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Modeling of Heavy Vehicle Chassis Frame with Finite Element Analysis

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Abstract

To denote the frame parts or basic structure of vehicle, the chassis has utilized. It is a keystone of the vehicle and a vehicle without the body is known to be Chassis. Chassis frame is the central mounting for all the components including the body. Hence it is also known as Carrying Unit (CU). The loads that will be acted on the frame are, loads with the short duration and momentary duration which will be occur during the curve taking, Impact loads due to the vehicle collision, static loads due to the parts of chassis and Over loads. Generally, the Chassis will be failed due to these loads. Hence, by modifying the current design with reverse engineering to collect for the heavy duty truck having the capacity of 10 Ton the data we will be going to rectify those failures. We also conduct the structural analysis for the conventional material structural steel and one of the composite material for mitigating the chassis weight and stresses known as aluminum alloy material. Pro/Engineer tool is utilized for the modeling and assembly followed by Ansys analysis.

Keywords: *chassis frame, finite element analysis, ANSYS and Mechanical design suit*

1. Introduction

The modern automobiles construction has been formed by the chassis frame. A skeleton will be formed by the huge number of designs in pressed-steel frame on which all the components are mounted. Chassis and body of vehicle flexibly bolted during the manufacturing process that performs variety of functions. It ingest the reactions from the engine movements and axle movements, receives the wheels reaction forces in braking and acceleration, also ingests the forces of aerodynamic wind and road shocks through the suspension, and absorbs the major impact energy in case any accident occurs. Modern small car designing has been shifted gradually by fusing the body and chassis frame into a mono structuring element. The steel body shell will be strengthened with the braces in this grouping which makes it strict enough to withstand the forces that are applied on to it. The separate frames will be utilized for other cars to achieve the better noise-isolation characteristics. By introducing the components with heavier gauge steel in modern separate frame designs also leads to the limit intrusion in accidents.

1.1. Main Components of Chassis

The main components of the Chassis are:

- Frame: which has been made up of side members focused together with the help of cross members number
- Engine or power plant: Which provides power source
- Clutch: Which will be utilized for power connection and disconnection from the transmission system to the engine flywheel
- Gear Box
- U-Joint
- Propeller Shaft
- Differential

1.2. Functions of Chassis

- Carry the passengers load or the goods carried out in the body.
- Support the body load, engine load and load of gear box etc.,
- To resist the sudden breaking force or the acceleration force
- To resist the bad road condition stresses
- To resist the force of centrifugal while cornering

2. Types of Chassis Frames

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There are three types of Chassis frames named as: conventional frame, integral frame and semi integral frame.

Conventional frame: With the help of bolts and rivets both the cross side and long side members will be joined together to form this sort of frame. It has 2 long side and 5-6 cross side members. These frames have three sections, such as, channel section which resist to bending, tabular section that resists to torsion and box section for resisting both.

Integral Frame: Now a day, most of the busses and cars have been utilized by these types of frames. There is no frame and all the assembly units are attached to the body. The body itself carried out all the frame functions. These are very cheaper due to the long frame elimination but more economical due to the less weight. It has only drawback that it is very difficult to repair.

Semi - Integral Frame: Some of the vehicles will be fixed with the half frame in the front end and mounted on the engine gear box and front suspension. Hence, it is very easy to repair the damaged chassis frame by discarding the front frame easily. FIAT, European and some of American cars will be made up with this sort of chassis frames.

3. CAD

Throughout the history of our industrial society, many inventions have been patented and whole new technologies have evolved. Perhaps the single development that has impacted manufacturing more quickly and significantly than any previous technology is the digital computer. Computers are being used increasingly for both design and detailing of engineering components in the drawing office. Computer-aided design (CAD) is defined in many ways; it can be defined as the aiding of application of digital PCs and graphics software. In the other way the same can be defined as the product design enhancement from the conceptualization to documentation. CAD is most commonly associated with the use of an interactive computer graphics system, referred to as a CAD system. Computer-aided design systems are powerful tools and in the mechanical design and geometric modeling of products and components. There are several good reasons for using a CAD system to support the engineering design function:

- Productivity enhancement
- Design quality enhancement
- Uniform design standards
- Manufacturing database creation
- Inaccuracies elimination caused by drawings hand copying

Creo 2.0 (pro/engineer) provides easy to use solution tailored to the needs of small, medium sized enterprises as well as large industrial corporations in all industries, consumer goods, fabrications and assembly, electrical and electronics goods, automotive, aerospace etc.

4. Chassis Models

This section deals with the type of chassis models in the literature. Figure 1 shows that the patterns of side channel, the channel with the cross members has shown in figure 2.

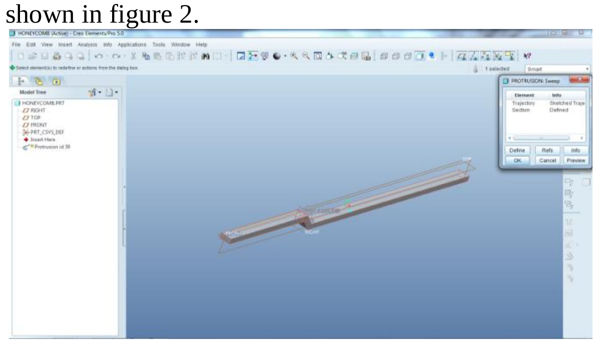

Figure 1. Side channel

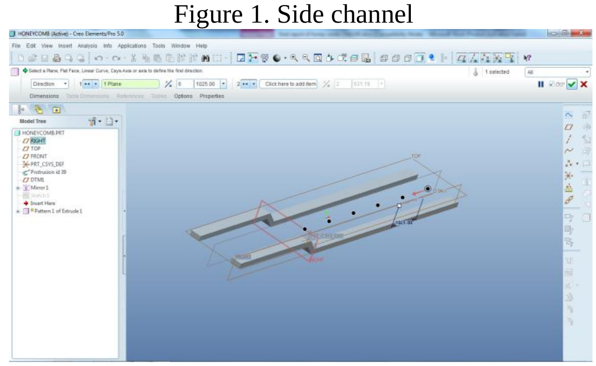

Figure 2. Channel with cross members using pattern

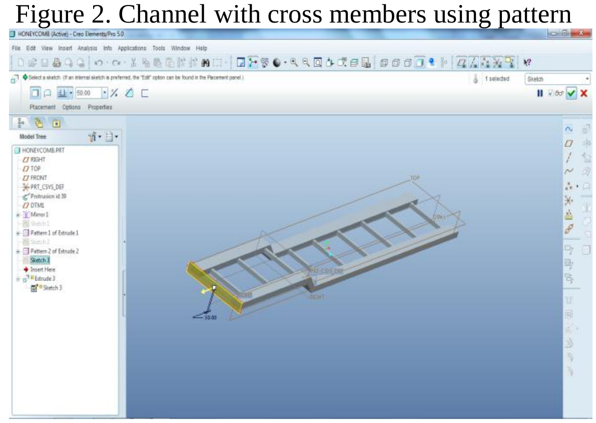

Figure 3. Final model of existing chassis

The model of honey comb chassis has been displayed in figure 4 and complete details of the same model

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showed in figure 5.

4.1. Honey Comb Chassis

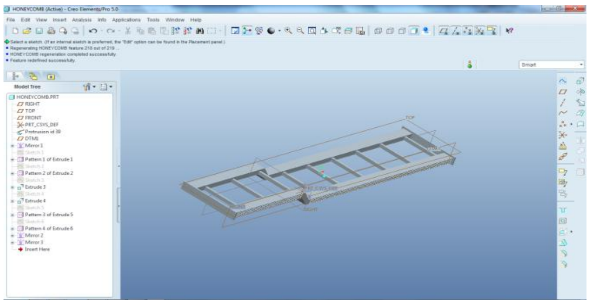


Figure 4. Final model of honeycomb chassis

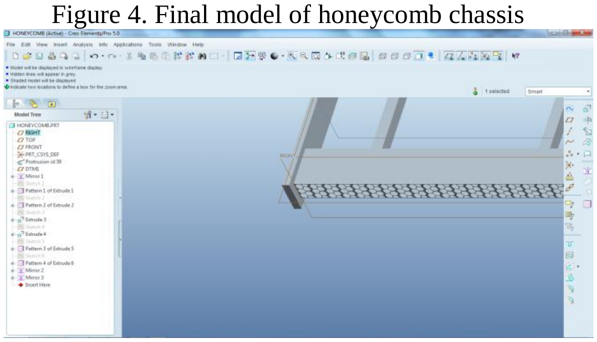


Figure 5. Detail of honeycomb chassis

4.2. 2D Drawings of Models

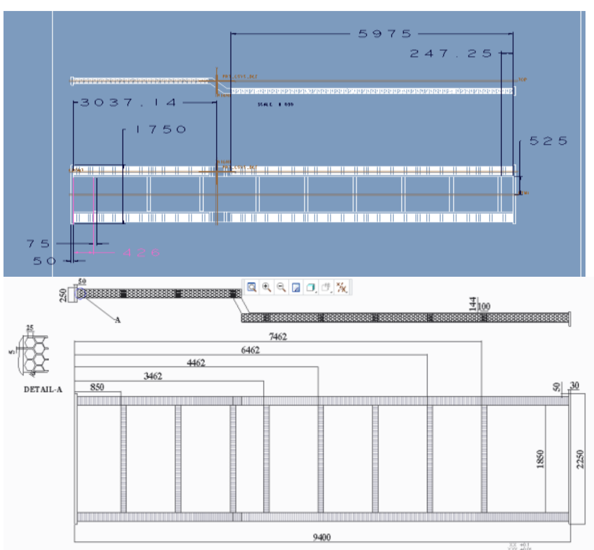
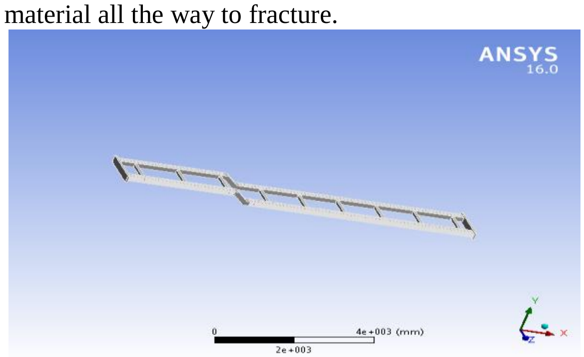


Figure 6. 2D drafting of honeycomb chassis

5. FINITE ELEMENT ANALYSIS

In 1943, R. Courant has developed the Finite Element Analysis (FEA) for obtaining the approximate solutions by utilizing the Ritz scheme of numerical analysis and variation minimization calculus to vibration systems. After few years, an author named as Turner has published a paper in 1956 that brought about a broader meaning for numerical analysis, by introducing complex structures stiffness and deflection. FEA has been limited to overpriced mainframe PCs in the early 70's, which was generally owned by the defense, aeronautics, nuclear and automotive industries. The unbelievably great enhancement in computing power and the gradual mitigation in the computers cost increases the interest in developing the FEA systems. Now a day, for producing the more accurate results everyone utilizes the supercomputers for all types of parameters. For the analysis of specific results a computer model or design associated with FEA will be utilized. It is used in new product design, and existing product refinement. A company is able to verify a proposed design will be able to perform to the client's specifications prior to manufacturing or construction. To qualify the structure or product for a new service condition, the modification of conventional or existing structure or product has been utilized. FEA might be utilized for helping to determine the modification of the design to achieve the new service conditions in case of structural failure. Two types of analysis have been widely used in present industries, one is 2-D modeling and the second is 3-D modeling. The 2-D modeling is very simple and can allow to the analysis on a normal PC but it is less accurate.
However, the 3-D modeling will produce more effective and accurate results but it needs fastest PC conditions. One can inject numerous functions or an algorithm within these schemes of 2-D or 3-D modeling that makes the behavior of the system is linear or non-linear. Where the systems those are linear will have low complexity but it does not consider the plastic deformation. While the non-linear systems will do account for plastic deformation and many. These are also capable of testing a material all the way to fracture.



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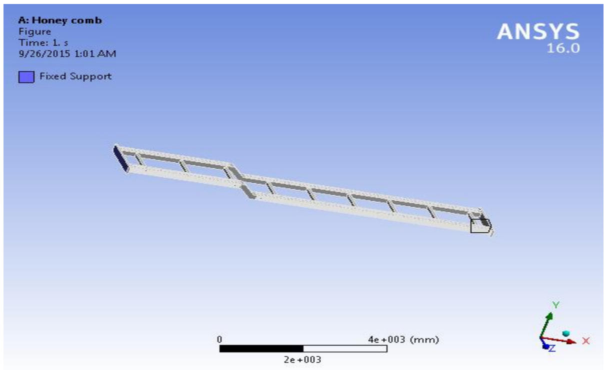
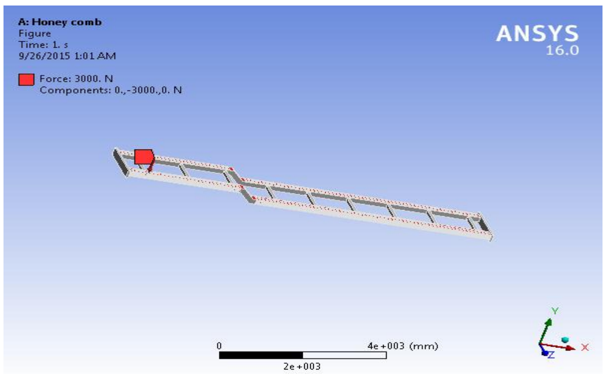
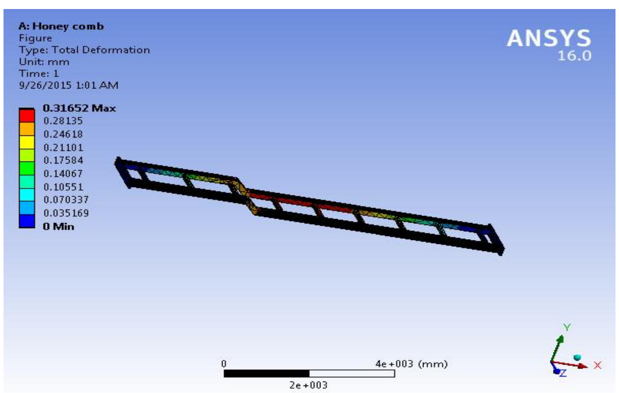
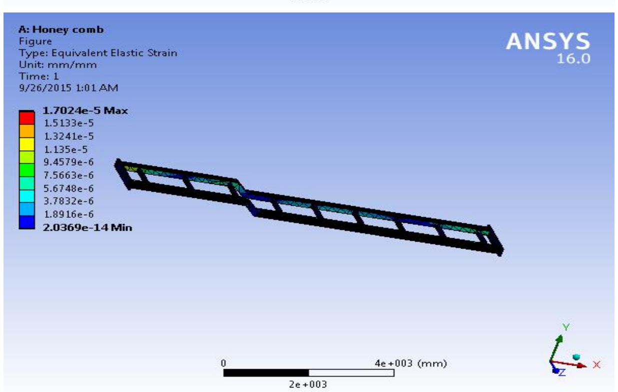
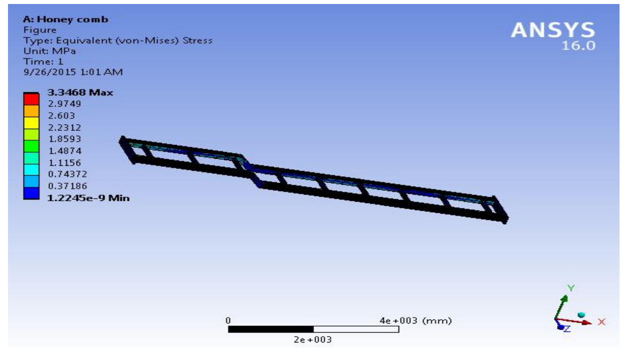










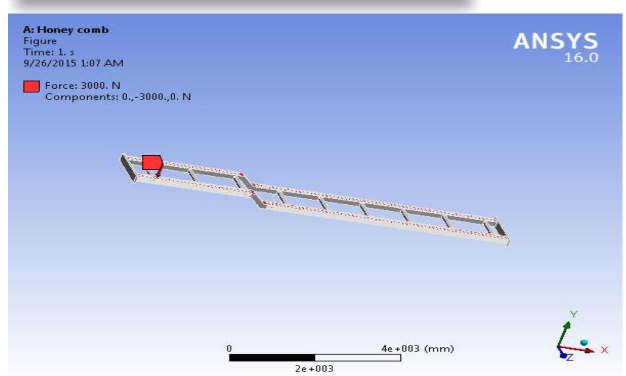
Material Data

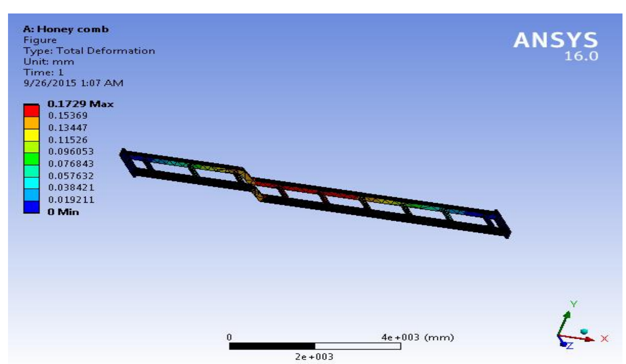
Structural Steel

Table 1: Structural Steel > Constants

Density	7.85e-006 kg mm^-3
Coefficient of Thermal Expansion	1.2e-005 C^-1
Specific Heat	4.34e+005 mJ kg^-1 C^-1
Thermal Conductivity	6.05e-002 W mm^-1 C^-1
Resistivity	1.7e-004 ohm mm

ANSYS





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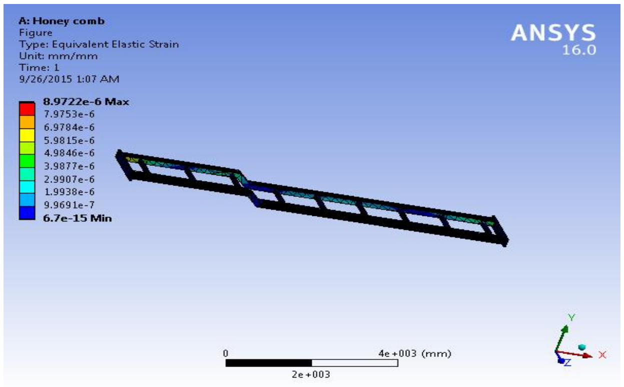

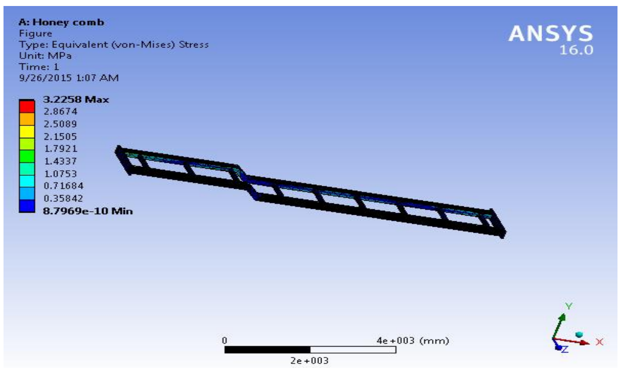

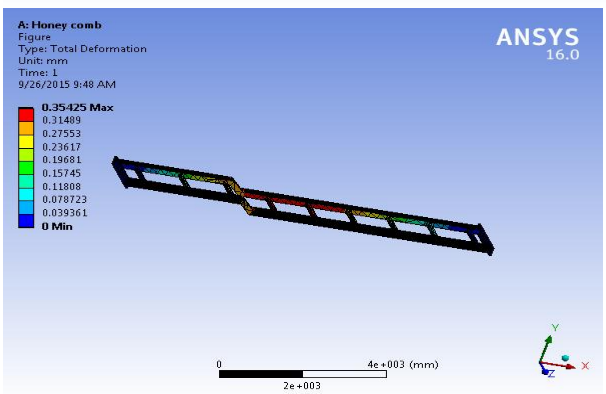

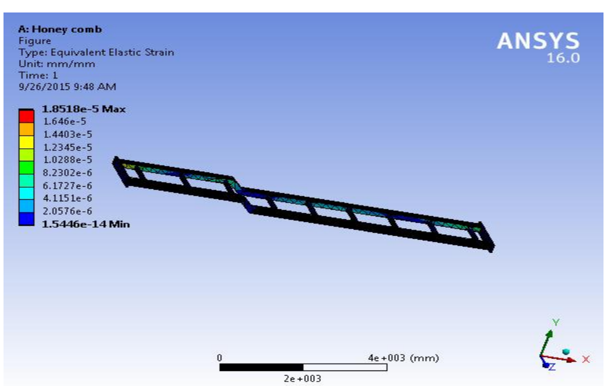

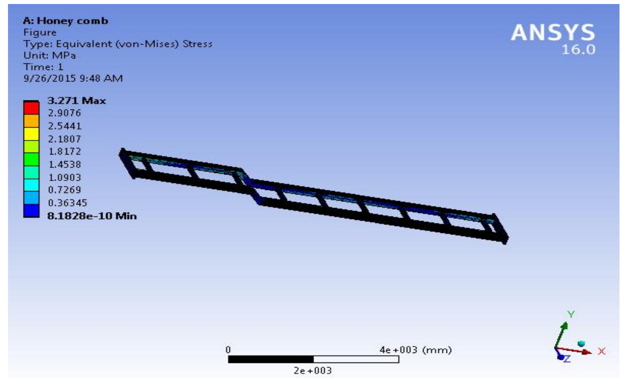

Material Data

Al SiC

Table 2: Al SiC> Constants

Density	2.7e-006 kg mm^-3

Table 3: Al SiC> Isotropic Elasticity

Temperature C	Young's Modulus MPa	Poisson's Ratio	Bulk Modulus MPa	Shear Modulus MPa
	1.8e+005	0.25	1.2e+005	72000

6. Conclusion

This design and analysis work's on "structural optimization of chassis and implementation of composite materials in heavy vehicle chassis to the weight reduction without structure quality mitigation". As per the problem description weight is the major part which effect on millage and cost of the chassis. The design and analysis concluded as follows:

- First literature survey and data collection was done to understand the rectification method and material selection.
- Next 3-D chassis regular modeling and honey comb has been developed in Pro-E for further analysis is Ansys tool.
- Honey comb structure chassis along with the S2-Glass will be the best choice as per the analytical analysis
- By using S2-Glass along with honey comb structure weight is mitigated up to 75% and quality has been enhanced by 87 %, which suggests that the proposed model and the material are better to be utilized.
- While comparing with the mild steel, manufacturing of the S2-Glass chassis very easy.

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