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DESIGN OF A LIGHTWEIGHT CHASSIS FOR E-RIKSHAW

AN IMPLEMENTATION PAPER

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Abstract

The electric vehicles such as E-rickshaw demand light weight body structure without compromising the quality of material. This project work is an effort to fulfil the requirement of electric automotive vehicles. CRCA (cold rolled close annealed) steel material is used in this redesigning procedure of chassis due to its lightweight quality and engineering properties. A slight modification in the section structure is also considered in this redesigning work. A C-channelled converted section is used instead of rectangular section as chassis structure manufacturing due to its easy installation and maintenance feature.

This redesign chassis frame will help to improve battery life as lower weight of the vehicle tends to lower consumption of fuel and load on battery will also be at a lower level thus ultimately the battery life will increase. This design may become the cost-effective solution to prevent the pollution causes and also provide the better outcome as the performance of the E-rickshaw.

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Keywords: Chassis, E-rickshaw, CRCA steel, C-channelled Chassis.

Introduction

Three wheeler Auto-rickshaws are considered to be small vehicles but are extensively used in many countries for small distance purpose especially within same city. These three wheelers are majorly used as taxi in urban areas in India due to inexpensive services. This entire study is based on the design of light-weight chassis frame appropriately designed for E-rickshaw structure to get a more efficient performance.

The chassis is considered to be one of the most significant components of an automotive structure. The frame which holds various mechanical components along with the body of vehicle such as the suspension system, axle assembly with wheels, braking system of automobile and the engine are also bolted onto the chassis frame [1]. The required strength and support towards the different vehicle components is provided by chassis structure and it helps to keep the automobile vehicle stiff and rigid as well. Accordingly the chassis also provides overall safety to the mechanical system. As it provides the torsional and bending stiffness and direct support to the other systems mounted on it. It helps to ensure the noise control and vibration control throughout the automobile system.

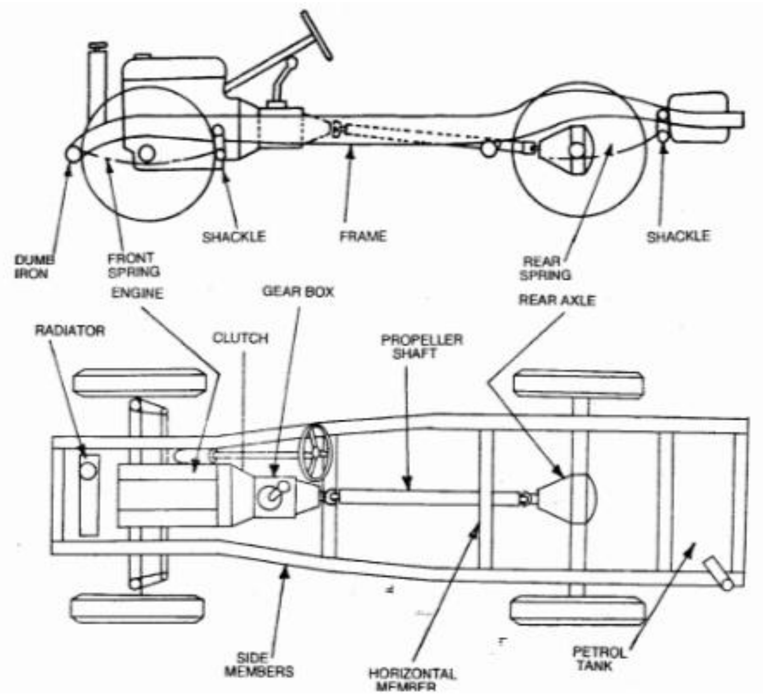

Fig. 1: Layout of basic chassis frame

Two characteristics of stiffness of frame are considered which are torsional stiffness and beaming aspects of frame stiffness. Along with the mechanical strength another important consideration is also take while design a chassis frames that it must have requisite bending and torsional stiffness for better handling characteristics [2]. The very basic and important phenomenon followed during design and fabrication of chassis structure is strength and stiffness of the material. The load carrying capacity of chassis structure should be high to withstand all the stress and load as it carries the entire load applied over the automobile structure.

Objective of Work

The main purpose to work on this project is to provide the efficient design of lightweight chassis frame for electric-rickshaw of coming years with useful information concerning materials, key performance indicators, the design process and guidelines for efficient chassis which can be used in E-rickshaw. To design a chassis that improves the overall dynamic performance of the rickshaw.

The objectives of this study are as follows:

- Selection of Engineering material having excellent mechanical properties for chassis.
- To construct the appropriate chassis design suitable for E-rickshaw.
- Analyse the behaviour of chassis structure after applying different load and pressure.
- To determine the maximum stress concentration areas and analysing the static structural behaviour of the chassis frame.

Literature Review

The papers presented by **A.HARI KUMAR [1]** is to find out best material and most suitable cross-section for an EICHER E2 TATA Truck ladder chassis with the constraints of maximum shear stress, equivalent stress and deflection of the chassis under maximum load condition. In present the Ladder chassis which are uses for making buses and trucks are C and I cross section type, which are made of Steel alloy (Austenitic). In India number of passengers travel in the bus is not uniform, excess passengers are travelling in the buses daily due to which there are always possibilities of being failure/fracture in the chassis/frame. Therefore Chassis with high strength cross section is needed to minimize the failures including factor of safety in design. In the present work, we have taken higher strength as the main issue, so the dimensions of an existing vehicle chassis of a TATA EICHER E2 (Model no.11.10) Truck is taken for analysis with materials namely ASTM A710 Steel, ASTM A302 Alloy Steel and Aluminium Alloy 6063-T6 subjected to the same load. The different vehicle chassis have been modelled by considering three different cross-sections namely C, I and Rectangular Box (Hollow) type cross sections. The problem to be dealt for this dissertation work is to Design and Analyse using suitable CAE software for ladder chassis. The report is the work performed towards the optimization of the automobile chassis with constraints of stiffness and strength. The modelling is done using CATIA, and analysis is done using ANSYS. The overhangs of the chassis are calculated for the stresses and deflections analytically are compared with the results obtained with the analysis software.

Amrendra Kumar Singh [2] has presented his study on truck chassis which is the structural backbone of any vehicle. The main function of the truck chassis is to carry the goods and payload placed upon it. The chassis frame has to bear the stresses developed and deformation occurs in it and that should be within a limit. This paper presents the study of the stress developed in chassis as well as deformation of chassis frame. The stress and deformation has been calculated for the chassis frame and the analysis has been done for the validation on the chassis frame. The model of the chassis has been developed in CREO (Pro-E) 2.0 and static structural analysis has been done in ANSYS WORKBENCH 15.0.

According to **Akash Singh Patel [3]** the chassis is the French word was used to denote the frame parts or main structure of vehicle, which is now, denotes the whole vehicle except body in case of heavy vehicles (that is vehicle without body is called chassis). In case of light vehicles of mono construction, it denotes the whole vehicle except additional fittings in the body. Automobile chassis usually refers to the lower body of the vehicle including the tires, engine, frame, driveline and suspension. Out of these, the frame provides necessary support to the vehicle components placed on it. Role of the chassis frame is to provide a structural platform that can connect the front and rear suspension without excessive deflection. Also, it should be rigid enough to withstand the shock, twist, vibration and other stresses caused due to sudden braking, acceleration, shocking road condition, centrifugal force while cornering and forces induced by its components. So, strength and stiffness are two main criteria for the design of the chassis. The present study has analysed the various literatures. After a careful analysis of various research studies conducted so for it has been found that there is the scope of optimizing different factors like weight, stress-strain values and deformation etc. by varying cross sections for modelling and analysis. This paper describes the design and Structural analysis of the heavy vehicle chassis with constraints of maximum stress, strain and deflection of chassis under maximum load. In the present work, the dimension of the TATA 2518TC chassis is used for the structural analysis of the heavy vehicle chassis by considering three different cross-sections, Namely C, I, and Hollow Rectangular (Box) type cross sections subjected to the same conditions. A three dimensional solid modelled in the

CAE software CATIA and analysed in ANSYS. The numerical results are validated with analytical calculation considering the stress distribution and deformation.

The research work presented by **Mr Birajdar M. D. [4]** describes the analysis of ladder chassis frame for Ashok Leyland truck Model No. IL super 3118. Practically load distribution on the chassis is not uniform across its total area, so according to the intensity of load it is possible to vary the area of ladder chassis. Analysing the effect of reduction in cross section area with constrains of bending stress, shear stress and deflection, reduction in area will save amount of material required for ladder chassis. Four different cases are considered and in each case height is reduced for some specific span of chassis where intensity of load is less. Reduction of area for some specific span will distribute nearly uniform stresses across its whole area. The research work is carried out on side member of ladder chassis particularly.

M. Anudeep [5] has developed a three-wheeler which has essentially a motion disturbance vibrating system with the ground providing input. The tyres which are in contact with the ground, convert this input displacement into a forcing function that force acts on the un sprung masses, linkages will constrain these masse so that they follow certain paths. Ride response will vary with variation in the tyres, suspension characteristics, the ground profile, physical dimensions and the inertial properties of the sprung and unsprang masses of the vehicle. Analysing the dynamic behaviour of vehicle using Finite Element modelling is the main objective of this thesis .This project also includes the response of the three wheeler chassis frame to road surface inputs and to provide the best vehicle in vibratory motions. In Finite element modelling, analysis is done to determine the dynamic behaviour of the vehicle in Harmonic and Transient excitations. Parametric study and modal analysis and has also been carried out. In order to get the maximum stresses, as the vehicle running on the road is subjected to the random vibrations spectrum analysis is carried out. We studied the results obtained from Finite element modelling in modal analysis and are compared with those of rigid body modelling. In Transient analysis excitation at the key nodes magnitude and acceleration values are analysed. Maximum stress point is noted from spectrum analysis. To improve the performance of vehicle conclusions were derived from the study and suggestions are made, thus stability is established.

As per the study performed by **Indu Gadagottu [6]** automotive chassis can be considered as the backbone of any vehicle its principle function is to safely carry the maximum load for all designed operating conditions. This paper describes design and analysis of heavy vehicle

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chassis. Weight reduction is now the main issue in automobile industries. Traditionally most common material for manufacturing vehicle chassis has been mild steel, in various forms. Over time, other materials have come into use, the majority of which have been is steel and Aluminium. In this paper traditional materials are replaced with composite materials [S-glass epoxy and E-glass epoxy] by using reverse engineering method. (Existing model, modified model, honey comb model). For validation the design is done by applying a single vertical loads acting on the chassis. And then Structural and, fatigue analysis will be carried out on three models to all materials and select the best material Impact analysis can also be done for the selection material in all models Software's used in this work solid works for modelling ANSYS 14.5 for analysis.

Proposed Methodology

This designing procedure is implemented on some mechanical design software such as CATIA V5, ANSYS and static analysis were completed by using finite element analysis (FEA). The stress distribution and structural properties and other mechanical properties of the chassis models are then analysed in ANSYS WORKBENCH throughout the finite element analysis. Weight of the proposed design of chassis frame is then compared with the previous existing model of chassis made of conventional material.

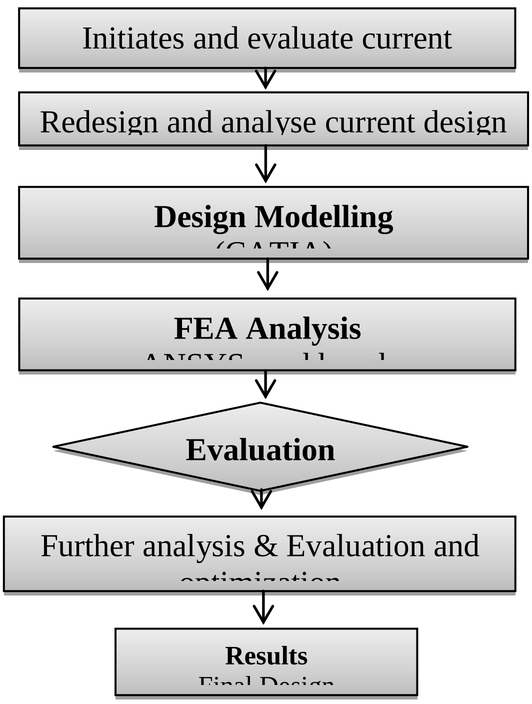

Fig.2: Flowchart of proposed methodology

Selection of Material

Cold rolled close annealed steel sheets offer a variety of outstanding properties along with easy formability and a smooth, clean surface.

Engineering properties of CRCA is mentioned in tabular form:

Property	Value
Density	7.85 gcm^3
Tension Yield Strength	290MPa
Ultimate Strength	590MPa
Young's Modulus	2E+08 MPa
Poisson's Ratio	0.28

Table 1: Material property

Modelling of Chassis Frame

Chassis model designs implemented in ANSYS for finite element analysis of other parameters such as 'structure weight', 'behaviour & effects of stress application' and 'deformation' etc.

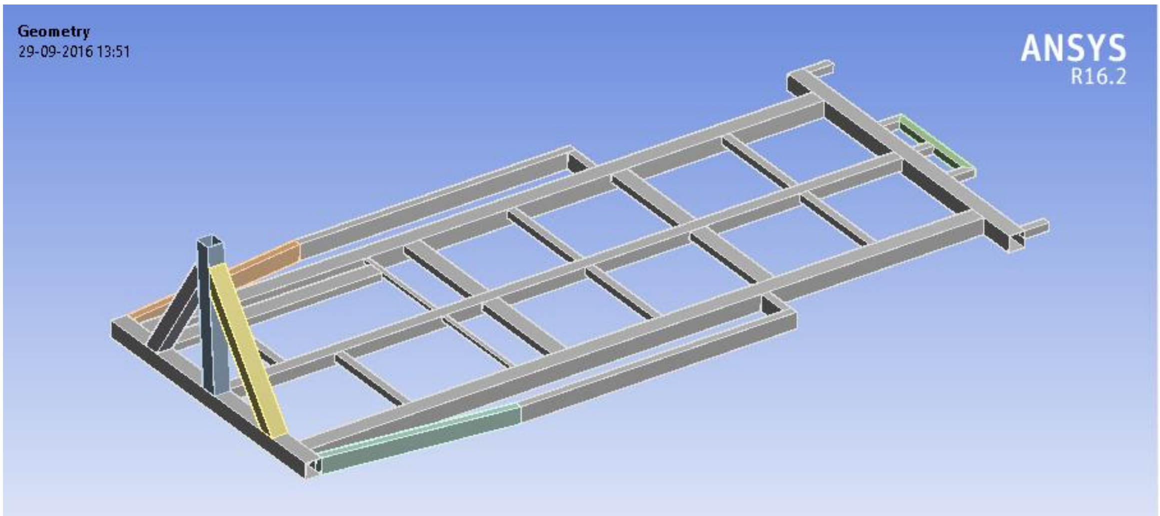

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Fig. 3: Structural design of Chassis frame

Mesh Generation

Meshing of the C-channel converted chassis frame model is done in ANSYS WORKBENCH. The meshing is done on the model with 138324 number of nodes and 139401 numbers of tetrahedral elements.

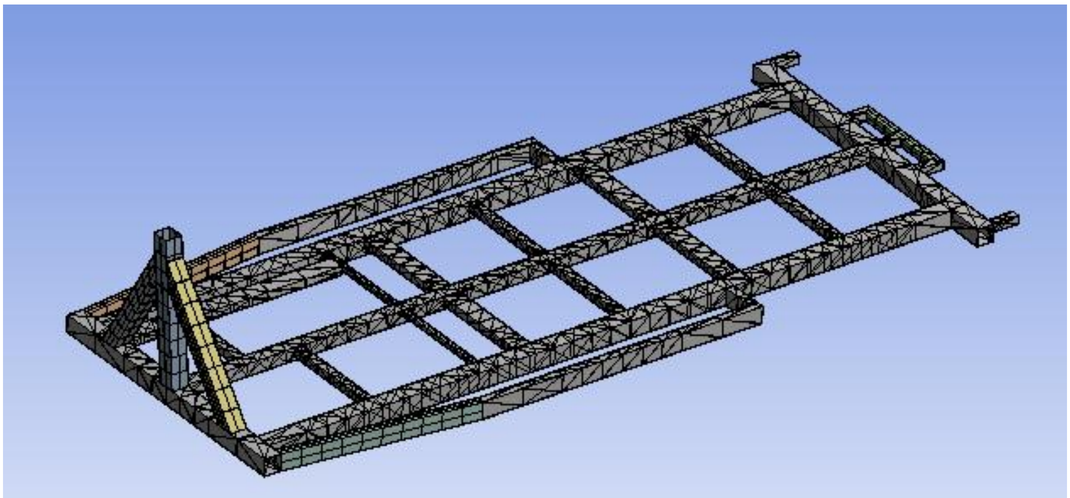

Fig.4: View of Meshed model of Chassis frame

Number Of Nodes	**138324**
Number Of Elements	**139401**

Results

Following are the results obtained from static structural analysis on existing chassis design model and C-channel converted CRCA steel chassis model.

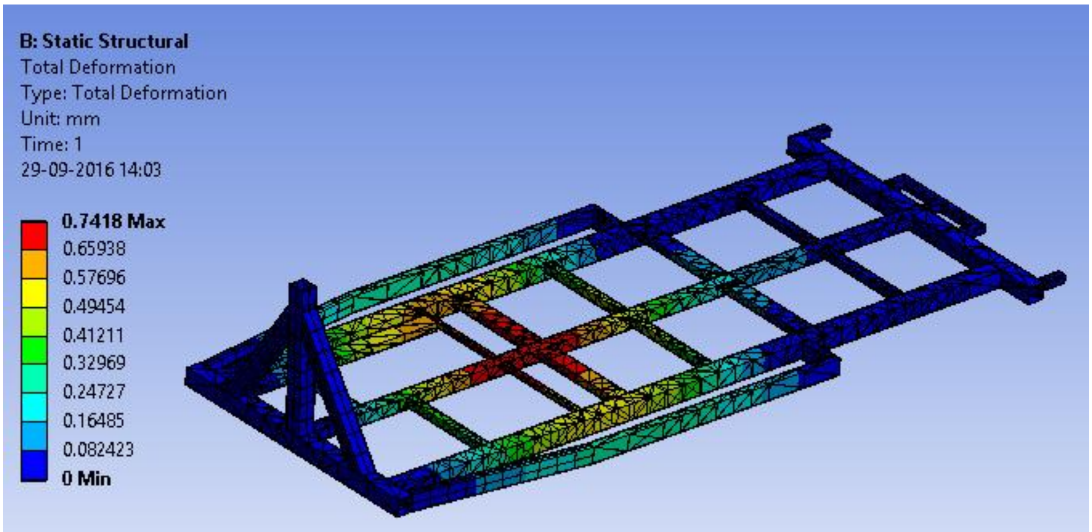

Fig.5: Deformation in existing design of chassis model

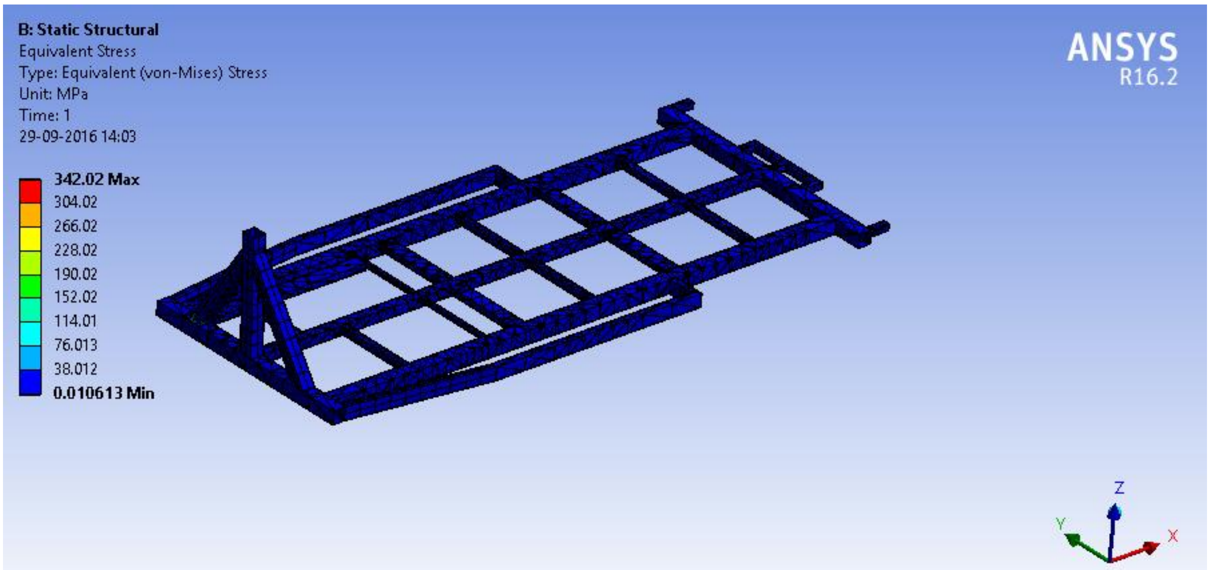

Fig.6: Stress in existing design of chassis model

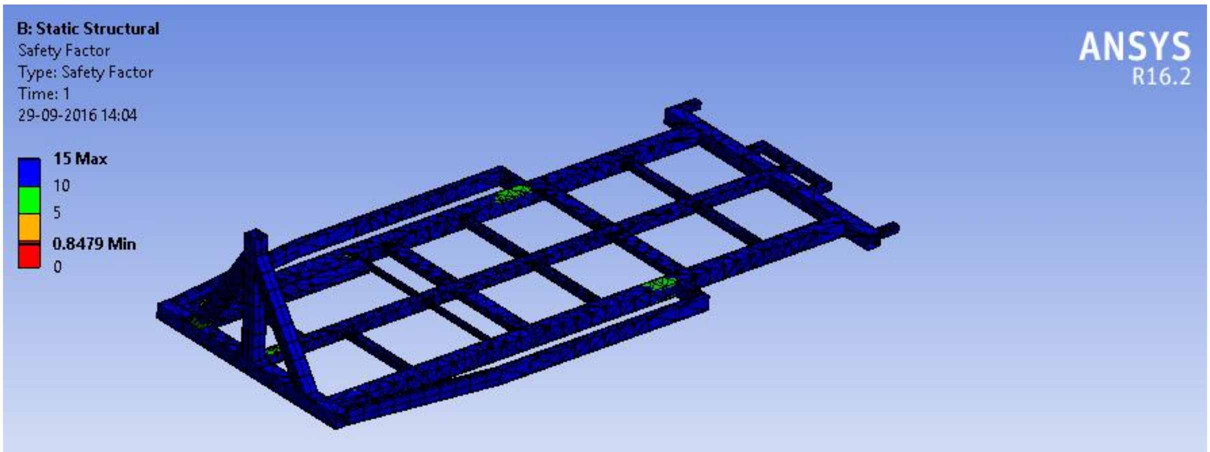

Fig.7: Factor of safety for existing chassis model

Results obtained for C-channel converted CRCA steel chassis model:

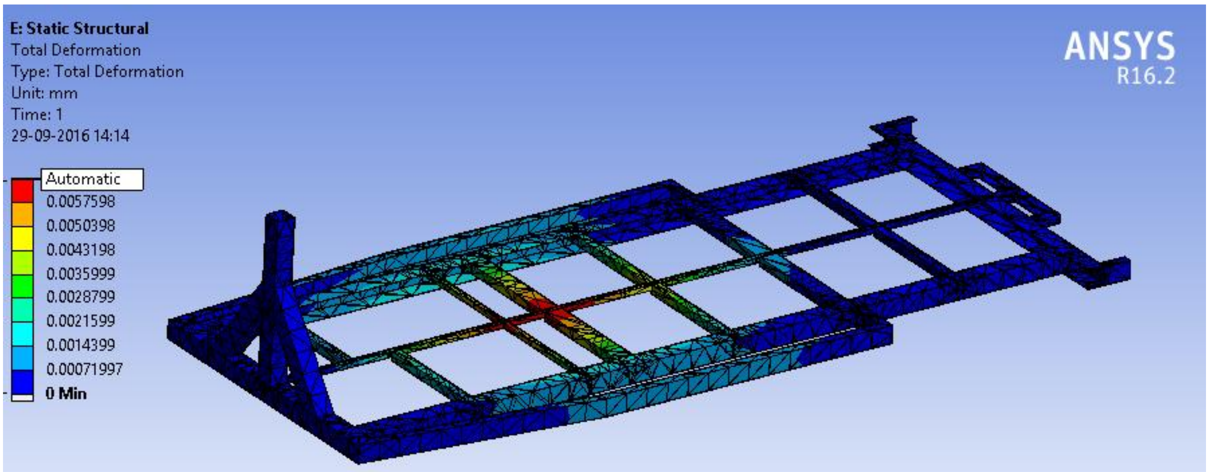

Fig.8: Deformation in C-channel converted existing Chassis

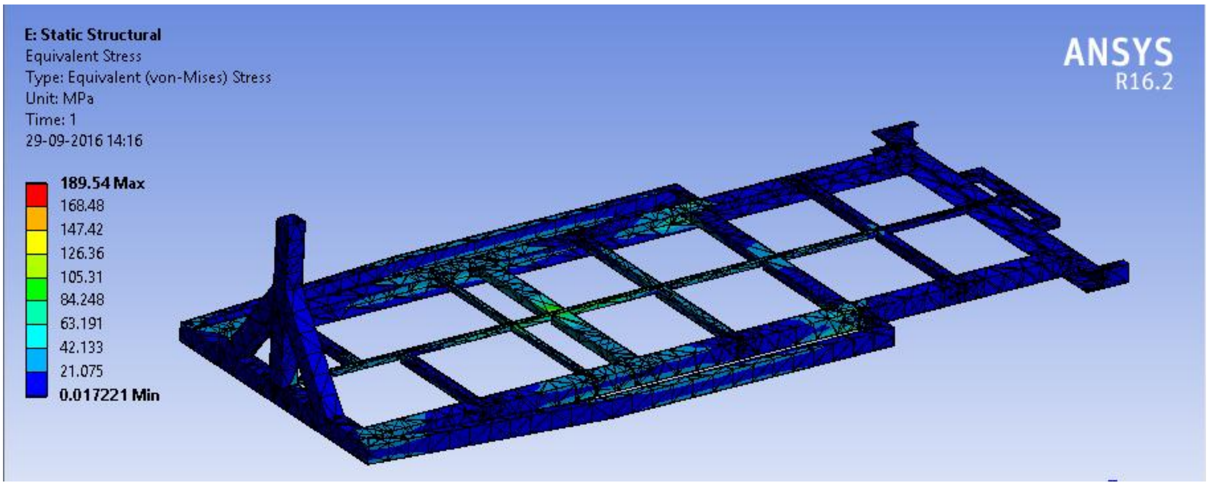

Fig.9: Stress in C-channel converted chassis

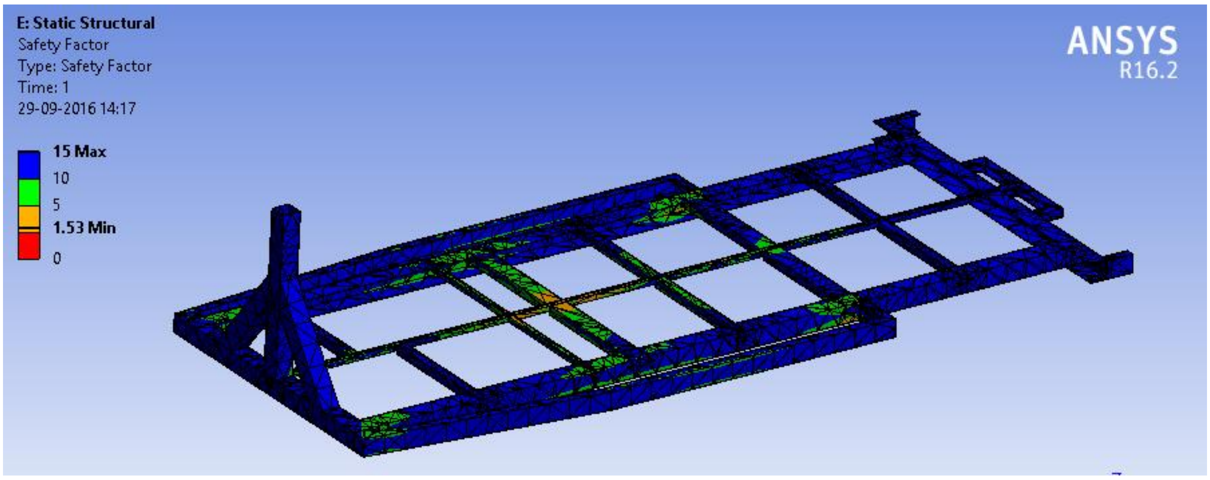

Fig.10: Factor of Safety in C-channel converted existing chassis

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