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Design and Analysis of Automobile Frame

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Abstract: Chassis or frame is a major component in a vehicle. In chassis different type of failures are occur due to static and dynamic loading condition. In this present work static and dynamic load characteristics are analyzed using FE models from this work. It is found that identifying location of high stress area, analyzing vibration, natural frequency and mode shape by using finite element method. Modal updating of automobile chassis model will be done by adjusting the selective properties such as mass density and Poisson's ratio. Predicted natural frequency and mode shape will be finding by using ansys software. The cad geometry of chassis is generated in solid works and model and static analysis is done in ansys workbench.

Keywords: Chassis, Frame, Vehicle, Dynamic, FE, Modal.

I. INTRODUCTION

A vehicle frame, also known as its chassis, is the main supporting structure of a motor vehicle to which all other components are attached, comparable to the skeleton of an organism. Until the 1930s, virtually every (motor) vehicle had a structural frame, separate from the car's body. This construction design is known as body-on-frame.

A. Chassis Frame and Body

Introduction of Chassis Frame: Chassis is a French term and was initially used to denote the frame parts or Basic Structure of the vehicle. It is the back bone of the vehicle. A vehicle without body is called Chassis. The components of the vehicle like Power plant, Transmission System, Axles, Wheels and Tires, Suspension, Controlling Systems like Braking, Steering etc., and also electrical system parts are mounted on the Chassis frame. It is the main mounting for all the components including the body. So it is also called as Carrying Unit.

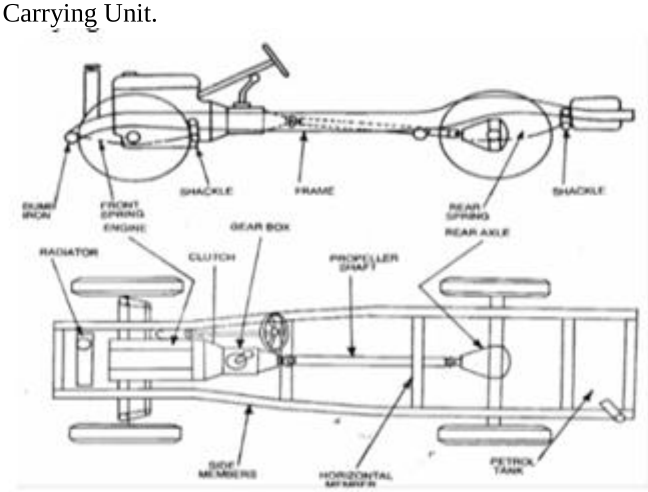


Fig.1. Chassis Frame and Body

B. Functions of the Chassis Frame

- To carry load of the passengers or goods carried in the body.
- To support the load of the body, engine, gear box etc.,
- To withstand the forces caused due to the sudden braking or acceleration
- To withstand the stresses caused due to the bad road condition.
- To withstand centrifugal force while cornering

C. Types of Chassis Frames

There are three types of frames

- Conventional frame
- Integral frame
- Semi-integral frame

II. LITERATURE SURVEY

Kenji KARITA, Yoichiro KOHIYAMA, Toshihiko KOBIKI, Kiyoshi OOSHIMA, Mamoru HASHIMOTO (2003) had developed a chassis made by Aluminium. The material selected for the frame is 6061-T6. They used the Variable section extrusion method for making the chassis. It's developed with the help of computer Aided Engineering. Aluminium material gives an advantage of weight reduction. From this study authors found that the Aluminium chassis meets the target of weight reduction, strength and rigidity. Also they concluded that the remaining technical issues will be addressed to enable commercial adoption of the aluminum frame. Alireza Arab Solghar, Zeinab Arsalanloo (2013) studied and analyzed the chassis of Hyundai Cruz Minibus. ABAQUS Software was used for modeling and simulation. Self weight of the chassis is considered for static analysis and Acceleration, Braking and Road Roughness were considered for dynamic analysis. It's observed that the stresses on chassis caused by braking were more compared with acceleration.

A. Functions

The main functions of a frame in motor vehicles are:

1. To support the vehicle's mechanical components and body
2. To deal with static and dynamic loads, without undue deflection or distortion.

These include:

- Weight of the body, passengers, and cargo loads.
- Vertical and torsional twisting transmitted by going over uneven surfaces.
- Transverse lateral forces caused by road conditions, side wind, and steering the vehicle.
- Torque from the engine and transmission.
- Longitudinal tensile forces from starting and acceleration, as well as compression from braking.
- Sudden impacts from collisions.

III. CONSTRUCTION

A. Frame Rails

Pickup truck frame: Notice hat-shaped cross member in the background, c-shape rails and cross member in center, and a slight arc over the axle. Typically the material used to construct vehicle chassis and frames is carbon steel; or aluminum alloys to achieve a more light weight construction. In the case of a separate chassis, the frame is made up of structural elements called the *rails* or beams. These are ordinarily made of steel *channel* sections, made by folding, rolling or pressing steel plate. There are three main designs for these. If the material is folded twice, an open-ended cross-section, either C-shaped or hat-shaped (U-shaped) results. "Boxed" frames contain chassis rails that are closed, either by somehow welding them up, or by using pre-manufactured metal tubing

B. C-Shape

By far the most common, the C-channel rail has been used on nearly every type of vehicle at one time or another. It is made by taking a flat piece of steel (usually ranging in thickness from 1/8" to 3/16") and rolling both sides over to form a c-shaped beam running the length of the vehicle.

C. Design Features

While appearing at first glance as a simple hunk of metal, frames encounter great amounts of stress and are built accordingly. The first issue addressed is beam height, or the height of the vertical side of a frame. The taller the frame, the better it is able to resist vertical flex when force is applied to the top of the frame. This is the reason semi-trucks have taller frame rails than other vehicles instead of just being thicker.

D. Frame Types

1. Ladder Frame

So named for its resemblance to a ladder, the ladder frame is one of the simplest and oldest of all designs. It consists of two symmetrical beams, rails, or channels running the length of the vehicle, and several transverse cross-members connecting them. Originally seen on almost all vehicles, the ladder frame was gradually phased out on cars in favor of perimeter frames and unitized body construction. It is now seen mainly on trucks.

Fig.2. A Bare Ladder Frame

2. Unibody

The term **unibody** or **unit-body** is short for **unitized body**, or alternatively unitary construction design. In this approach the vehicle's frame and body are integrated into a single strong structure. Integral frame and body construction requires more than simply welding an unstressed body to a conventional frame. In a fully integrated body structure, the entire car is a load-carrying unit that handles all the loads experienced by the vehicle — forces from driving as well as cargo loads. Integral-type bodies for wheeled vehicles are typically manufactured by welding preformed metal panels and other components together, by forming or casting whole sections as one piece, or by a combination of these techniques. Although this is sometimes also referred to as a monocoque structure, because the car's outer skin and panels are made load-bearing there are also still ribs, bulkheads and box sections to reinforce the body, making the description semi-monocoque more appropriate.

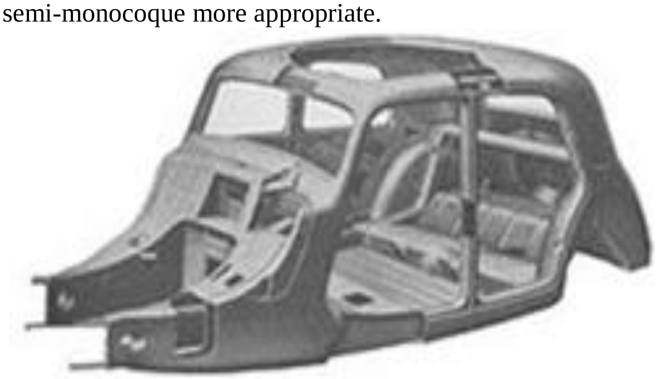


Fig.3. Citroen Traction Avant Body-Chassis Unit(1935)

E. Advantages and Disadvantages

1. Advantages

- Easier to design, build and modify (less of an issue now that computer-assisted design (CAD) is commonplace, but still an advantage for coach-built vehicles).

- Quieter, because the stresses do not pass into the body, which is isolated from the frame with rubber pads around the attachment bolts. This is less significant now, but historically bodies would squeak and rattle more as they rusted, lubricants drained, and fasteners loosened. Isolated bodies were affected to a lesser degree by these modes of aging.
- Easier to repair after accidents. This is crucial for taxicabs, because damaged bolt-on fenders can be replaced in the firm's own garage for petty cash, with the cab returned to earning status immediately, whereas a unibody body would require straightening by paid specialists on a machine expensive to rent — with the cab laid up for repair longer. Grand-Am allows tubular space frame cars to replace their unibody counterparts, as the cars can easily be repaired with new clips.
- Can allow a manufacturer to easily subcontract portions of work, e.g. as when Austin subcontracted the aluminum body work of the Austin A40 Sports to Jensen Motors.
- Can allow more torsional flexing before yielding (trucks, truck-base SUVs off roading) [5]

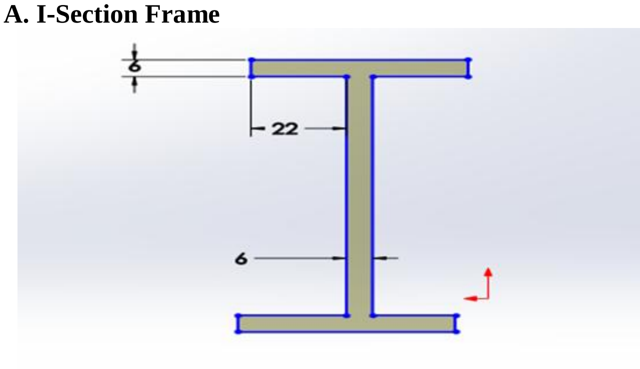
2. Disadvantages

- Heavier than unibody, causing lower performance and/or higher fuel consumption. Though reconstruction of a chassis in a metal like titanium can ensure a more lightweight material.
- Far less resistant to torsional flexing (flexing of the whole car in corners), compromising handling and road grip.
- Lack of a crumple zone causes higher rate of death and serious injury. Some cars have adopted a "front clip" and "rear clip" format similar to what is used in NASCAR where the car is split into three sections, and the clips absorb the impact, allowing the "clip" to be replaced when repairing the car.[7]

IV. INTRODUCTION TO SOLID WORKS

Solid works mechanical design automation software is a feature-based, parametric solid modeling design tool which advantage of the easy to learn windows ™ graphical user interface. We can create fully associate 3-D solid models with or without while utilizing automatic or user defined relations to capture design intent.

A. I-Section Frame



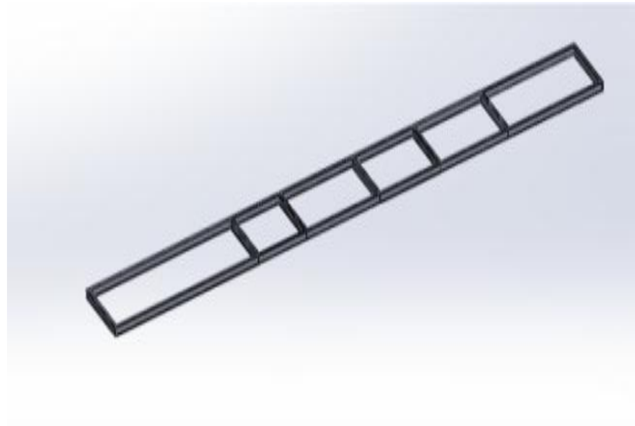


Fig.4. I Section Model.

B. C-Section Frame

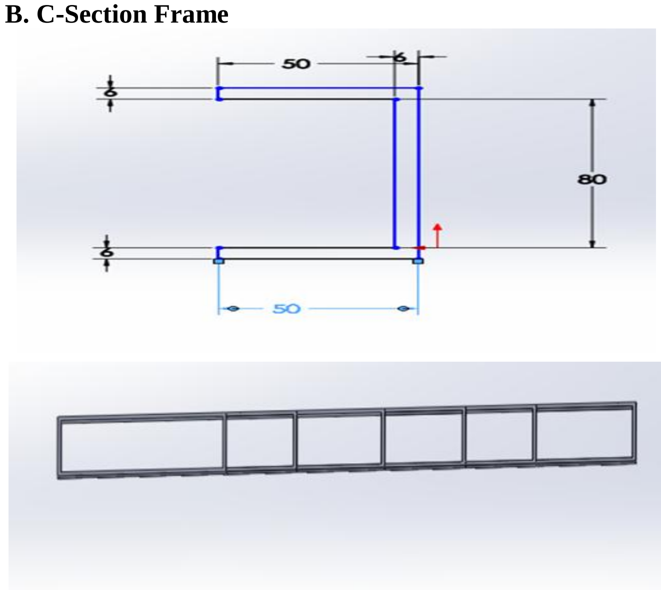


Fig.5. C- Section Model

C. Box Type Frame

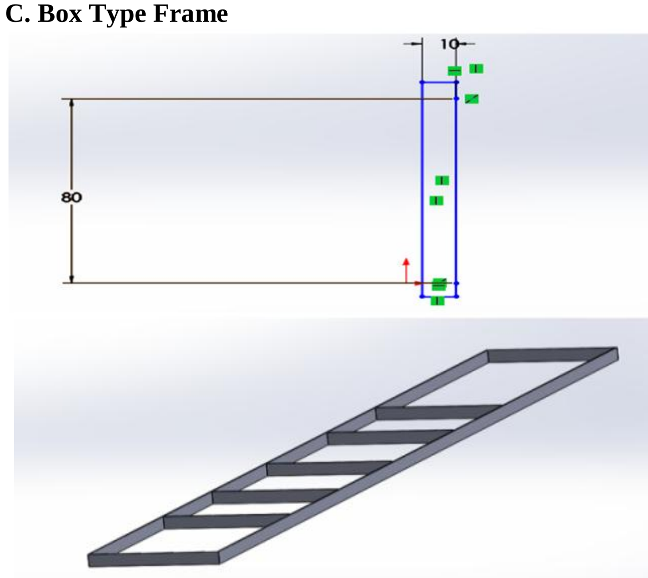


Fig.6.

V. INTRODUCTION TO MODAL ANALYSIS

Modal analysis is the study of the dynamic properties of structures under vibration excitation. Modal analysis is the field of measuring and analyzing the dynamic response of structures and or fluids during excitation. Examples would include measuring the vibration of a car's body when it is attached to an electromagnetic shaker, or the noise pattern in a room when excited by a loudspeaker.

VI. MODAL ANALYSIS

A. Model Analysis on I Sec Automobile Chassis

1. Material: alloy steel

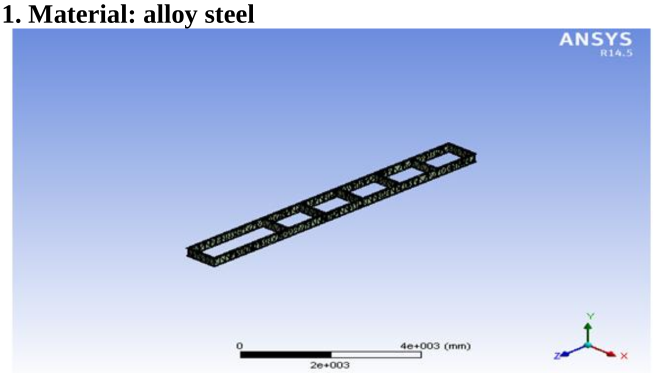


Fig.7. Meshing

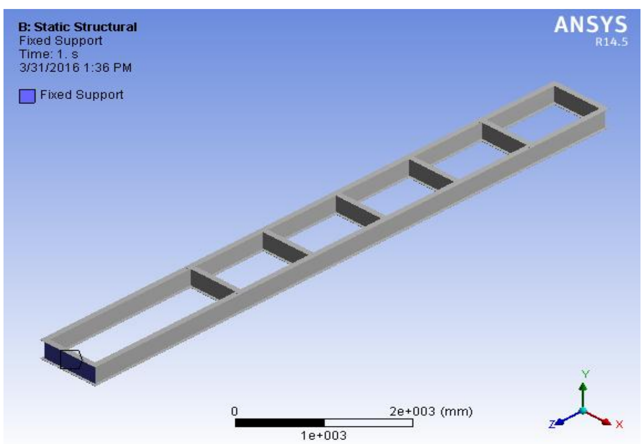


Fig.8. Fixed at Both Ends

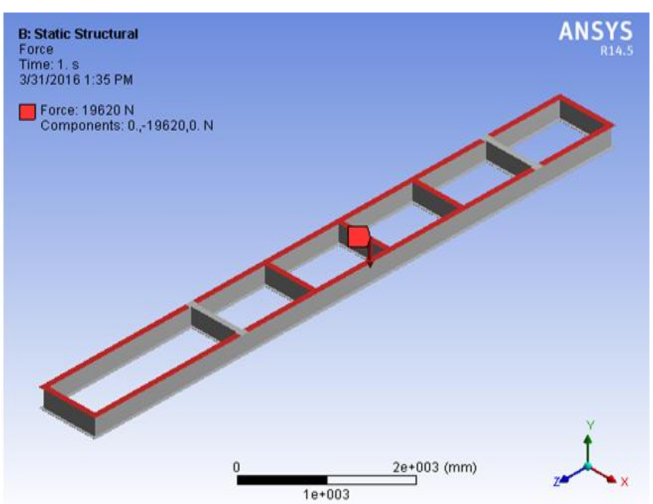


Fig.9. Load: 19620N

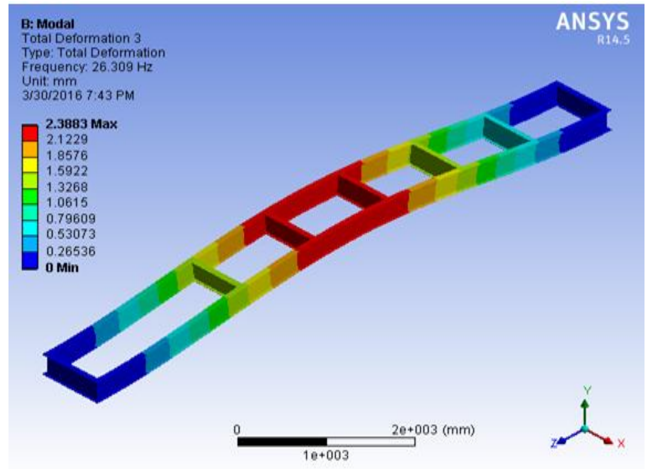


Fig.10. Mode Shape 1

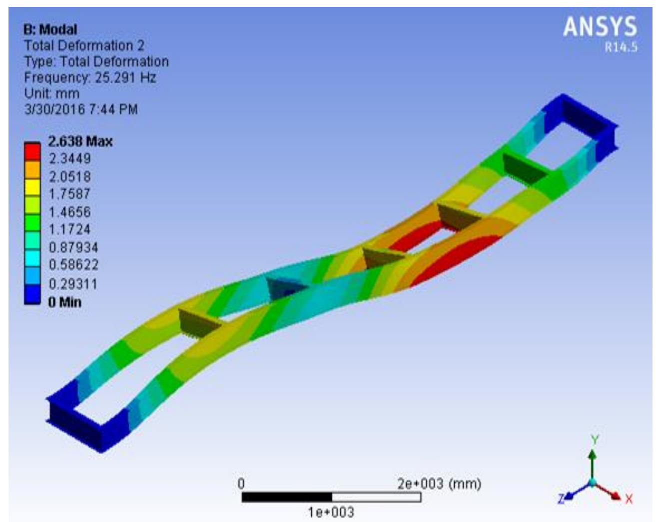


Fig.11. Mode Shape 2.

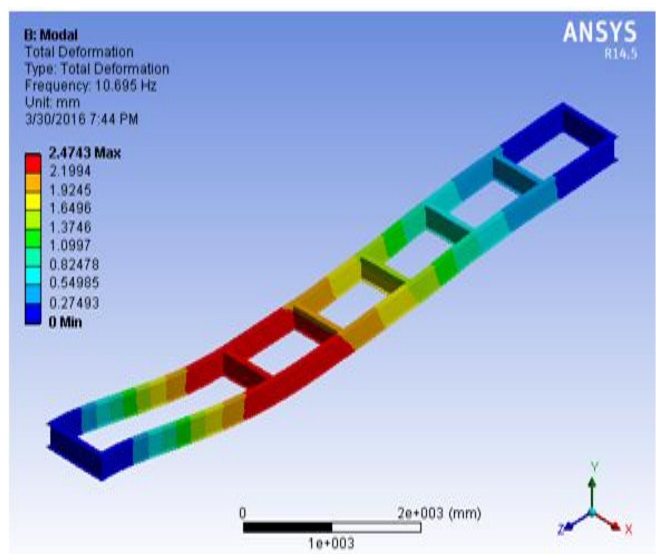


Fig.12. Mode Shape 3

Same procedure is followed for the another material i,e Aluminum Alloy

B. Modal Analysis on C Section Automobile Chassis

1. Material: Alloy Steel

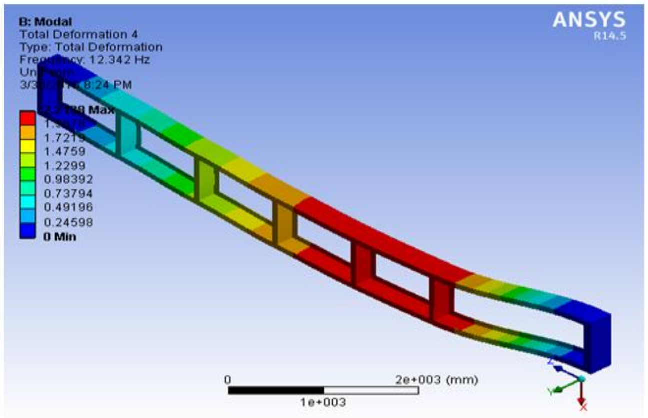


Fig.13. Mode Shape 1

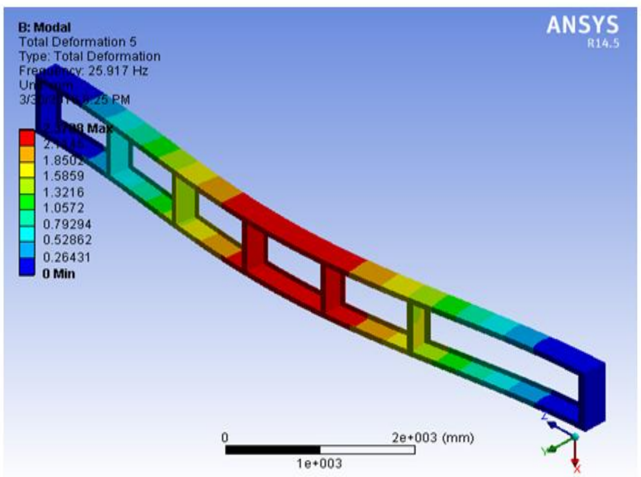


Fig.14. Mode Shape 2

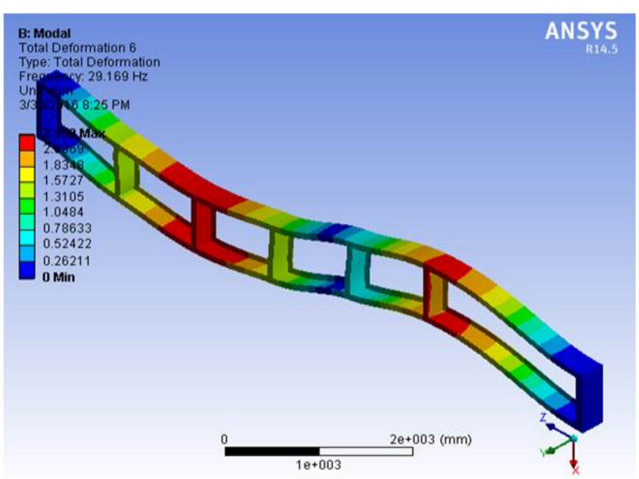


Fig.15. Mode Shape 3

Same procedure is followed for the another material i,e Aluminum Alloy

C. Modal Analysis on Box Section of Automobile Chassis

1. Material: alloy steel

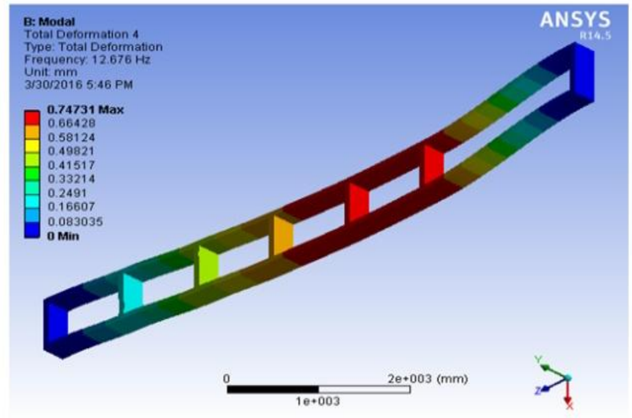


Fig.16. Mode Shape 1

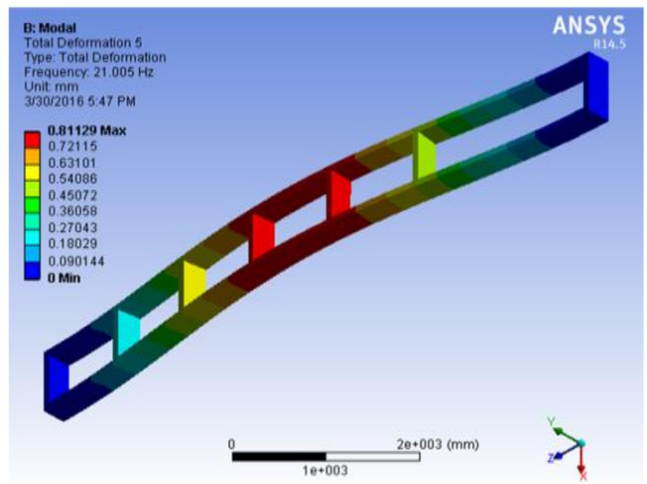


Fig.17. Mode Shape 2

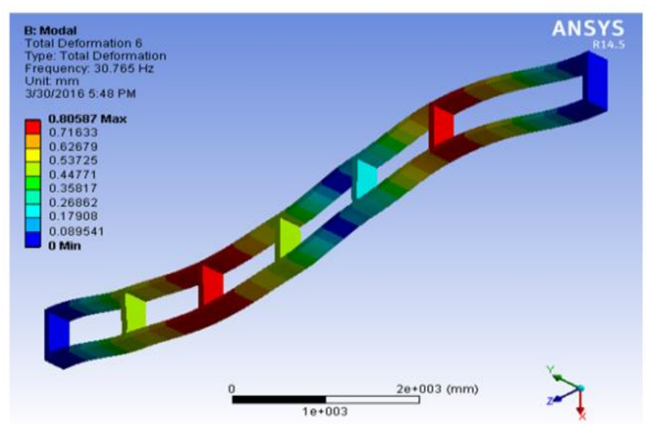


Fig.18. Mode Shape 3

Same procedure is followed for the another material i,e Aluminum Alloy

VII. STATIC ANALYSIS

A. Static Analysis on I Sec Automobile Chassis

1. Material: Alloy steel

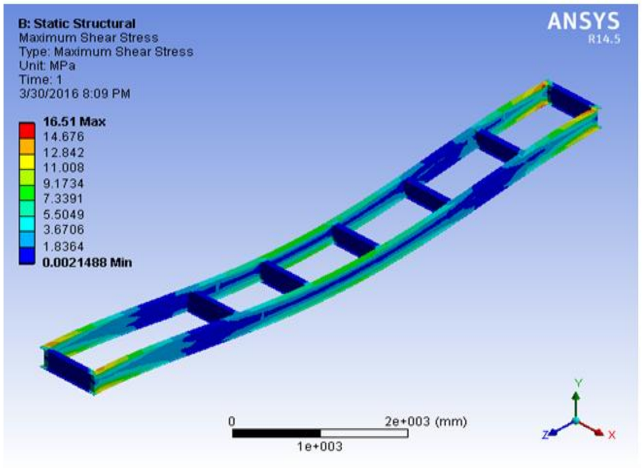


Fig.19. Maximum Stress

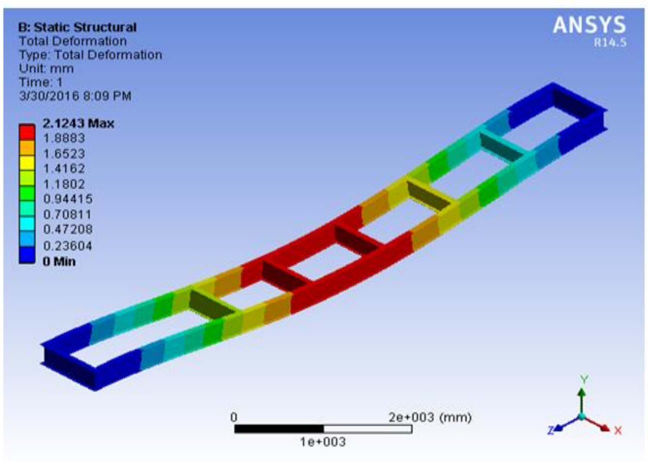


Fig.20. Deformation

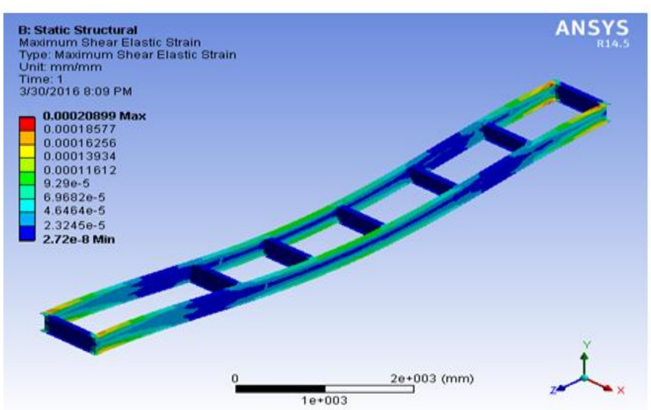


Fig.21. Strain

Same procedure is followed for the another material i,e Aluminum Alloy

B. Static Analysis on C Sec Automobile Chassis

1. Material: alloy steel

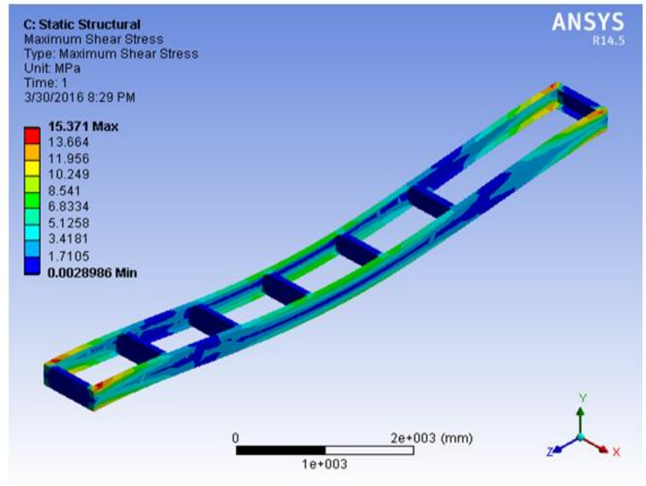


Fig.22. Maximum Stress

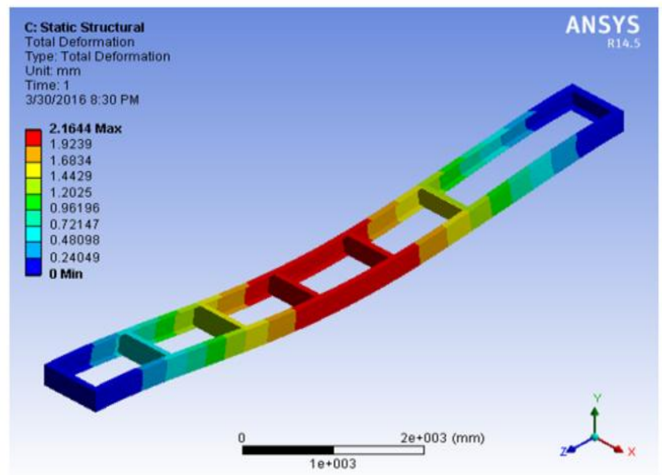


Fig.23. Total Deformation

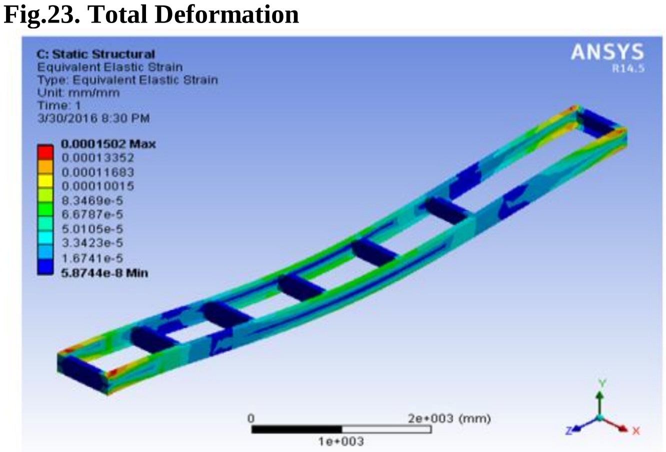


Fig.24. Strain

Same procedure is followed for the another material i,e Aluminum Alloy

C. Static Analysis on Box Section Automobile Chassis

1. Material: alloy steel

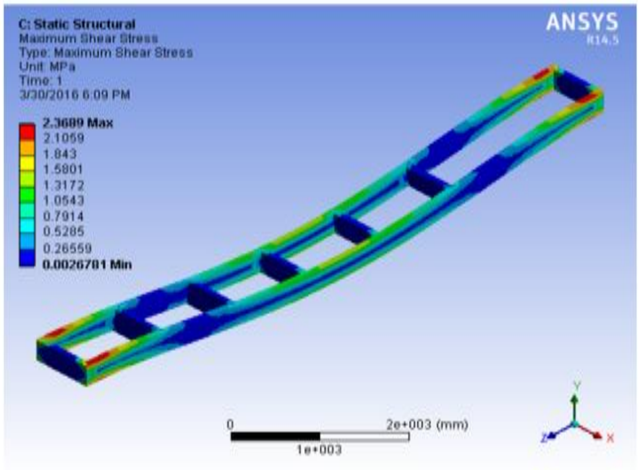


Fig.25. Stress

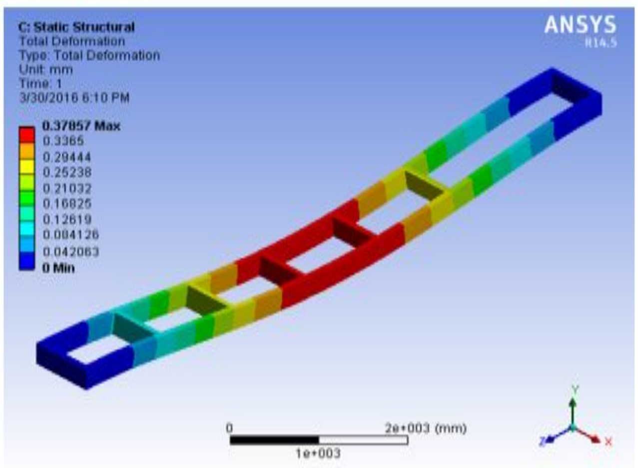


Fig.26. Deformation

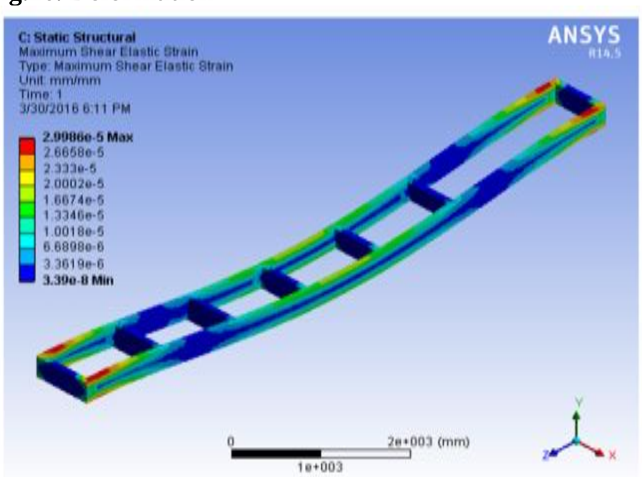


Fig.27. Strain

Same procedure is followed for the another material i,e Aluminum Alloy

VIII. RESULTS TABLE

TABLE I. For Modal Analysis

section	material	Frequencies (Hz)			Deformation(mm)		
box	Aluminum alloy	12.635	20.767	30.721	1.2459	1.3531	1.3446
	Alloy steel	12.676	21.005	30.765	0.74731	0.81129	0.80587
I	Aluminum alloy	10.636	25.118	25.994	4.1265	4.4047	3.9843
	Alloy steel	10.695	25.291	26.309	2.3883	2.638	2.4743
C	Aluminum alloy	12.261	25.602	28.978	3.6943	3.9686	3.9283
	Alloy steel	12.342	25.917	29.169	2.2128	2.3788	2.352

TABLE II. For Static Analysis

section	material	Load(N)	Max. shear stress(mpa)	Deformation(mm)
box	Aluminum alloy	19620	2.373	1.0736
	Alloy steel	19620	2.3	0.3
I	Aluminum alloy	19620	16.447	6
	Alloy steel	19620	16.51	2.16
C	Aluminum alloy	19620	15.38	6.164
	Alloy steel	19620	15.37	2.165

IX. CONCLUSION

- Modeling of automobile chassis is done in solid works with different cross section
- The cross sections were considered as box,I,C
- Static and modal analysis is carried out find out the stress and deformations with correspond to the applied load.
- 19620N load is applied on the chassis to find out the stresses and deformations occurred in the chassis model
- Modal and static analysis is carried out in ansys workbench
- Material consider for the analysis are aluminum alloy and alloy steel**.**
- Static and modal analysis is carried out on different cross sections with different material to choose the most applicable material.
- Box section automobile chassis has shown less stress and less deformation values compared with the other cross sections.

- But box type chassis is not suitable for all applications so c section automobile is preferred over the other two types.
- Modal analysis is done find out the mode shapes at natural frequency.
- Aluminum material chassis has shown less stress values and high deformation values.

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