Design and Analysis of E-Scooter Chassis Frame

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Abstract – *The Electric Scooter is an eco-friendly transport system which will be useful for present and broadly for future generations, so that they can use renewable energy resources to power their vehicles instead of fossil fuels and produce less pollutants or no pollutants. The frame is considered as the foundation which is even termed as the skeleton for a vehicle that supports an objective it its construction and protection for integrated parts in the vehicle. The electric scooter frame which we designed is made by considering set of requirements from the data analysis and reviews, suggestions and experience which will improve the accuracy and precision of the overall scooter by the acceptance of all the engineering principles. The main objective of our paper is to design the frame for the scooter and to perform analysis i.e. impact analysis and weight analysis using finite analysis software.*

***Key Words*: Electric Bike, Design specifications, 3D model, Drafting, impact analysis, weight analysis.**

1. INTRODUCTION

India is a nation which has the second largest population and is one of the busiest road networks in the world. Because of this overwhelming population, accidents are most common resulting in major source of death in the country. There is one death every four minutes and an average of 1200 road crashes every day with a whopping 1.47 lakh deaths per annum India. The two-wheeler accidents involved in more than 30% of road accident deaths. One of the main parts to be considered in the bike to reduce the impact of accidents on the user is the frame of the bike. The frame acts as a skeleton and supports the major components and systems by taking various loads of the bike. Different components are mounted on the frame providing them with strength to carry their specific individual loads. The frame also supports various components like seat, bodyworks, accessories, etc. Battery and motor are also mounted on the frame. The frame must be able to resist against shocks and impacts of the vehicle and provide stiffness thus protecting the user and vital parts of the vehicle. The design of the frame also depends on the transmission, steering and suspension. The analysis depends on various factors. Out of these factors we have chosen impact and weight analysis into consideration.

An effective design must be economical and safe under extreme loading conditions also. The design must be able to withstand for all the loads and impacts considered. Therefore, analysis gives us the information of the frame during these impacts

2. LITERATURE SURVEY

Many studies have been performed on design and analysis of electric vehicle in previous work end up with following conclusions.

kenji karita, had developed a chassis made by Aluminium. The material selected for the frame is AISI 1018. 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 aluminium frame

Alireza Arab Solghar, Zeinab Arsalanloo studied and analysed the chassis of Hyundai Cruz Minibus. ABAQUS Software was used for modelling 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.

Roslan Abd Rahman, (2008) used FEM stress analysis as a preliminary data for fatigue life prediction. They used ABAQUS software for simulation and analysis and also taken ASTM Low Alloy steel AISI 1018 for study. Primary objective was to find the high stressed area where the Fatigue Failure will start. It's found that the chassis opening area having contact with bolt experiences high stress.

Teo Han Fui, have studied the 4.5 Ton truck chassis against road roughness and excitations. Vibration induced by Road Roughness and excitation by the vibrating components mounted on chassis were studied. Chassis responses were examined by stress distribution and displacements. Mode shape results determine the suitable mounting locations of components like engine and suspension systems.

3. DESIGNING

1 Purpose and Goals

The chassis is the backbone of the moped; it must support all the vehicle subassemblies as well as protect the driver. The chassis design is crucial to the success of the project because if the chassis fails, that puts the moped and the driver at tremendous risk. The goal of the frame will be to protect the driver, offer sturdy mounting for all subsystems, maintain all safety rules and regulations, and still be lightly.

2 Background

These mopeds are all powered by electric motors. To extract maximum acceleration from this motor a lightweight chassis is necessary. At the same time the chassis must undergo the rigors of Indian roads. To analyze a structure that will undergo such loads, finite element analysis (FEA) is often a viable solution. FEA breaks the structure into smaller elements and analyzes each element as a body and can calculate the stress, deflection and other reactions of any structure. A Transient FEA will be the main simulation done to optimize the weight and strength of the mopeds Chassis. From here forward a few assumptions have been made to aid design and analysis.

3 Design Objectives

To build a chassis to meet all of the previously mentioned goals the frame must:

· Endure the maximum dynamic load.

· Keep a driver safe from all the different terrains.

· Keep the weight of the moped well balanced.

· Keep the center of weight at the lowest point possible for easy maneuvering.

· Abide by all rules and Regulations.

·Weigh less than 65kgs.

·Have mounting structures for all subsystems that will withstand the loads produced by those subsystems.

4 Design

The design of the chassis has to incorporate two major things, driver comfort and safety and subsystem mounting. The driver safety for the design section is simply satisfying all of the SAE frame rules.

5 Driver Comfort and safety

To verify that a driver of 6 foot 3 inch, 250lbs would fit comfortably into the designed chassis model the required calculations was done here in the designing phase, taking in consideration that is specially designed for students the handlebar is set higher than usual to for straight back and promote a calm and slow drive.

6 Design measures

1. CAD model is the priority to initiate any design concept, so that we can see whether its prototype when constructed, how it will behave. Hence 3-D modeling tool used was **CATIA v5 R17**.

2. Keeping in mind the bends as much they can be given to avoid weld spots by using a continuous member rather than putting up weld spots all around so that the weight can be kept lower, which is an essential point for E-BIKE.

3. Manufacturability is utmost important i.e. we need to keep in mind that simpler fabricating processes shall be used for an accurate design.

7 Chassis Modeling by Using CATIA V5 R20-

This chassis is done mainly by using the following features.

1) Pad 2) Mirror 3) Rectangular pattern 4) Multi section solid 5) Shaft and 6) Rib.

- **Pad**: Pad is used to add material normal to a cross section or along a reference line.
- **Mirror**: It is used to create a body in opposite location through a reference plane.
- **Rectangular pattern**: It is used to create duplicate objects in a rectangular way with required measurements in a linear direction.
- **Multi section solid**: It is used to add material among multiple cross sections with equal ratio or unequal ratio.
- **Shaft**: It is used to create a circular or cylindrical shape objects with required cross section through an axis line with required angle.
- **Rib**: It adds material by sweeping a profile along a center curve.

4. 3D MODEL

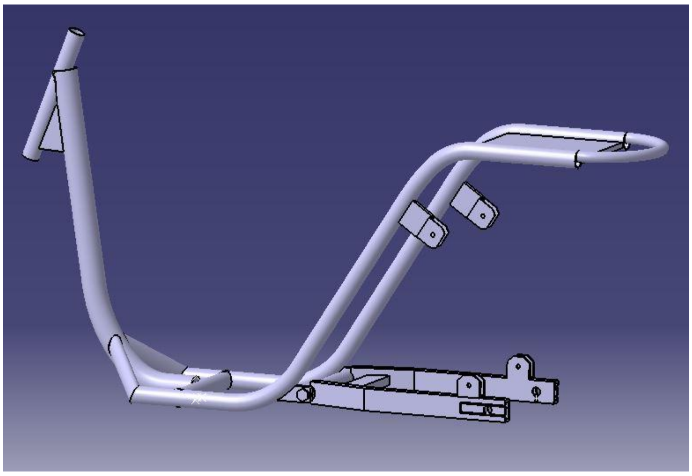

Fig. Chassis Isometric View

Fig. Chassis Front View

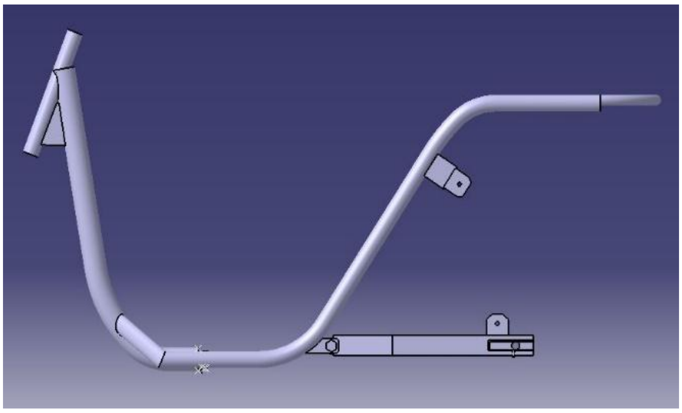

Fig. Chassis Side View

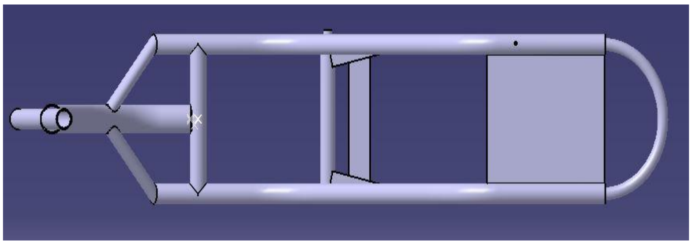

Fig. Chassis Top View

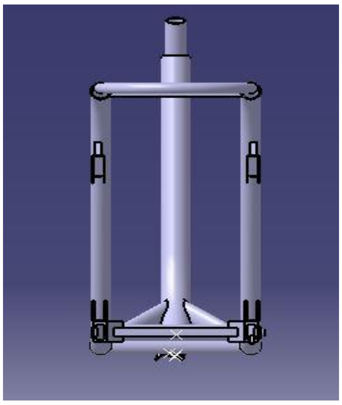

Fig. Chassis Back View

DESIGN SPECIFICATIONS:

Length	1140mm
Width	220mm
Handle height	1000mm
Head tube angle	27^{o}
Seat height	665mm

Table 1: Design Specifications

MATERIAL SPECIFICATIONS:

The selection of material also plays a very important role in the analysis of any structure. The material that we considered is AISI 1018. This is because it has less density and a good strength. It is also available in market at a reasonable price. We used 1.25-inch diameter, 2mm thickness seamless pipes for the complete frame. The composition and properties of AISI 1018 are listed below:

Element	**Content**
Carbon, C	0.14 - 0.20 %
Iron,Fe	98.81 - 99.26 % (as remainder)
Mangnese ,Mn	0.60 - 0.90 %
Phosphurus,P	≤ 0.040 %
Sulfur ,S	≤ 0.050 %

Table 2: Material chemical composition

PROPERTY	VALUE
Density	7.87 g/cc
Ultimate Tensile Strength	440 MPa
Yield Strength	370 MPa
Modulus of elasticity	205 GPa

Table 3: Material Mechanical Properties

5. SIMULATION AND ANALYSIS

Ansys

The ANSYS Workbench platform is the framework upon which the industry's broadest and deepest suite of advanced engineering simulation technology is built. An innovative project schematic view ties together the entire simulation process, guiding the user through even complex multi physics analyses with drag-and-drop simplicity. With bi-directional CAD connectivity, powerful highly-automated meshing, a project-level update mechanism, pervasive parameter management and integrated optimization tools, the ANSYS Workbench platform delivers unprecedented productivity, enabling Simulation Driven Product Development. ANSYS works on three principles; those are Penalty method, Lagrange method and augmented Lagrange method. These principles used in the process of contact analysis and non – linear analysis. In this project ANSYS 14.5 played a major role, all the analysis was done with the implementation of ansys. Mainly Modal ANSYS and Static Structural ANALYSIS were done in this Project. Modal and Stress Analysis was done on master rod and thermal analysis was done on piston.

1. Modal Analysis

In this Modal ANSYS, only the deformation of the component was calculated with applying forces and boundary conditions. The deformation will be calculated at different natural frequencies and it was mentioned as different modes. Applying of the boundary conditions will give you the specified directional deformation along with the total deformation.

2. Static Analysis

After the preprocessing, the solution has to be done. From solution phase, choose the new analysis as static. Then solve the current load step option. The solution will be done, the following table given the Von – Mises stress at various loads.

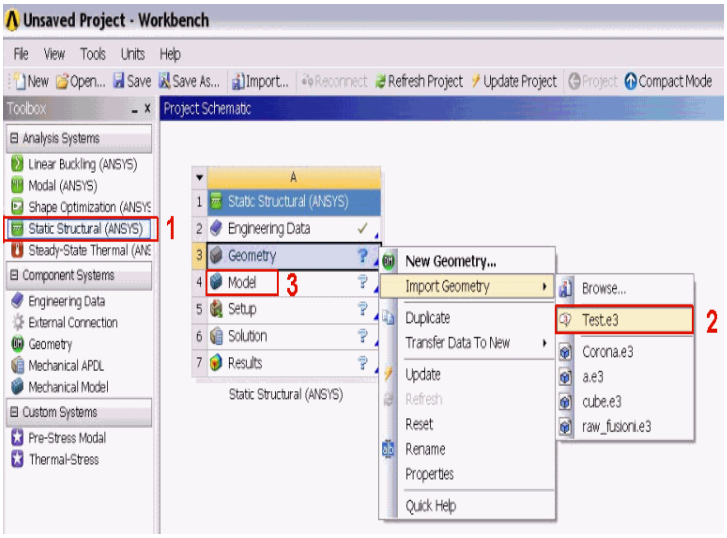

Fig: Main Window of Ansys Workbench 14.5

Importing of the chassis will be done after opening of the workbench. For the supporting purpose of the geometry, the file format of cat part will be changed into IGES format. This is to match up the graphical properties of the **CATIA V5 to ANSYS WORKBENCH 14.5**

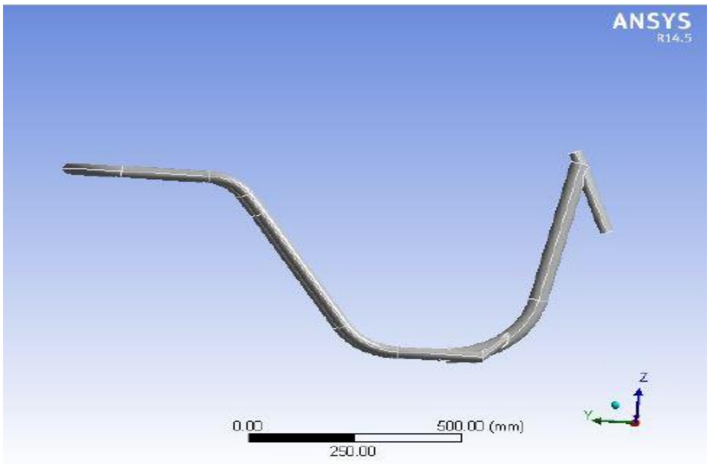

Fig: Imported Geometry

3. Mesh

This is the operation where the normal geometry will be converted into Finite Element Model. Finite element model involves in the division of the geometry in to no. of elements which represents the FEA principle.

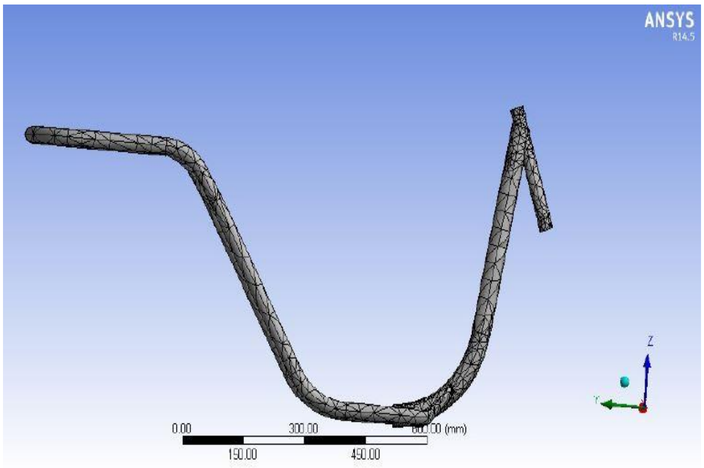

Fig: Meshing

6. LOAD ANALYSIS

1. Load On Static Structure :

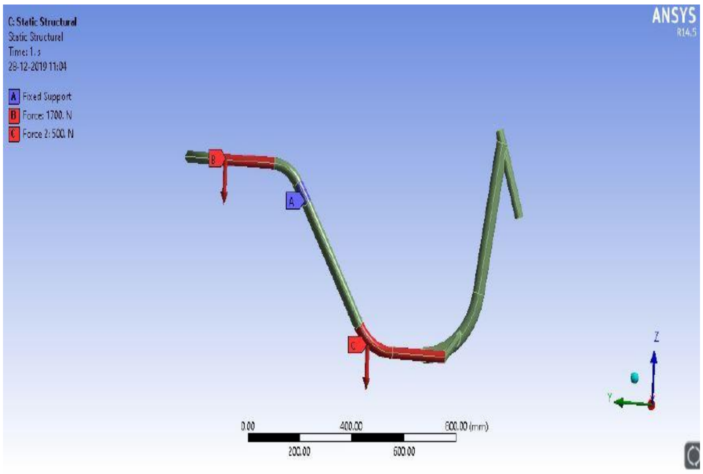

Fig: Static Structural

Define by	Components
Coordinate System	Global Coordinate System
X Component	0. N (ramped)
Y Component	0. N (ramped)
Z Component	1700. N (ramped) -500. N (ramped)

Table 4: Global Coordinate System.

2. Material Data (MILD STEEL)

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

Table 5: Material Data.

7. LOAD ANALYSIS RESULTS:

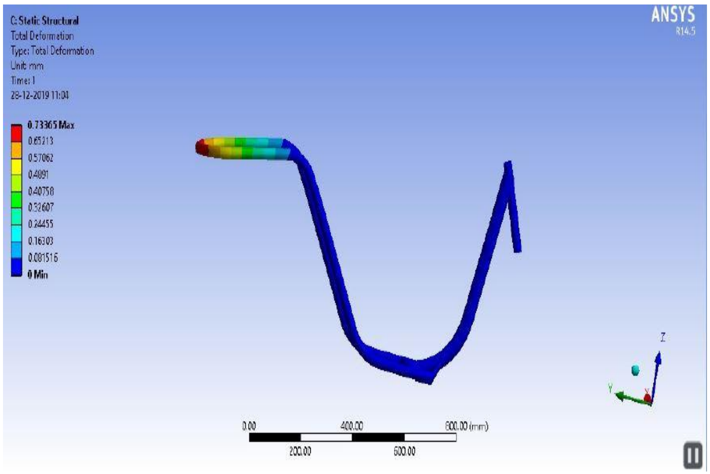

Fig: Total Deformation

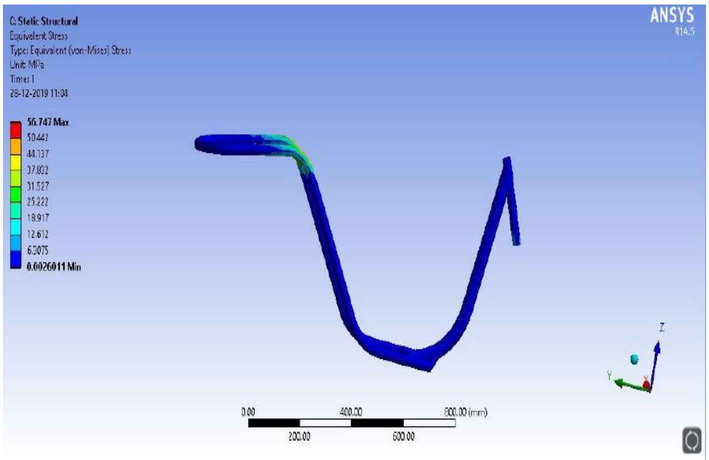

Fig: Equivalent (von-Mises) Stress

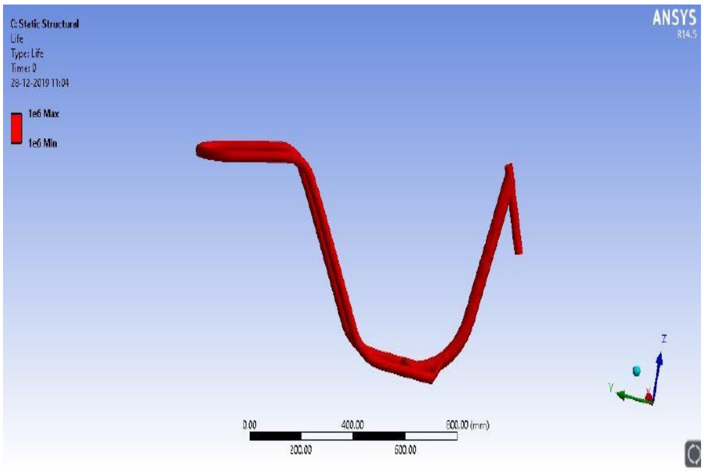

Fig: Total life

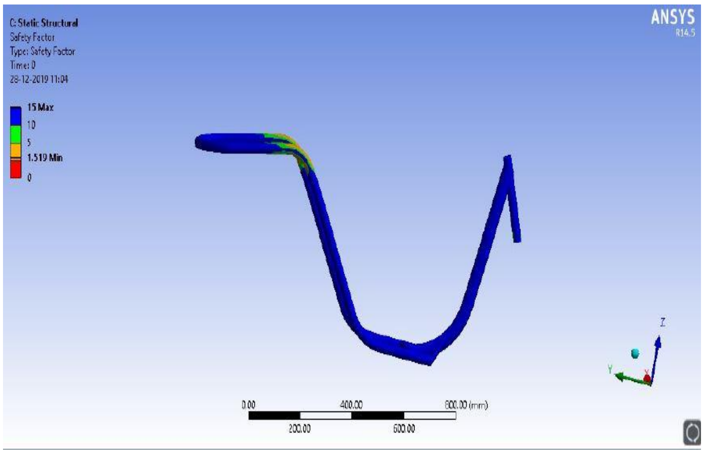

Fig: Safety Factor

3. Result Table:

Table 6: Result Table

Type	Total Deformation	Equivalent (von-Mises) Stress
Minimum	**0 mm**	**2.6011e-003 MPa**
Maximum	**0.73365 mm**	**56.747 MPa**

8. IMPACT ANALYSIS

1. Impact On Static Structure:

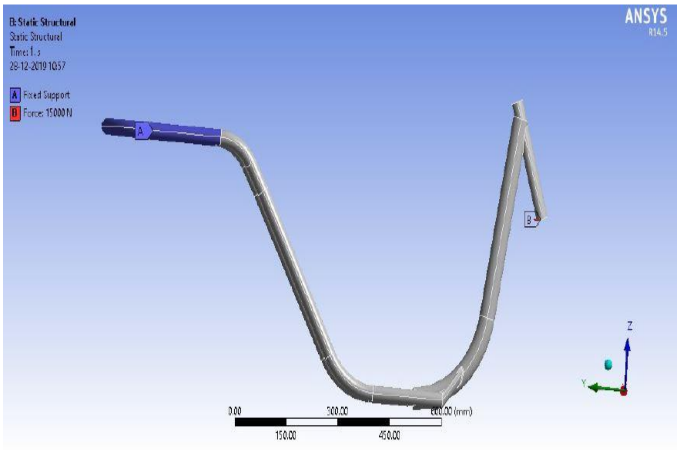

Fig: Static Structural (A)

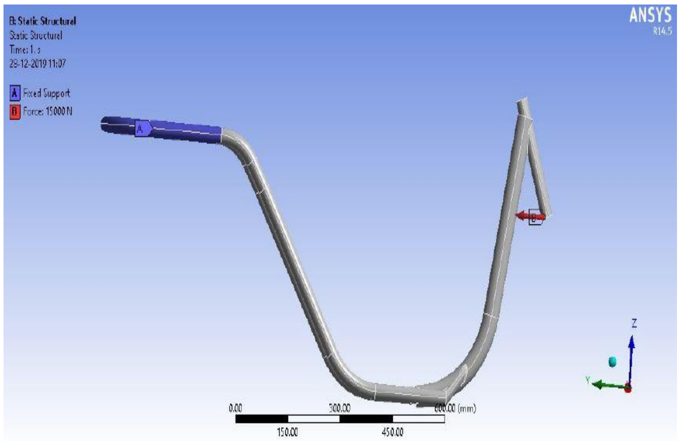

Fig: Static Structural (B)

Define by	Components
Coordinate System	Global Coordinate System
X Component	0. N (ramped)
Y Component	15000. N (ramped)
Z Component	0. N (ramped)

2. Material Data (MILD STEEL)

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

Table 7: Material Data

9. IMPACT ANALYSIS RESULTS:

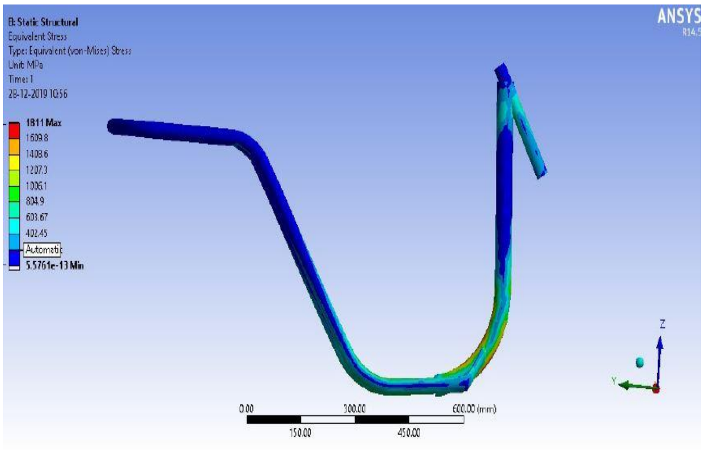

Fig: Equivalent (von-Mises) Stress

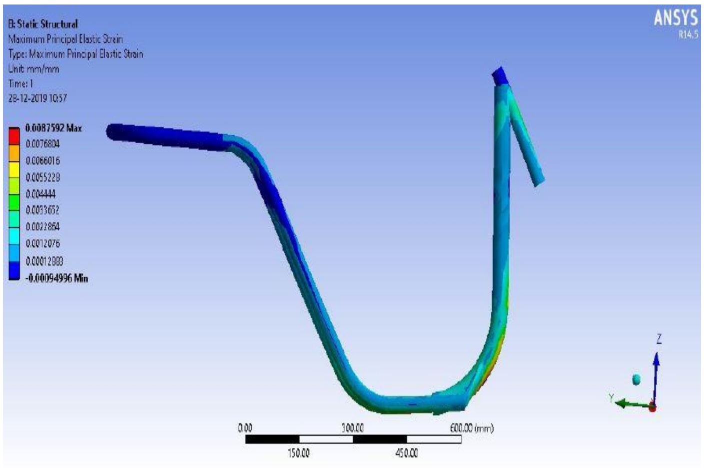

Fig: Maximum Principal Elastic Strain

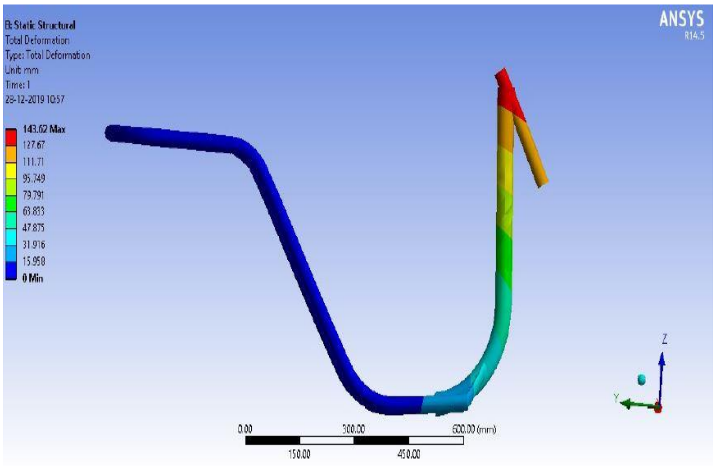

Fig: Total Deformation

3. Result Table:

TYPE	Equivalent (von-Mises) Stress	Maximum Principal Elastic Strain	Total Deformation
Minimum	**5.5761e-013 MPa**	**9.4996e-004 mm/mm**	**0. mm**
Maximum	**1811. MPa**	**8.7592e-003 mm/mm**	**143.62 mm**

Table 8: Result Table

10. CONCLUSION:

The design and functional requirements of an electric scooter were considered while designing the frame. The frame design not only provides better strength but also better components mounting. A FEA model was created and an analysis of the frame was carried out for different **LOADS** and **IMPACTS** which showed that **the design is safe for even the maximum load of 170kg i.e. 1667N.**

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NOMENCLATURE:

Quantity	Symbol
Density	**ρ**
Coefficient of Thermal Expansion	**α**
Specific Heat	**c**
Thermal Conductivity	**k**
Resistivity	**Ω**
Stress	**σ**
Strain	**ε**
Modulus of Elasticity	**E**

Table 9: Nomenclature table.

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