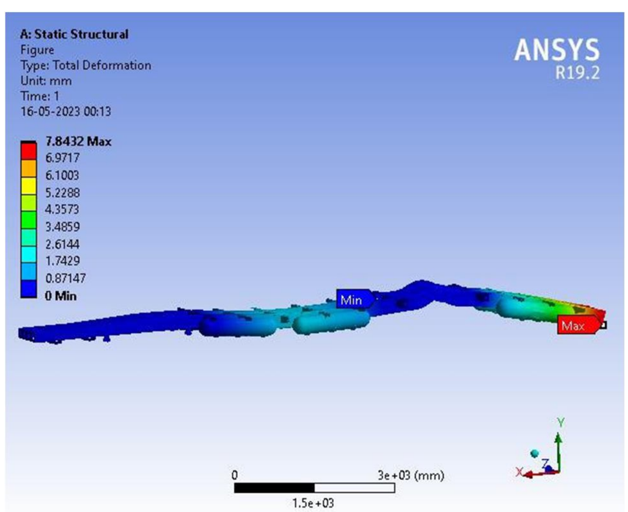


H. Total Deformation

Frequency To Be Applied

Mode	Frequency [Hz]	Mode	Frequency [Hz]
1	17.5	11	97.12
2	25.922	12	106.76
3	31.543	13	108
4	39.617	14	115.79
5	41.88	15	124.58
6	57.087	16	79.764
7	63.449	17	156.35
8	65.072	18	157.73
9	79.764	19	160.51
10	92.462	20	174.1

I. Equivalent Stress



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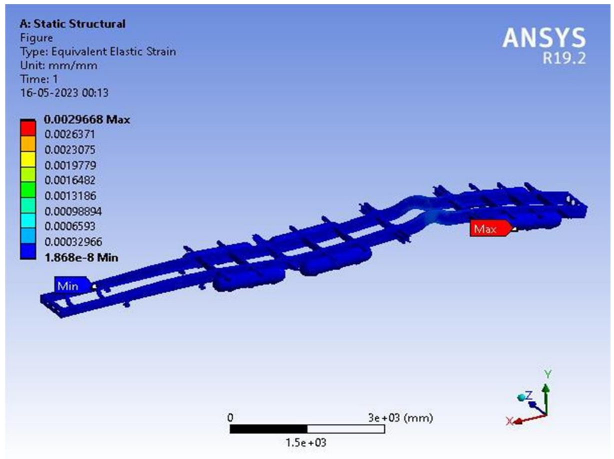
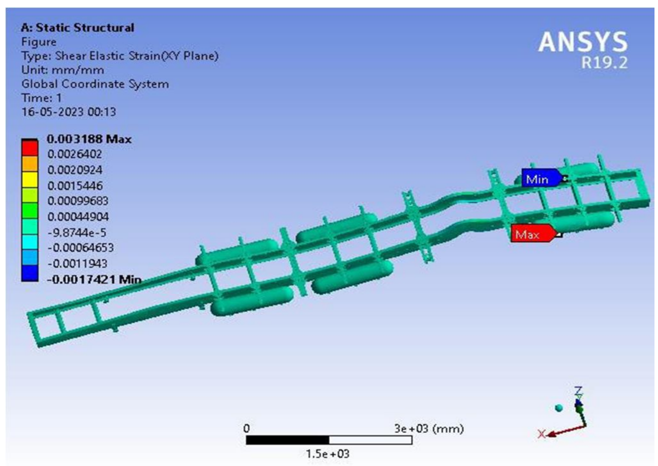
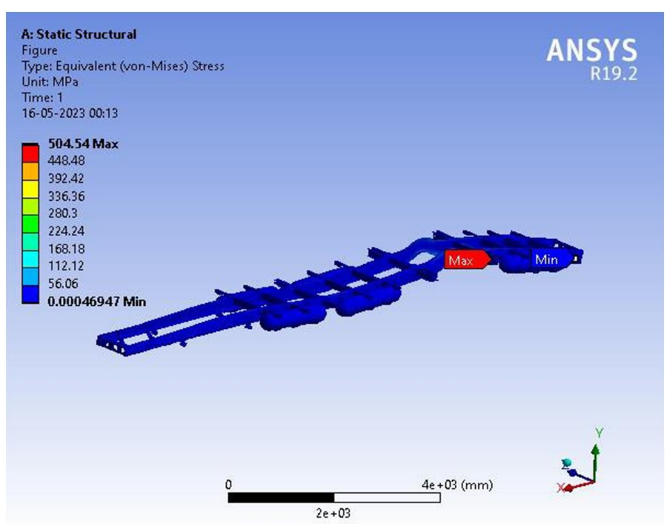
J. Equivalent Elastic Strain



K. Static Structural > Solution > Shear Elastic Strain





IV. RESULT

A. Structural Steel Static Analysis Results

Type	Total Deformation	Equivalent (von-Mises) Stress	Maximum Principal Stress	Equivalent Elastic Strain	Maximum Principal Elastic Strain	Shear Stress	Shear Elastic Strain
Results							
Minimum	0. mm	1.7522e-004 MPa	-86.736 MPa	8.4719e-009 mm/mm	-2.8142e-005 mm/mm	-119.59 MPa	-1.5546e-003 mm/mm
Maximum	6.9925 mm	684.79 MPa	656.72 MPa	4.233e-003 mm/mm	2.686e-003 mm/mm	348.25 MPa	4.5272e-003 mm/mm
Average	1.2053 mm	9.9729 MPa	5.4816 MPa	6.4541e-005 mm/mm	3.5597e-005 mm/mm	0.33026 MPa	4.2934e-006 mm/mm

B. Structural Steel Modal Analysis Results

Object Name	Total Deformation										
	1	2	3	4	5	6	7	8	9	10	11
Results											
Minimum	0. mm										
Maximum	7.2238 mm	3.9837 mm	2.7781 mm	6.961 mm	5.3751 mm	3.4707 mm	6.301 mm	5.793 mm	3.1127 mm	2.9846 mm	3.4087 mm
Average	0.58638 mm	0.5201 mm	0.61643 mm	0.61348 mm	0.26458 mm	0.77445 mm	0.26846 mm	0.68138 mm	0.86682 mm	0.86094 mm	0.59439 mm
Frequency	17.301 Hz	25.621 Hz	31.177 Hz	39.19 Hz	41.39 Hz	56.405 Hz	62.673 Hz	64.316 Hz	77.916 Hz	78.83 Hz	91.391 Hz

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Object Name	Total Deformation									Equivalent Stress	
	12	13	14	15	16	17	18	19	20	1	2
Results											
Minimum	0. mm									8.0583e-006 MPa	1.561e-003 MPa
Maximum	7.2238 mm	6.584 mm	6.1057 mm	3.119 mm	3.2614 mm	3.4716 mm	4.9875 mm	3.8786 mm	7.2262 mm	59.884 MPa	356.4 MPa
Average	0.29098 mm	0.15436 mm	0.35321 mm	0.71501 mm	0.86563 mm	0.89871 mm	0.70799 mm	0.85503 mm	0.85138 mm	1.5345 MPa	25.405 MPa
Frequency	96.066 Hz	105.6 Hz	106.83 Hz	114.47 Hz	123.06 Hz	154.41 Hz	155.85 Hz	158.57 Hz	172.02 Hz	17.301 Hz	172.02 Hz

C. *4130 Static Structural Analysis Results*

Object Name	Total Deformation	Equivalent Stress	Maximum Principal Stress	Equivalent Elastic Strain	Maximum Principal Elastic Strain	Shear Stress	Shear Elastic Strain
Results							
Minimum	0. mm	4.6947e-004 MPa	-68.519 MPa	1.868e-008 mm/mm	-1.3605e-005 mm/mm	-138.96 MPa	-1.7421e-003 mm/mm
Maximum	7.8432 mm	504.54 MPa	406.56 MPa	2.9668e-003 mm/mm	1.7321e-003 mm/mm	254.29 MPa	3.188e-003 mm/mm
Average	1.2925 mm	9.6697 MPa	5.3755 MPa	6.1933e-005 mm/mm	3.4296e-005 mm/mm	0.32143 MPa	4.0854e-006 mm/mm

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D. 4130 Modal Analysis Results

Object Name	Total Deformation										
	1	2	3	4	5	6	7	8	9	10	11
Results											
Minimum	0. mm										
Maximum	4.727 mm	3.9857 mm	2.7779 mm	6.967 mm	5.3754 mm	3.4832 mm	6.301 mm	5.7969 mm	3.0394 mm	3.0573 mm	3.4081 mm
Average	0.58622 mm	0.52011 mm	0.61641 mm	0.61258 mm	0.26446 mm	0.77394 mm	0.2683 mm	0.68023 mm	0.86727 mm	0.85981 mm	0.59453 mm
Frequency	17.5 Hz	25.922 Hz	31.543 Hz	39.617 Hz	41.88 Hz	57.087 Hz	63.449 Hz	65.072 Hz	78.839 Hz	79.764 Hz	92.462 Hz

Object Name	Total Deformation									Equivalent Stress	
	12	13	14	15	16	17	18	19	20	1	2
Results											
Minimum	0. mm									7.0066e-006 MPa	1.5744e-003 MPa
Maximum	7.2322 mm	6.5881 mm	6.1242 mm	3.1213 mm	3.2641 mm	3.4602 mm	4.9465 mm	3.9406 mm	7.2358 mm	61.692 MPa	372.47 MPa
Average	0.29063 mm	0.15427 mm	0.34899 mm	0.715 mm	0.86532 mm	0.8993 mm	0.72053 mm	0.85412 mm	0.85105 mm	1.574 MPa	26.07 MPa
Frequency	97.12 Hz	106.76 Hz	108. Hz	115.79 Hz	124.58 Hz	156.35 Hz	157.73 Hz	160.51 Hz	174.1 Hz	17.5 Hz	174.1 Hz

V. OUTCOME FROM LITERATURE REVIEW

1) The literature review highlights the importance of using CAE tools to design and analyze multi-section heavy vehicle chassis frames.
2) CAE tools such as ANSYS, FEA, and CATIA have proven useful in designing models that reduce weight while maintaining strength and rigidity.
3) Analysis has also shown that the use of low alloy steel and a right angle spherical ring provides the best combination of strength and rigidity.

4) Composite compressed natural gas cylinders have many advantages over metal cylinders, including lighter weight and improved safety.
5) However, the design and production process must be carefully controlled in terms of quality and safety.
6) More research is needed to evaluate the durability and reliability of mixed CNG cylinders for automotive use.

VI. CONCLUSION

1) The chassis model was modeled in Solidworks and then analyzed in Ansys for the same and different loads.
2) After analysis a comparison made between C, I, and Unsymmetrical-C on the bases of its new materials also in terms of stress and deformation to find out the better chassis.
3) Concluding that by using FEM software we can optimize the weight of the chassis frame and it is possible to analyze modified chassis frame before manufacturing.
4) The maximum shear stress, maximum equivalent stress and displacement are reduced and yield strength of chassis material is so large and if we consider results and yield strength
5) Making recommendations for future research and development in the field of composite CNG cylinders, including areas for improvement in terms of safety, durability, and cost-effectiveness

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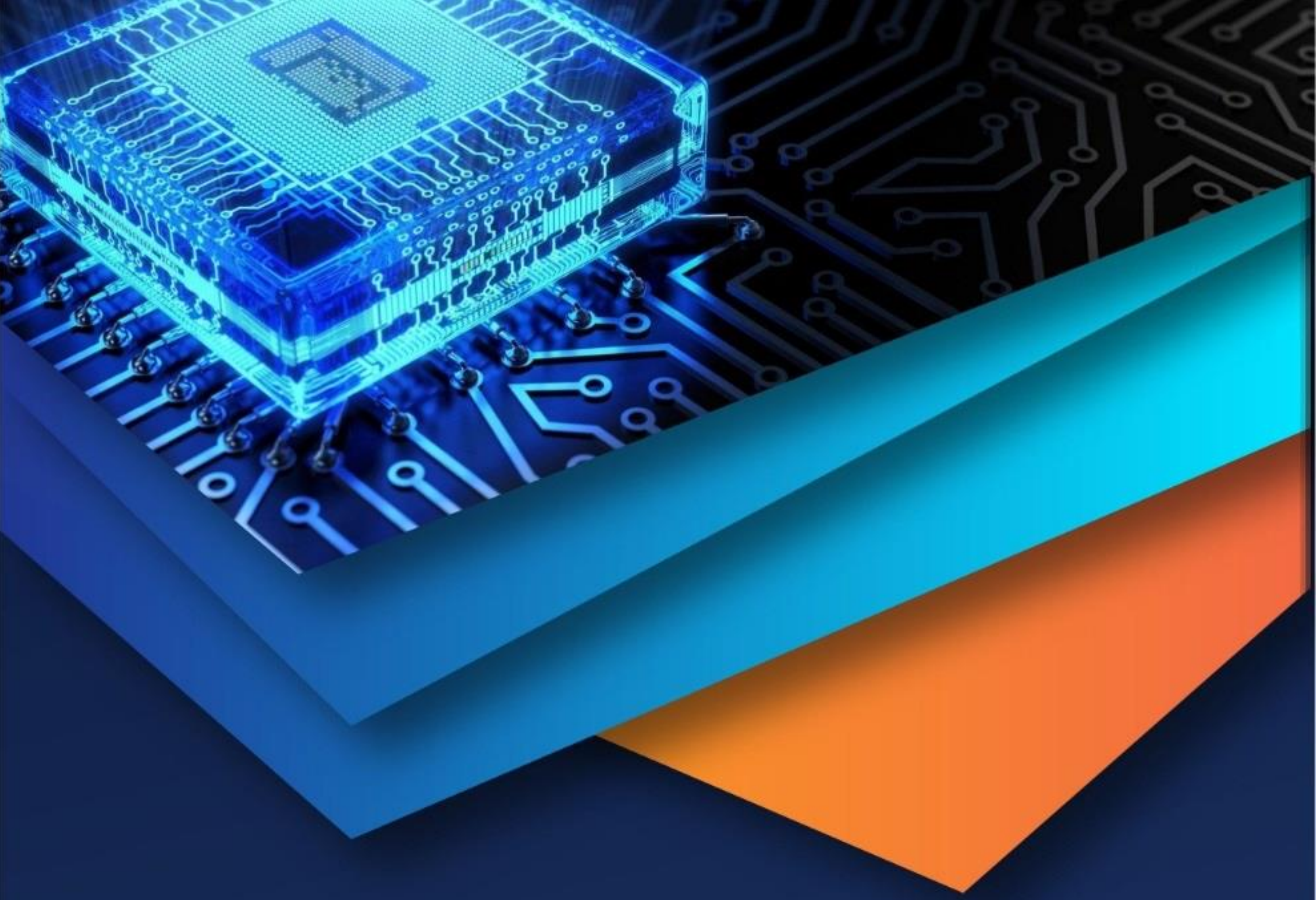

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