FRAME & BODY WORKS REPORT

FRAME

INTRODUCTION:

The frame of a vehicle is the skeleton. One of the main factors considered during designing the Eco-Spartan is safety. Safety for driver and costly components such as panel and motor should be ensured from damage. The other main factor is weight reduction which is a challenge to improve safety and stability with reduced weight.

OBJECTIVE:

Since the use of solar vehicle is for economy it indeed must have a low weight chassis but it shouldn't come with a loss in safety. The design is to optimise the frame for safety along with reduced weight by application of few special features.

Softwares used:

SolidWorks 2013, Creo2, ANSYS

FRAME TEST:

1. Front Impact
2. Rear Impact
3. Side impact
4. Torsional test
    1. Front torsional test
    2. Back torsion test
5. Static loading (Load carrying capacity)

Material Study:

Material	Hot Rolled Steel	Cold Rolled Steel	Aluminium
Technical Name	**AISI 1020 HR**	**AISI 1020 CR**	**T6 6160 Aluminium**
General study	Appearance -*rough* More malleable Best for making beams & I sections Final size has to be considered. *Pros:* Weldability *Cons* : column & lateral buckling occurs	Appearance – *smooth* More precise in dimension. More durable and tolerant Final product size will be of close tolerance. *Pros*: *harder / stronger / less ductile* when compared with hot rolled steel	Appearance- White Light weight More ductile, prone to dent Rigidity is less compared to other two Pros: light weight *Cons*: Costly, difficulty to weld

Density	7.77g/cc	7.8g/cc	2.7g/cc
Tensile strength	Ultimate- 420 MPa Yield- 350 MPa	Yield - 205 Mpa Ultimate - 380 Mpa	Yield - 241Mpa Ultimate -300Mpa
Bulk Modulus	140 GPa	140 Gpa	76 GPa
Shear modulus	80.0 GPa	70 Gpa	26GPa
Young's Modulus	205 GPa	210 Gpa	75 GPa
Hardness(Brinell)	121	111	245 MN m-2
Elongation at Break (in 50 mm)	15 %	25%	17%
Reduction of Area	40 %	50%	55%
Thermal Conductivity	51.9 W/m-K	51.9 W/m-K	173 W /m-k
Specific heat capacity	0.486 J/g-°C @Temperature >=100 °C 0.519 J/g-°C @Temperature 150 - 200 °C	0.486 J/g-°C @Temperature >=100 °C 0.519 J/g-°C @Temperature 150 - 200 °C	0.896 j/g-^{o}c
Melting Point			580^{O}C
Cost/ Kg			
Composition	HOT ROLLED: C -0.17 - 0.23 %; Fe-99.08-99.53 %; Mn-0.30-0.60%; P - 0.040%; S - 0.050%	COLD ROLLED: C-0.17 - 0.23 %; Fe-99.08 - 99.53 %; Mn-0.30 - 0.60 %; P<= 0.040 %; S<= 0.050 %	ALUMINIUM: Cr- 0.04-0.35; Cu-0.15-0.4; Fe-0.7; Si-0.4-0.8; Zn0.25, Ti-0.15

Based on the above material study and commercial availability its opted that AISI 1020 CR is best material for frame design.

DESCRIPTION:

Various dimension of Steel are used based on their application and mode of stress acting.

1.1inch dia & 1.2mm thick steel tubes - Primary structural frame

2. 0.75inch dia & 1mm thick steel tubes- Supporting members and other secondary frame

3. 0.5inch dia & 1mm thick steel tubes - minor supports and stress distributors

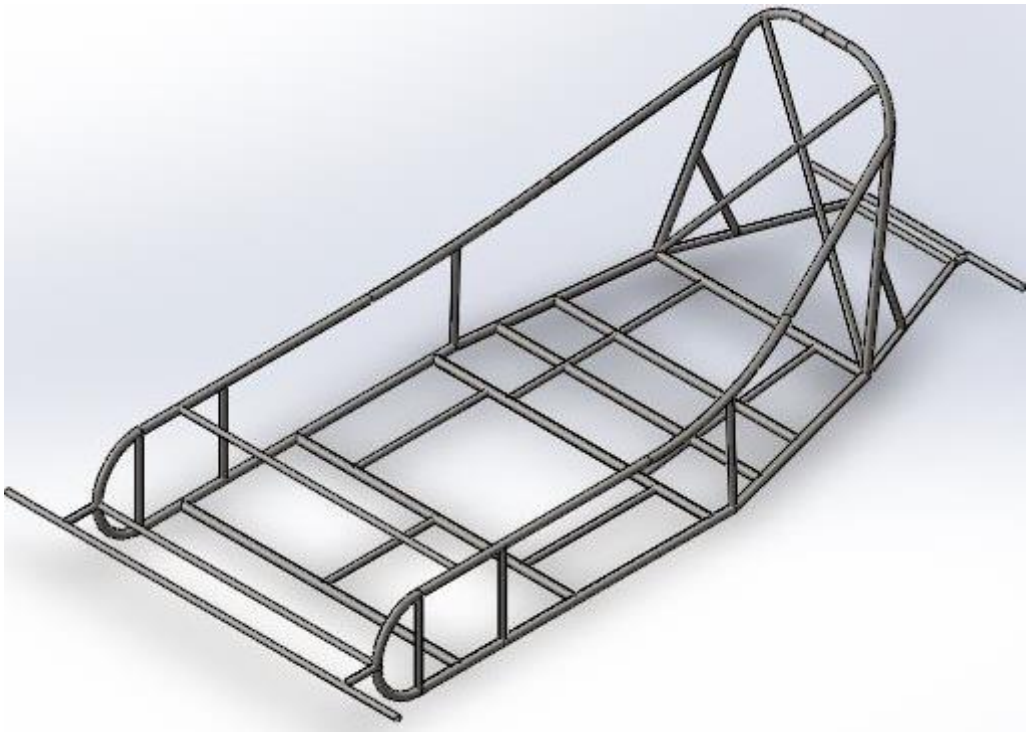
Weigh Of the Frame:

By analysis using simulation with the material AISI 1020 Cold rolled steel

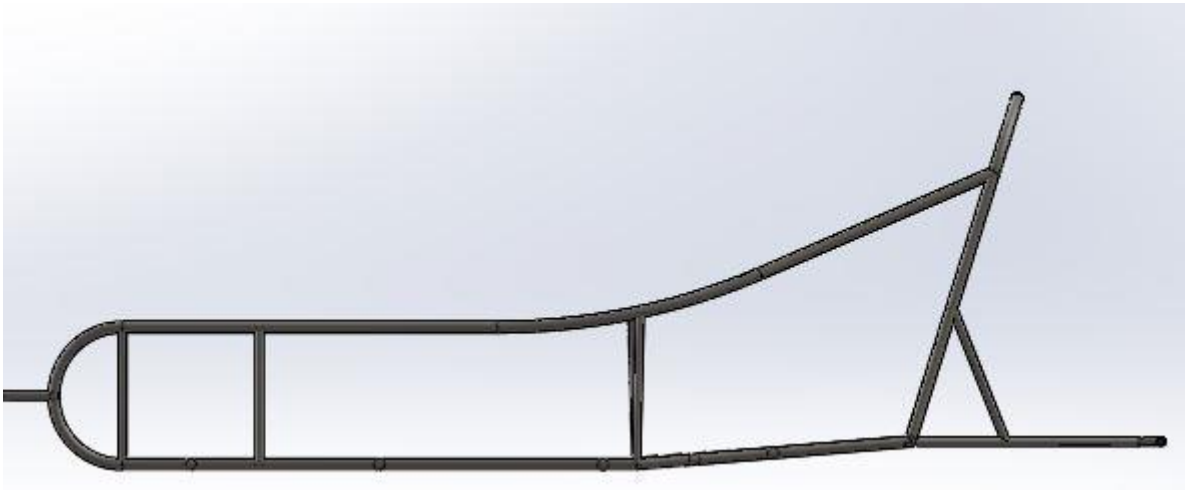
The estimated weight of the frame is 16kg (Using Solid Works)

FRAME DESIGN

Isometric View

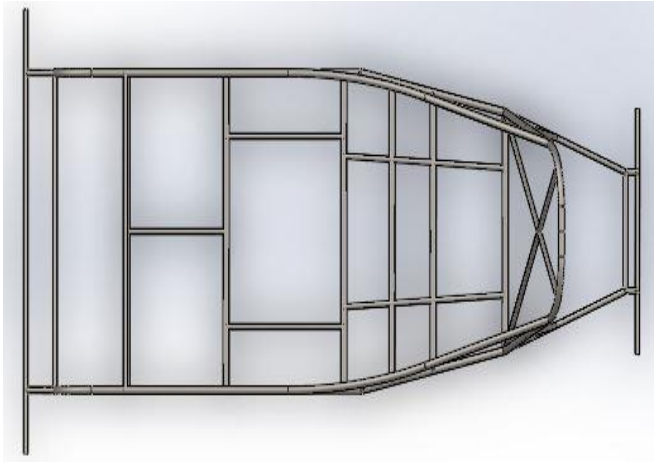


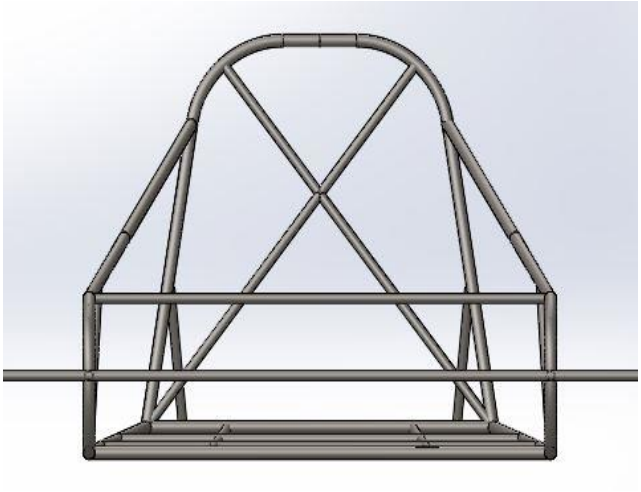
Side View



Top view

Front view





TESTS ON FRAME

The tests are carried out based on following procedure and parameters.

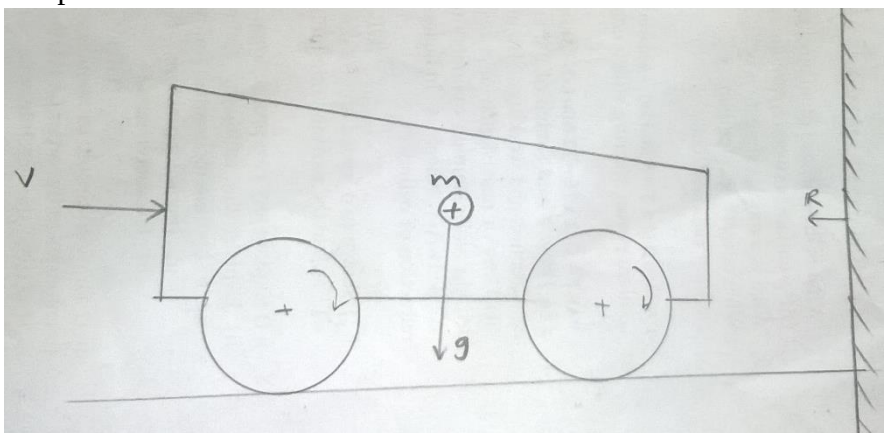
Consider the vehicle hits an inelastic fixed object eg. Concrete wall

The four components of force are: magnitude, direction, point of application, and line of action

Weight of Vehicle m : 180kgf (Driver weight = 60kgf)

Speed of Vehicle v : 40km/hr = 12m/s

Time on impact t : $1/10^{th}$ of a second



Consider the total mass of vehicle as a single unit.

Determination of Impact Force (F):

We know, Force = Mass x Acceleration => F=M x a

Determination of mass `M':

Mass M = weight/gravity = 180/9.81 = **21kg**

Determination of Acceleration `a':

Acceleration = Change in velocity = $(v_o-v_1)/t$

Where v_o =velocity after impact = 0m/s

v_1= velocity before impact = 40km/hr = 12m/s

t = time on impact = 0.1sec

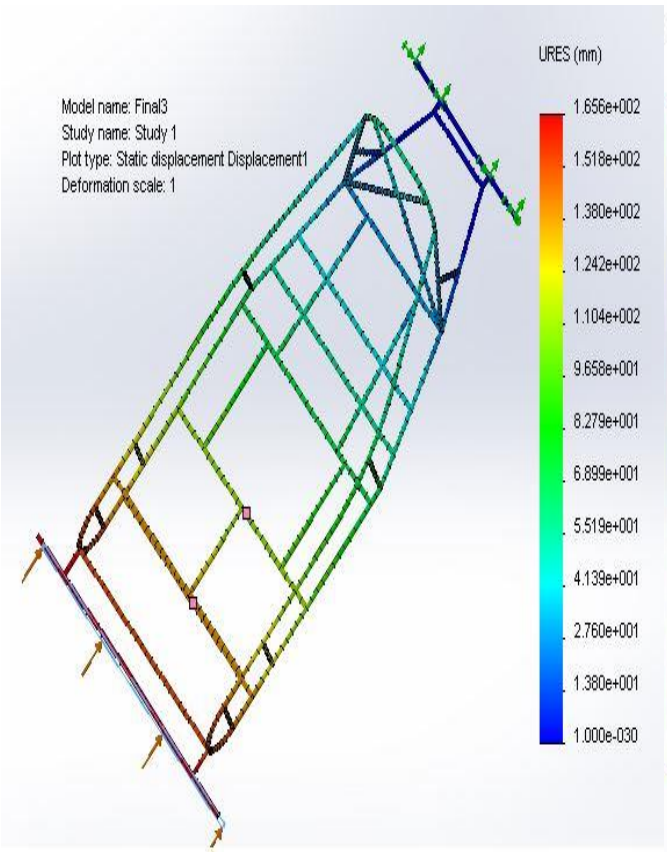
Acceleration a = (0-12)/0.1 = **-120m/s^2 (- sign means deceleration)**

Calculation of Impact Force:

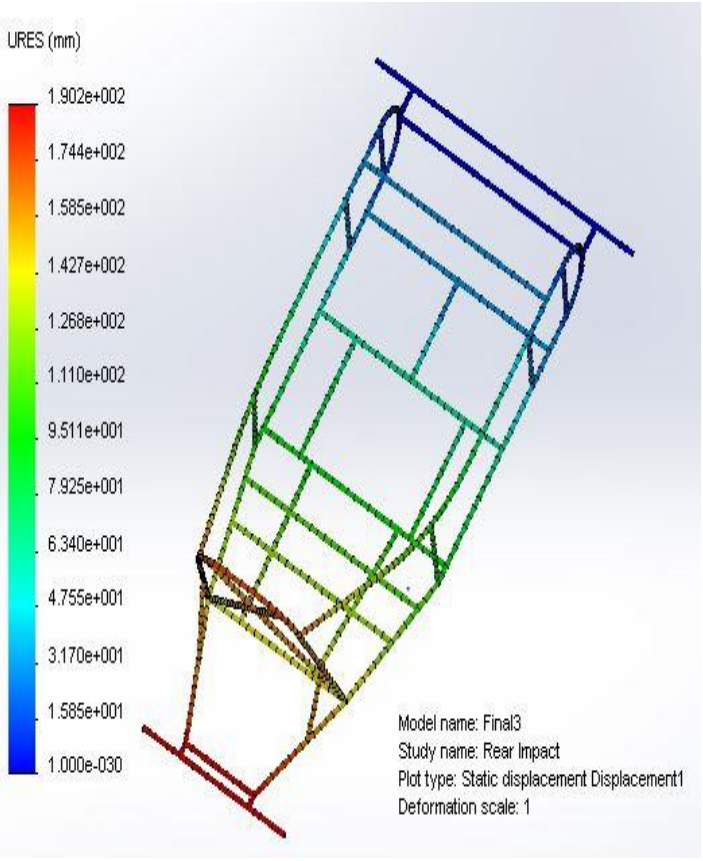
Force F = M x a = 21 x 120 = **2520N**

Impact force is 14 times the weight of the vehicle. The following test are carried out under this calculated force.

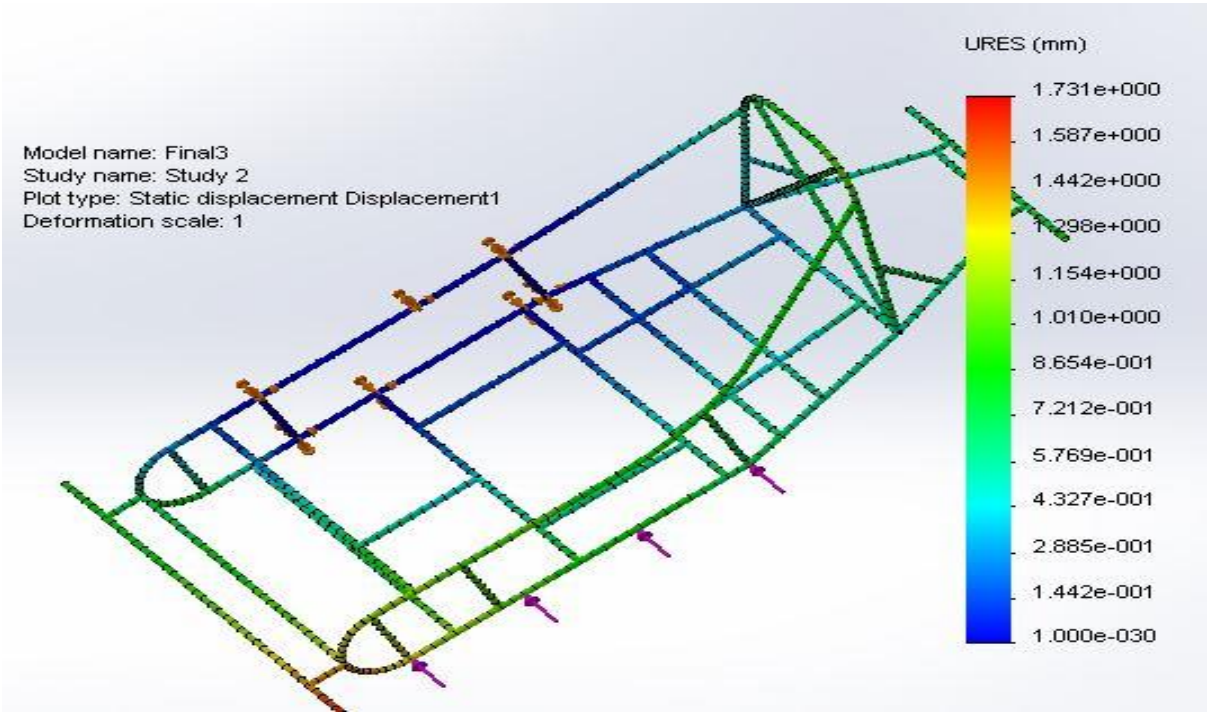
1. FRONT IMPACT TEST



2.REAR IMPACT TEST



3.SIDE IMPACT



TEST	Min. FOS	Max Displacement (URES) In mm	Max. Stress Axial and Bending
FRONT IMPACT	4.3	160	550 MPa
REAR IMPACT	2.2	190	650MPa
SIDE IMPACT	5.4	1.731	140MPa

4. TORSION TEST

This test determines the rigidity of the frame and ensures safety in real time. Torsion will occur when a wheel takes a sudden pit where load gets shifted to one side. Vehicle must be in such a way it takes in these sudden torsional loads.

Calculation:

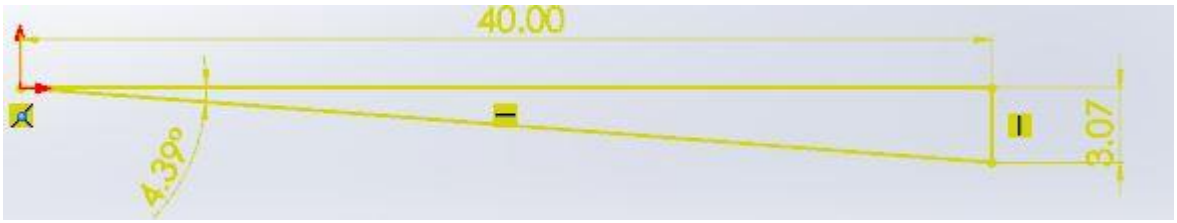
One side of the frame is fixed and load is applied on the other side. The following simulation is done with load of 1000N

The result is expressed as *Torsional stiffness* i.e how much moment the frame requires to undergo 1^{o} of deflection

$K = M/\Theta$ M- moment N.m | Θ - angle deflected ^{0}degree

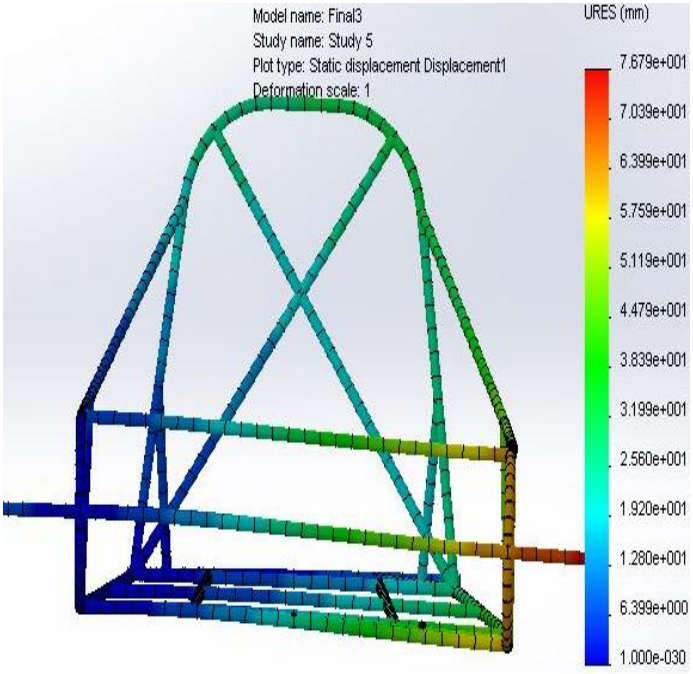
Eg. M= Force x distance = 1000N X 1.016m(40in)=1016Nm

Θ= calculated using drawing

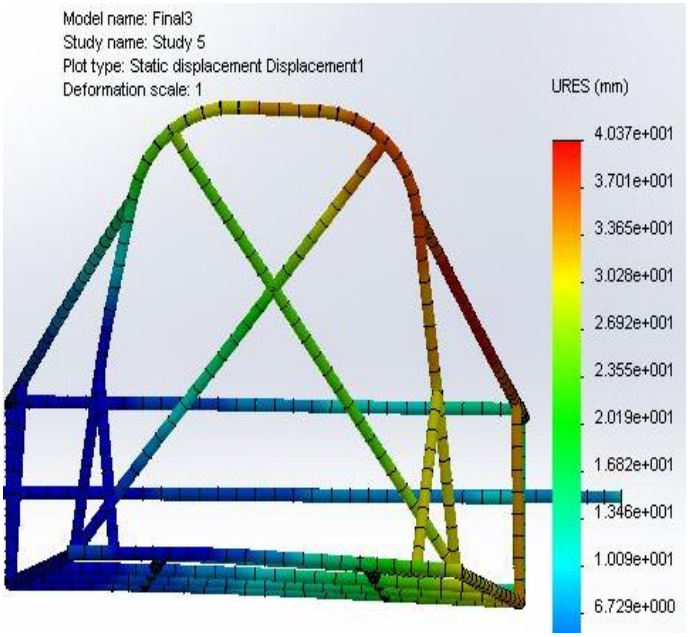


K=M/Θ = 1016/4.39 = 232Nm/degree

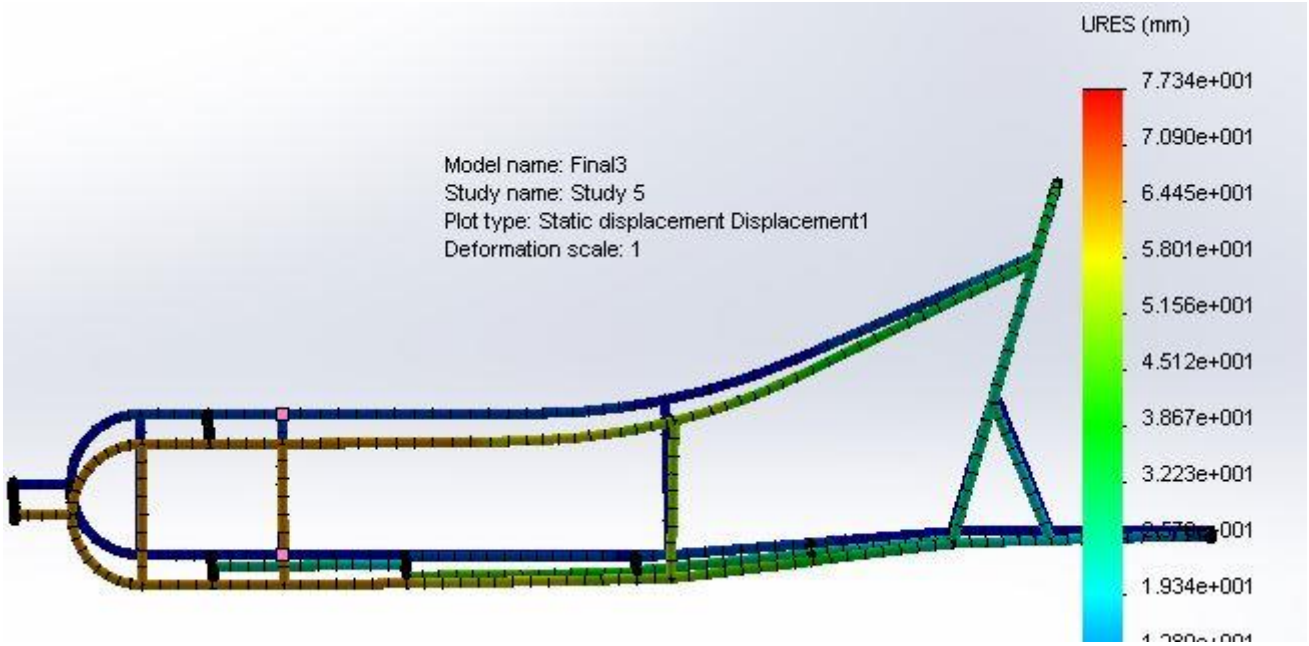
Front Torsion



Back Torsion



Full Torsion



Test	Front Torsion	Back Torsion	Full Torsion
Min. FOS	2.8	2.34	2.4
Max. displacement in mm	76.79	40.37	77.34
Torsional Stiffness	210Nm/deg	254Nm/deg	232Nm/deg
Max. Stress –Axial and Bending	240MPa	180MPa	235Mpa
Max. Stress - Torsion	160MPa	90MPa	140MPa

5. STATIC LOADING:

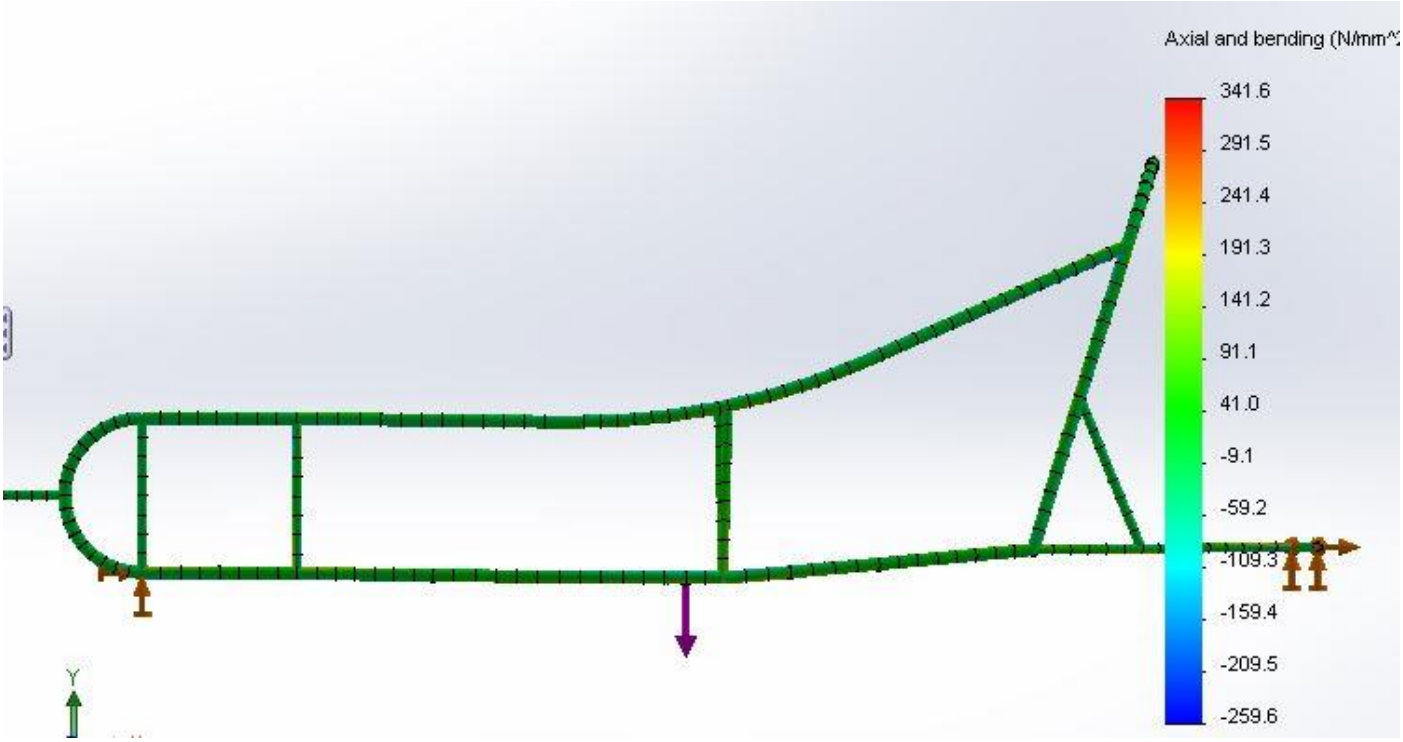
Load carrying capacity of the vehicle must be tested, based on that welding of frame tubes to prevent failure due to stress concentration.

Max load acting on vehicle is where maximum vertical displacement will occur.

Calculation:

Load = weight of driver+ battery weight + additional load= 1000N

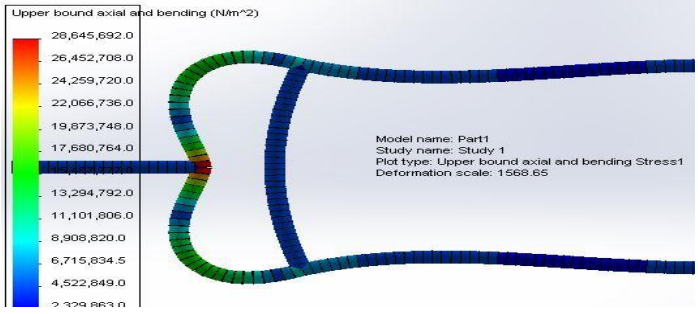
Test	Min. FOS	Max. Displacement
Static Loading	**2.1**	**13.84mm**

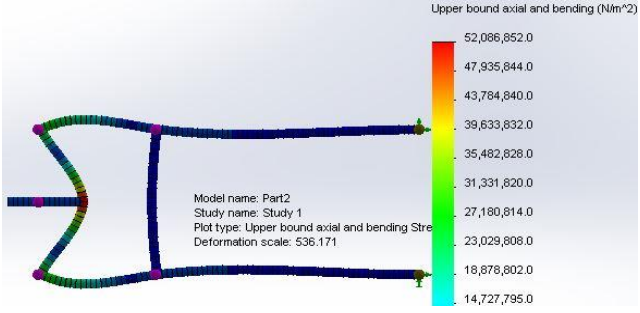


SPECIAL FEATURES

1. Circular Beam

The frame tube is heated and bent to a circular structure.





Comparison Study(Tested under 250N)

Parameters	Curved Beam	Straight Beam
Max. Stress N/mm^2	72	94
Min. FOS	12.2	8.4

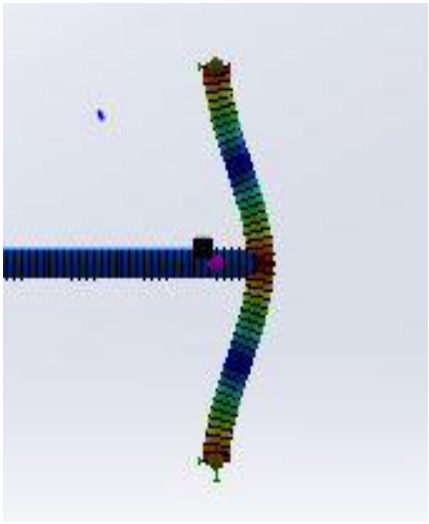
Advantage over straight structure:

- Load gets distributed evenly as there is no sharp curves.
- Ability to bead more load and take in more stress before deformation.

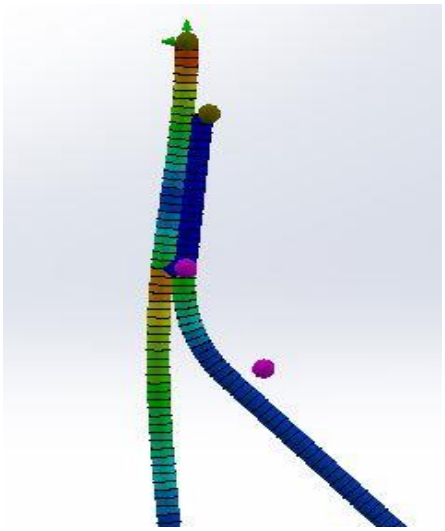
2. Parallel Welding

One of the main failure to expect is welding failure. In order to overcome this issue parallel welding is done. The welding area is increased to effectively take in more stress without deforming. Other positive in this is that the welding is subjected to compressive load. A solid body can withstand more compressive stress than tensile stress. This improves the strength of the frame.(This feature is not included in tests to simplify analysis)

Deformation test results:



Perpendicular weld



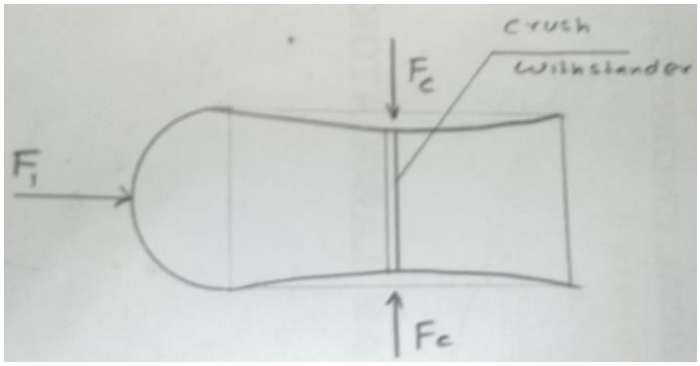
Parallel weld

Advantage:

More the area of weld = More the strength of weld = Less stress concentration

3. Curved Structures

The frame structures are bent inward to 1^o-2^o.This helps the beam to bend inward instead of bending outward. Bending outward can create cracks easily in the weld as it induce tensile stress. Curving inward induces compressive stress which can be absorbed by a cross member.



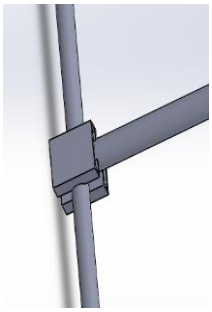
Here a pushing force acts on the curved part. Due to pre-existing inward curve the linear members start to buckle and go inwards and this is supported by a crush withstanding member (Short steel pipe).

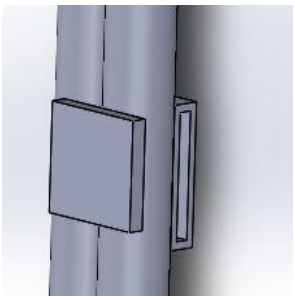
Advantage:

- Adds additional safety to the frame

4. Plate welds

Joints bearing more loads the weld is given additional strength using plates. This increases the joint strength thus helping improve safety of frame.





CONCLUSION:

The design in optimised as shown above and safety, economy and vehicle dynamics has been ensured and the results are more than convincing.

TEST	Minimum FOS
Weight of Frame	15.94
Front impact	4.3
Rear Impact	2.2
Side Impact	5.4
Front Torsion	1.8
Back Torsion	1.34
Full Torsion	1.64
Static Loading	2.1

The driver and the costly components are safe guarded from usual chances of accident.

BODY WORKS

INTRODUCTION

While the frame being the skeleton, the body works are the skin. The vehicle must look attractive and look elegant for marketing. Since the cost limitations are high. Simple, less costly yet effective bodyworks has to be done.

DESCRIPTION:

Bodyworks used in the vehicle comes in categories

1. Base covering
2. Provisions for placements of components
3. Painting and appearance

1. Base Covering:

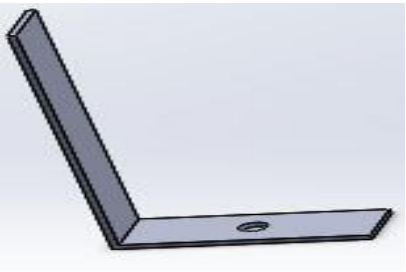
The base must be covered to prevent unwanted air turbulence of air and dust from coming up to the driver from the ground. It also provides room for driver to adjust and stand up.

Battery and circuit box are placed over this covering. It also adds up look for the vehicle.

Material used	Thickness	Weight
Dimond Sheet	2mm	8kg

2. Provisions for placement of components

L-Clamps are used to keep the batteries and circuit box in position so that they won't slip and disturb the driving of the vehicle. These clamps have position for bolts and are fixed to the bottom cover.



3. Painting and Appearance

The vehicle is painted using paints. This prevents rusting of frame structure and other metals. This fairly improves the endurance life of the vehicle. While adding attractive look to the vehicle. A fine smooth paint can reduce resistance from air drag.

Surface area to be painted	Thickness paint	Volume of paint required
2.4 m^2	1mm	0.0024m^3=2.4litres

Additional team logo painting adds up an advantage.

CONCLUSION:

All bodyworks help improve comfort and elegance to the vehicle. This is a add in advantage to feel good about the vehicle when driving.