20055_SAMANVAYA RACING_CAE Report

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1. INTRODUCTION

The objective of this report is to present the CAD design & analysis of our vehicle for ADVANCE EFFICYCLE 2020 SEASON.

Our aim is to design a vehicle with good built quality and better strength by using a high strength material for roll cage. We have also considered various measures for compactness, better ergonomics, safety etc. For this we have designed the roll cage in SOLIDWORKS 2016 x64 SR15.0. The analysis is done for different materials to finalize the material for roll cage

2. FRAME MATERIAL DETAILS

The material is used with different cross-sections and its separate combinations are written below:

i. Steel (AISI 1018)
Cross-Section Type; 1in x 0.84in x 2mm

ii. Steel (AISI 1018)
Cross-Section Type; 1.25in x 1.13in x 1.5mm

iii. Steel (AISI 4130)
Cross-section type; 1.25in x 1.13in x 1.5mm

iv. Steel (AISI 4130)
Cross-section type; 1.25in x 1.11in x 1.65mm

PROPERTIES/MATERIAL	SAE 1018	SAE 4130
Density (gm/cm^3)	7.87	7.85
Elongation (%)	16-27	17-28
Elastic Modulus (GPa)	205	205
Yield Strength (MPa)	365	460
Ultimate Tensile Strength (MPa)	440	560
Poisson Ratio	0.29	0.29
Shear Modulus (GPa)	80	80
Cost (per m)	Rs.375	Rs.525
Roll Cage Weight (kg)	32Kg	32.8Kg
Lead time for delivery (days)	7	7

3. CALCULATION OF BENDING STRENGTH AND BENDING STIFFNESS

		Bending Strength	Bending Stiffness
	Unit	N/m^2	Nm^2
Material-1	AISI 1018		
Cross Section	A=1in B= 0.84in T = 2mm	291.31	2.128 x10^3
Material-2	AISI 1018		
Cross Section	A= 1.25in B= 1.13in T =1.5mm	371.99	3.381 x10^3
Material-3	AISI 4130		
Cross Section	A= 1.25in B= 1.13in T =1.5mm	468.82	3.381 x10^3
Material-4	AISI 4130		
Cross Section	A=1.25in B=1.11in T=1.65in	354.46	3.014 x10^3

We know that,

Bending strength is given by: **$M= (S_y*I)/C$**
Where: S_y = Yield strength
C = Distance from neutral axis to extreme fiber

Also, Bending Stiffness is considered to be proportional to the product EI.

i.e. **Bending Stiffness $\propto$ E.I**
Where: E= Modulus of elasticity
I= Second moment of area for the structural cross section

Bending Strength

M(Material 1) =365*10^{-6} x(1.01 x10^4)/(12.7 x 10^{-3})

= 291 .31 N/m^2

M(Material 2) =365 * 10^{-6} x(1.61 x 10^4)/(15.875 x 10^{-3})

= 371.99 N/m^2

M(Material 3) =460 * 10^{-6} x(1.61 x 10^4)/(15.875 x 10^{-3})

= 468.82 N/m^2

M(Material 4) =460 * 10^{-6} x(1.22 x 10^4)/(15.875 x 10^{-3})

= 354.46 N/m^2

4. CAE ANALYSIS OF VEHICLE/FRAME

Impact force = 2G
Meshing Conditions- Relevance Centre= Fine
Relevance=100
Element Size= 10mm

4.1. FRONTAL IMPACT ANALYSIS

Material-1 (Steel AISI 1018,1inx0.84inx2mm)

a) Assumption & Considerations:

Following assumptions & consideration were made for performing the analysis for frontal impact on frame/vehicle.
Impact force was applied on the foremost part of the roll cage.

Mounting points of suspension arms were fixed.

Initial Speed=9.11m/s

Final Speed=0m/s

Reaction time=0.13s

b) Calculation of Impact Forces:

Work Done= $(0.5*M*V_{final}^2 - 0.5*M*V_{initial}^2)$

$|W|=|-0.5*M*V_{initial}^2|$

$=|-0.5*245*9.11^2|$

=10166.5 Nm

Work Done=Force * Displacement

=(F*S)

$S=\text{Impact Time}*V_{max}$

=0.13*9.114

=1.184m

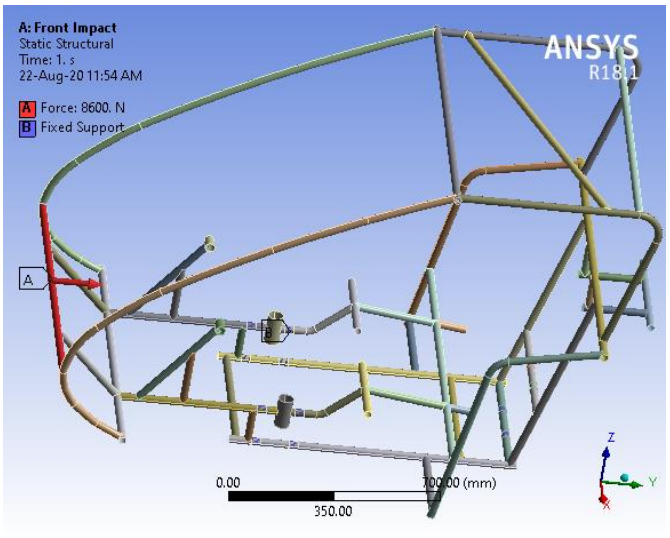
So,

F=W/S

=10166.5/1.184

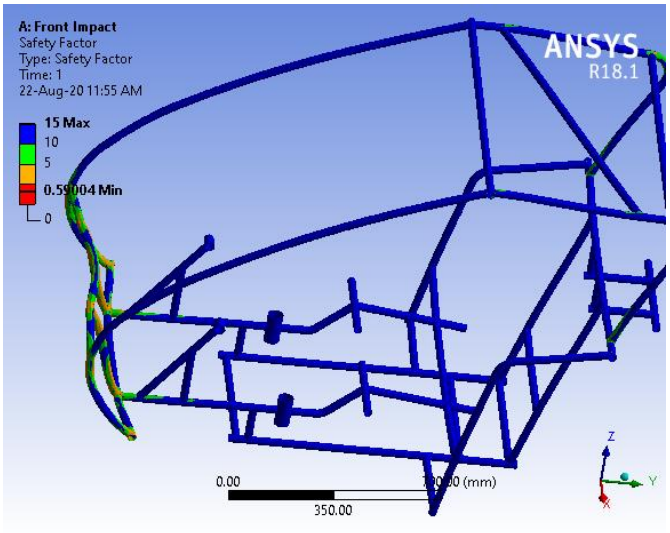
=8586.5 N

≈8600 N

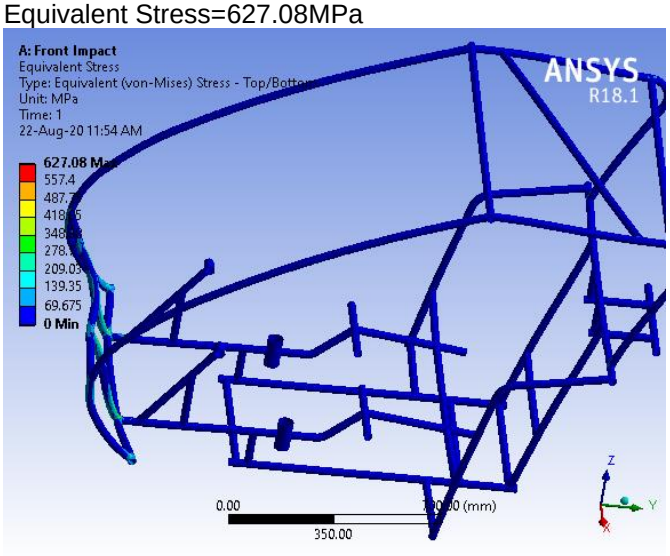


c) Analysis Results:

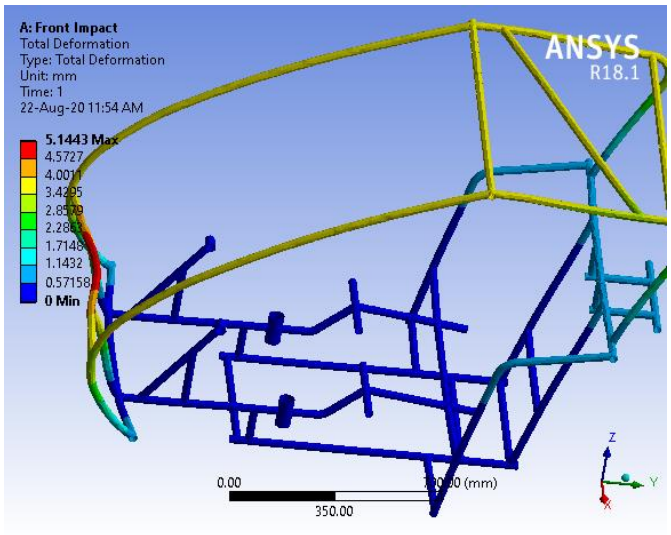
Safety Factor=0.59



Equivalent Stress=627.08MPa



Total Deformation = 5.14 mm



d) Optimizations:

* Unnecessary members are removed

* T joints are preferred instead of corner joints

Material-2 (Steel AISI 1018,1.25inx1.13inx1.5mm)

a) Assumption & Considerations:

Following assumptions & consideration were made for performing the analysis for frontal impact on frame/vehicle.
Impact force was applied on the foremost part of the roll cage.

Mounting points of suspension arms were fixed.

Initial Speed=9.11m/s

Final Speed=0m/s

Reaction time=0.13s

b) Calculation of Impact Forces:

Work Done= $(0.5*M*V_{final}^2 - 0.5*M*V_{initial}^2)$

$|W|=|-0.5*M*V_{initial}^2|$

$=|-0.5*245*9.11^2|$

=10166.5 Nm

Work Done=Force * Displacement

=(F*S)

$S=\text{Impact Time}*V_{max}$

=0.13*9.114

=1.184m

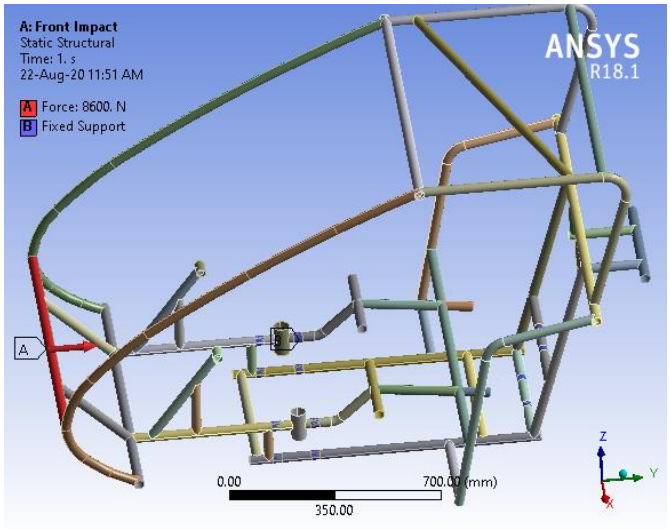
So,

F=W/S

=10166.5/1.184

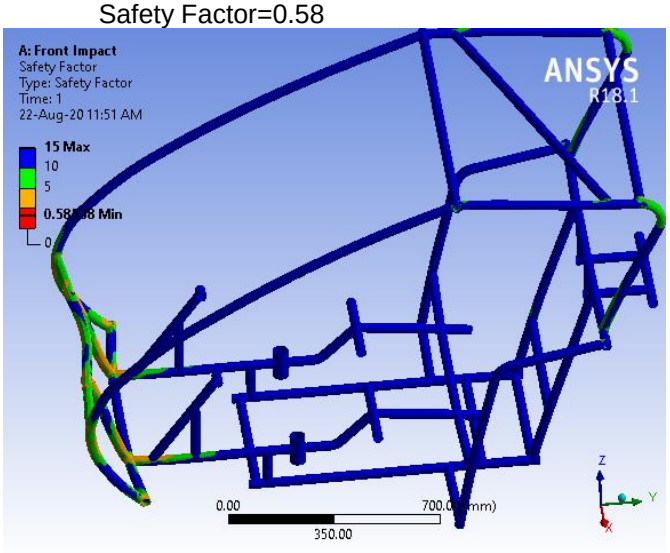
=8586.5 N

≈8600 N

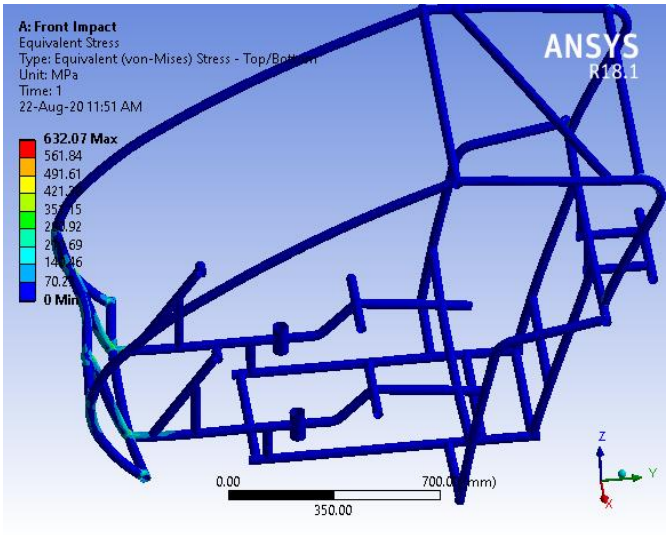


c) Analysis Results:

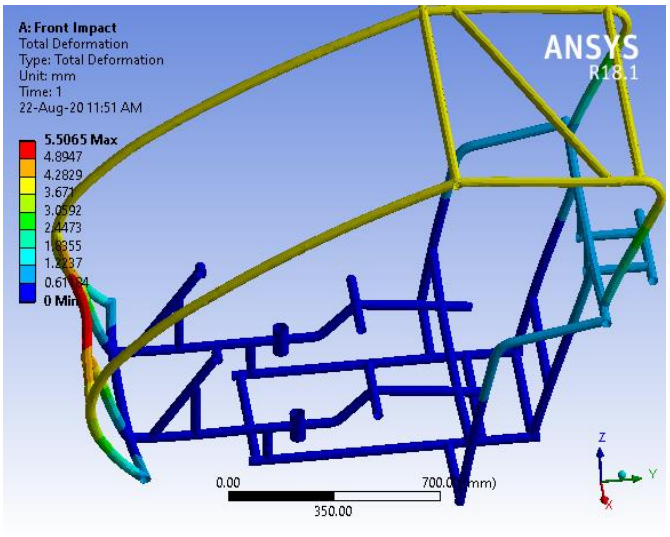
Safety Factor=0.58



Equivalent Stress=632.07MPa



Total Deformation = 5.50 mm



d) Optimizations:

* Unnecessary members are removed

* T joints are preferred instead of corner joints

Material-3 (Steel AISI 4130,1.25inx1.13inx1.5mm)

a) Assumption & Considerations:

Following assumptions & consideration were made for performing the analysis for frontal impact on frame/vehicle.

Impact force was applied on the foremost part of the roll cage.

Mounting points of suspension arms were fixed.

Initial Speed=9.11m/s

Final Speed=0m/s

Reaction time=0.13s

d) Calculation of Impact Forces:

Work Done= $(0.5*M*V_{final}^2 - 0.5*M*V_{initial}^2)$

$|W|=|-0.5*M*V_{initial}^2|$

$=|-0.5*245*9.11^2|$

=10166.5 Nm

Work Done=Force * Displacement

=(F*S)

S=Impact Time*V_{max}

=0.13*9.114

=1.184m

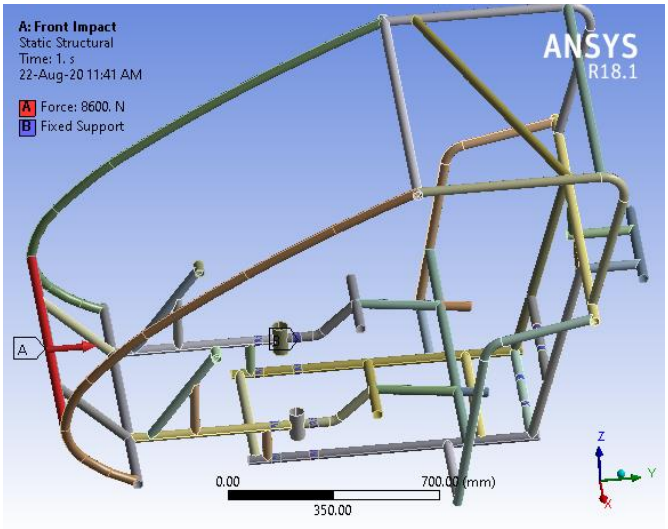
So,

F=W/S

=10166.5/1.184

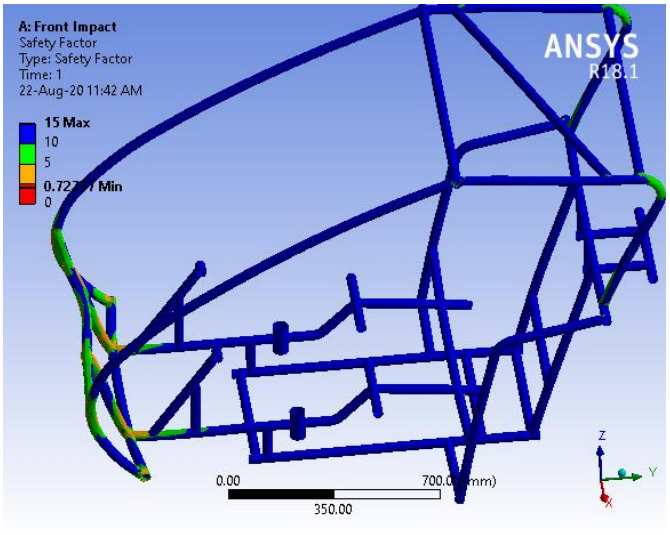
=8586.5 N

≈8600 N

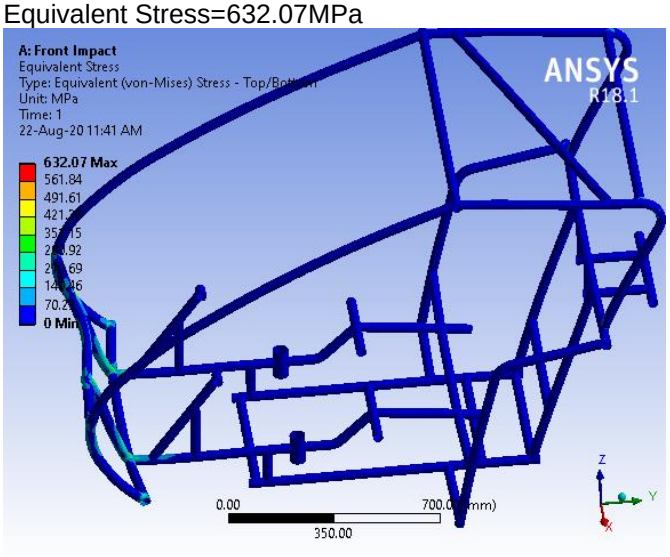


b) Analysis Results:

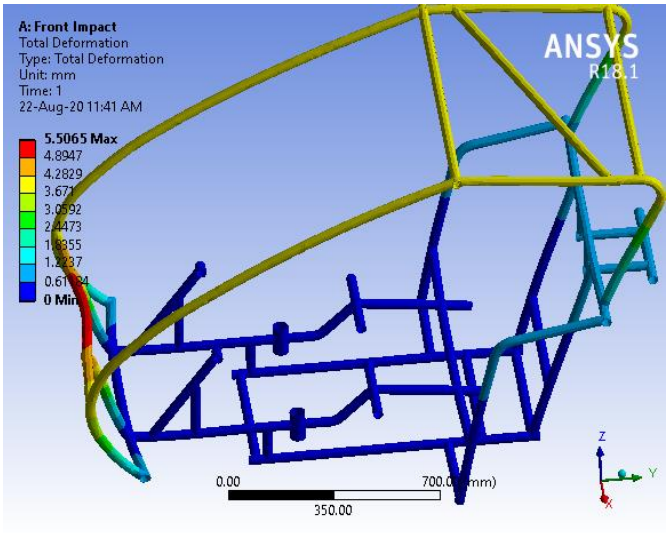
Safety Factor=0.72



Equivalent Stress=632.07MPa



Total Deformation = 5.50mm



d) Optimizations

* Unnecessary members are removed

* T joints are preferred instead of corner joints

Material-4 (Steel AISI 4130,1inx1.11inx1.65mm)

a) Assumption & Considerations:

Following assumptions & consideration were made for performing the analysis for frontal impact on frame/vehicle.
Impact force was applied on the foremost part of the roll cage.

Mounting points of suspension arms were fixed.

Initial Speed=9.11m/s

Final Speed=0m/s

Reaction time=0.13s

b) Calculation of Impact Forces:

Work Done= $(0.5*M*V_{final}^2 - 0.5*M*V_{initial}^2)$

$|W|=|-0.5*M*V_{initial}^2|$

$=|-0.5*245*9.11^2|$

=10166.5 Nm

Work Done=Force * Displacement

=(F*S)

$S=\text{Impact Time}*V_{max}$

=0.13*9.114

=1.184m

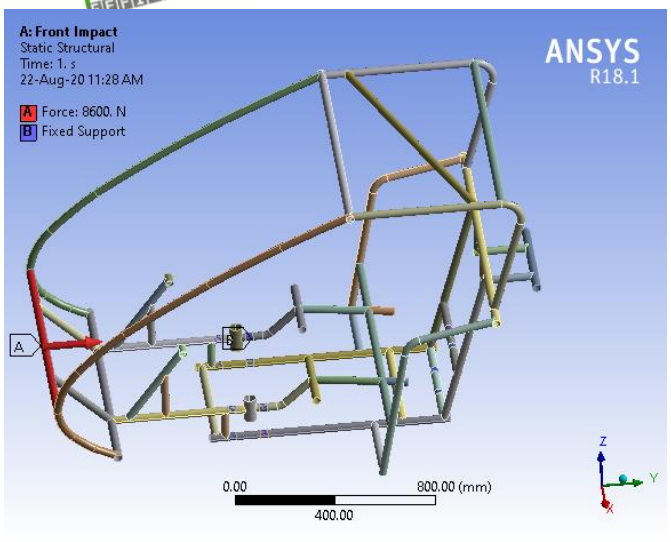
So,

F=W/S

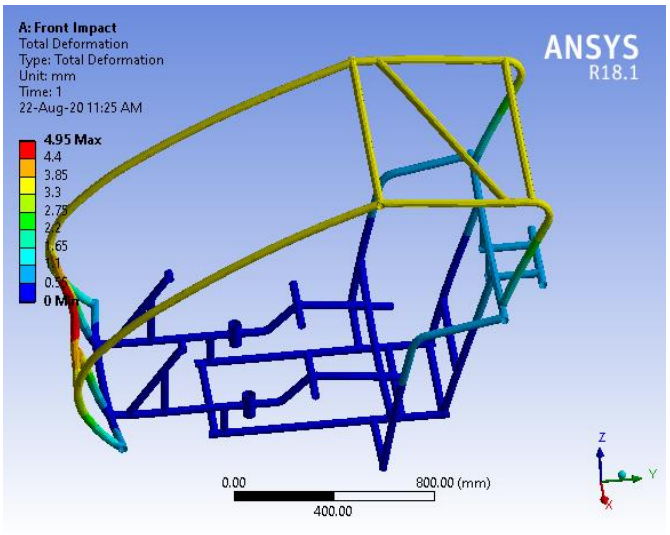
=10166.5/1.184

=8586.5 N

≈8600 N

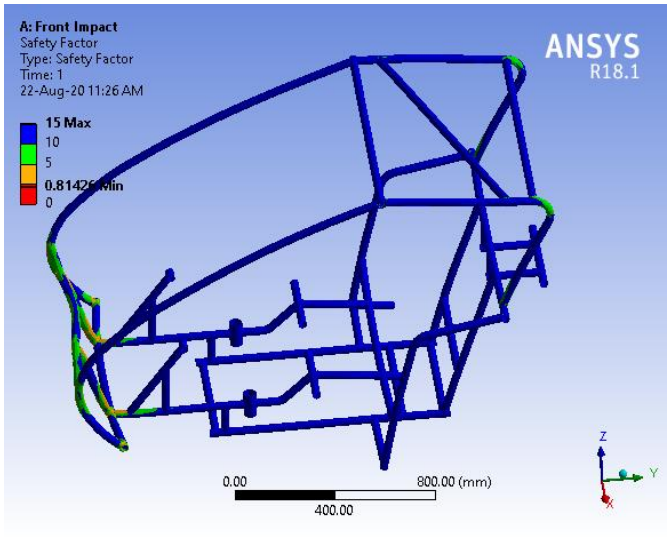


Total Deformation= 4.95 mm

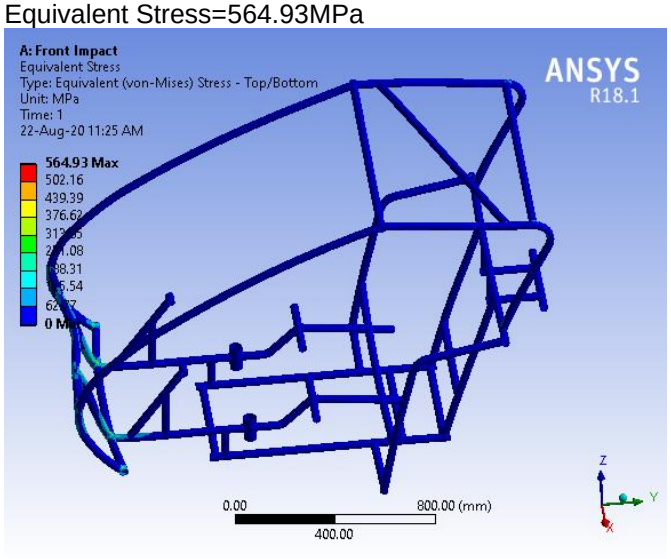


c) Analysis Results:

Safety Factor=0.81



Equivalent Stress=564.93MPa



d) Optimizations:

* Unnecessary members are removed

* T joints are preferred instead of corner joints

4.2. SIDE IMPACT ANALYSIS

Material-1 (Steel AISI 1018, 1inx0.84inx2mm)

a) Assumption& Considerations:

Following assumptions & consideration were made for performing the analysis for frontal impact on frame/vehicle.
Impact force was applied on the foremost part of the roll cage.

Mounting points of suspension arms were fixed.

Initial Speed=9.114m/s

Final Speed=0m/s

Reaction time=0.30s

b) Calculation of Impact Forces:

Work Done= $(0.5*M*V_{final}^2 - 0.5*M*V_{initial}^2)$

$|W|=|-0.5*M*V_{initial}^2|$

$=|-0.5*245*9.114^2|$

=10166.5 Nm

Work Done=Force * Displacement

=(F*S)

S=Impact Time*V_{max}

=0.30*9.114

=2.73m

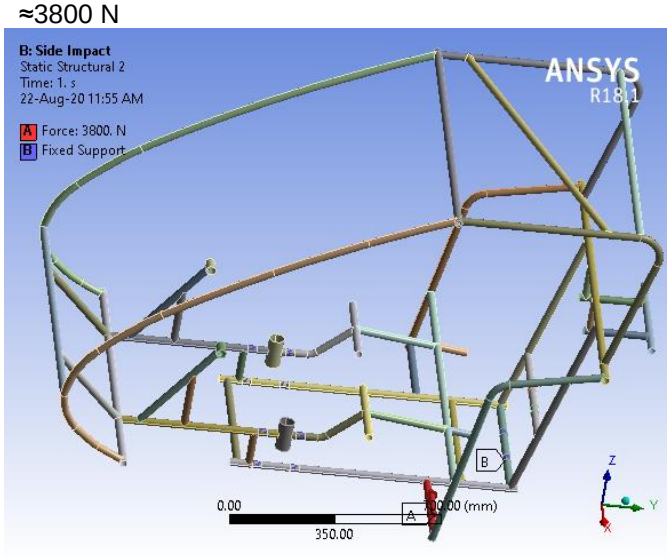
So,

F=W/S

=10166.5 /2.73

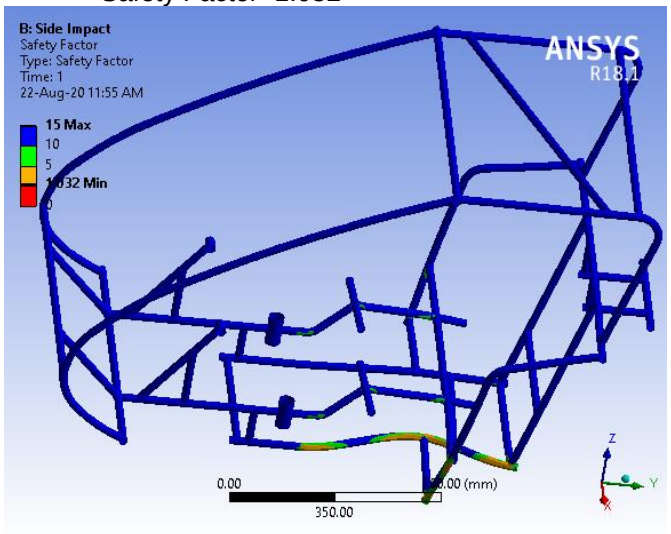
=3723.9 N

≈3800 N

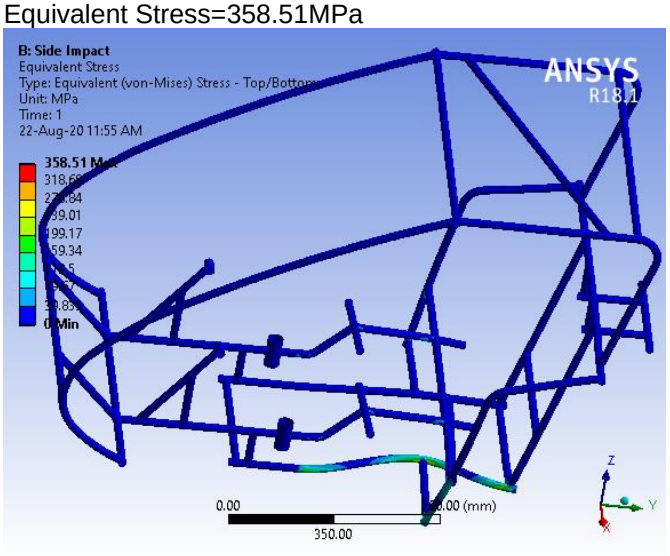


c) Analysis Results:

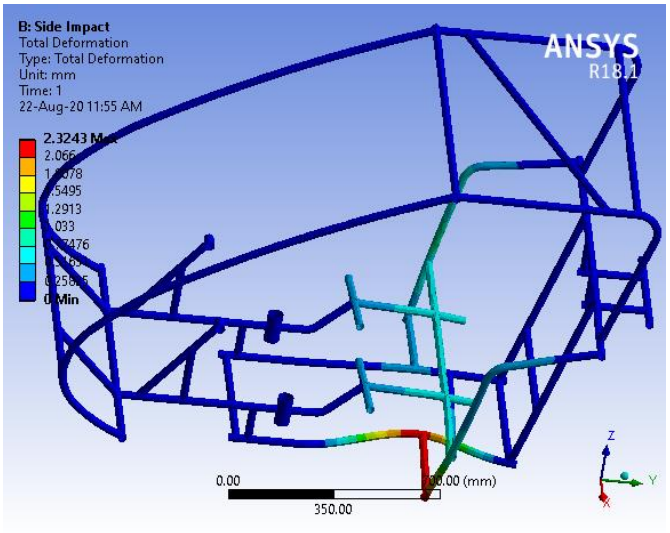
Safety Factor=1.032



Equivalent Stress=358.51MPa



Total Deformation = 2.32mm



d) Optimizations:

* Unnecessary members are removed

* T joints are preferred instead of corner joints

Material-2 (Steel AISI 1018, 1.25inx1.13inx1.5mm)

a) Assumption & Considerations:

Following assumptions & consideration were made for performing the analysis for frontal impact on frame/vehicle.
Impact force was applied on the foremost part of the roll cage.

Mounting points of suspension arms were fixed.

Initial Speed=9.114m/s

Final Speed=0m/s

Reaction time=0.30s

b) Calculation of Impact Forces:

Work Done= $(0.5*M*V_{final}^2 - 0.5*M*V_{initial}^2)$

$|W|=|-0.5*M*V_{initial}^2|$

$=|-0.5*245*9.114^2|$

=10166.5 Nm

Work Done=Force * Displacement

=(F*S)

S=Impact Time*V_{max}

=0.30*9.114

=2.73m

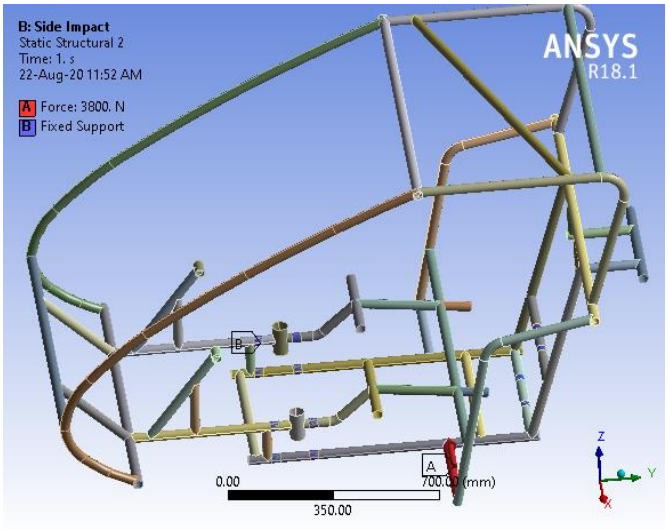
So,

F=W/S

=10166.5 /2.73

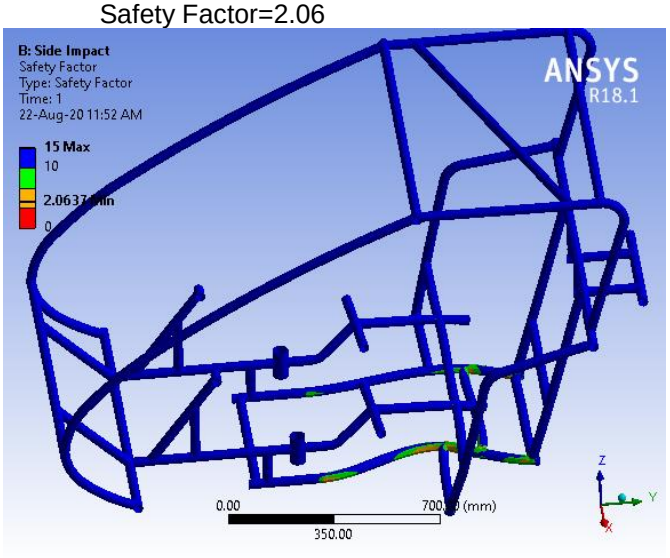
=3723.9 N

≈3800 N

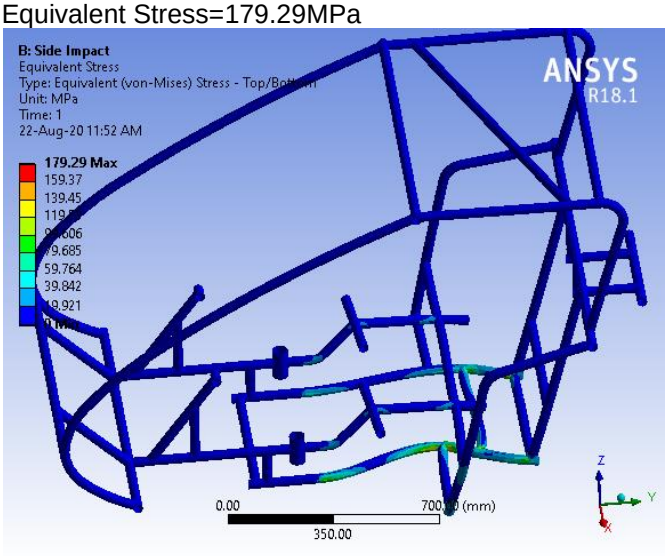


c) Analysis Results

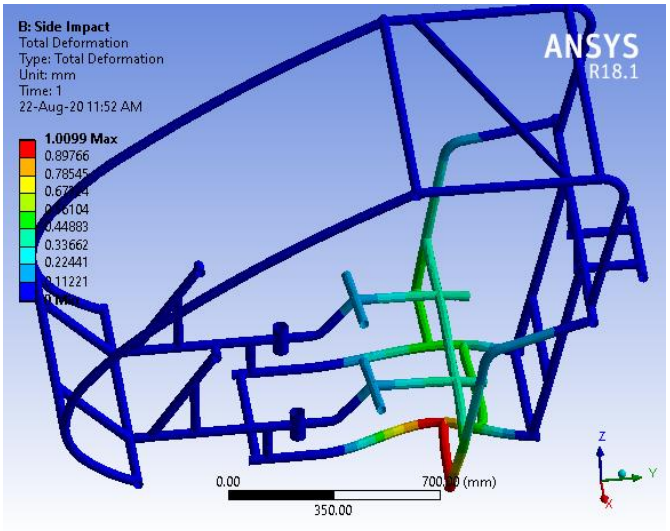
Safety Factor=2.06



Equivalent Stress=179.29MPa



Total Deformation = 1.00mm



d) Optimizations:

* Unnecessary members are removed

* T joints are preferred instead of corner joints

Material-3 (Steel AISI 1018, 1.25inx1.13inx1.5mm)

a) Assumption & Considerations:

Following assumptions & consideration were made for performing the analysis for frontal impact on frame/vehicle.
Impact force was applied on the foremost part of the roll cage.

Mounting points of suspension arms were fixed.

Initial Speed=9.114m/s

Final Speed=0m/s

Reaction time=0.30s

b) Calculation of Impact Forces:

Work Done= $(0.5*M*V_{final}^2 - 0.5*M*V_{initial}^2)$

$|W|=|-0.5*M*V_{initial}^2|$

$=|-0.5*245*9.114^2|$

=10166.5 Nm

Work Done=Force * Displacement

=(F*S)

S=Impact Time*V_{max}

=0.30*9.114

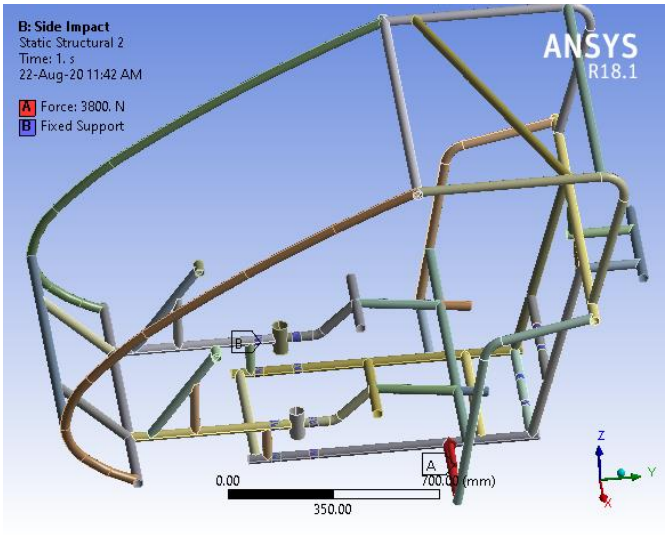
=2.73m

So,

F=W/S

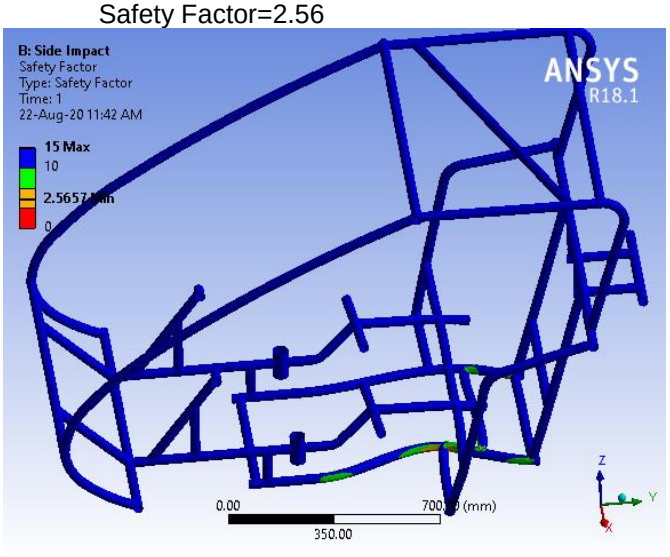
=10166.5 /2.73

=3723.9 N

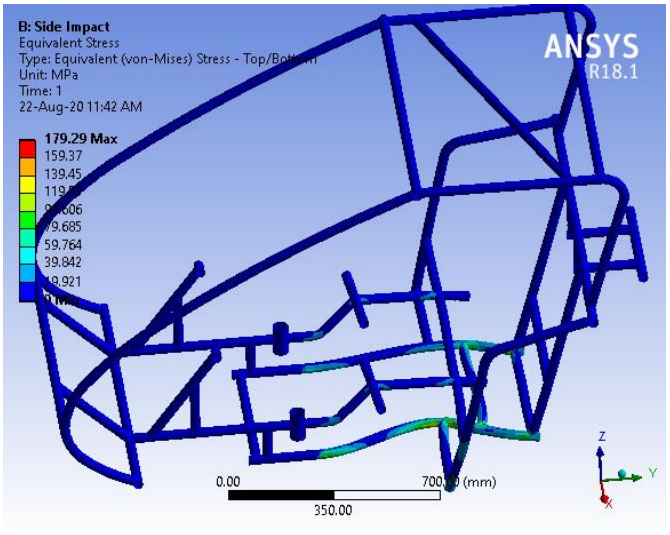


c) Analysis Results

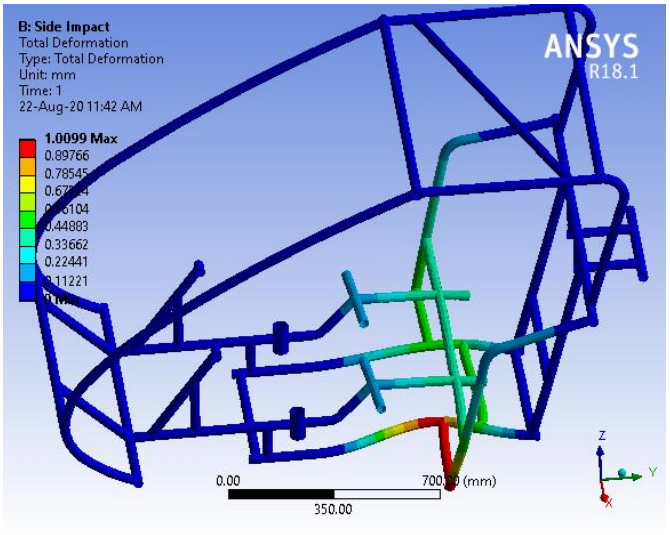
Safety Factor=2.56



Equivalent Stress=179.29MPa



Total Deformation = 1.00mm



=(F*S)

S=Impact Time*V_{max}

=0.30*9.114

=2.73m

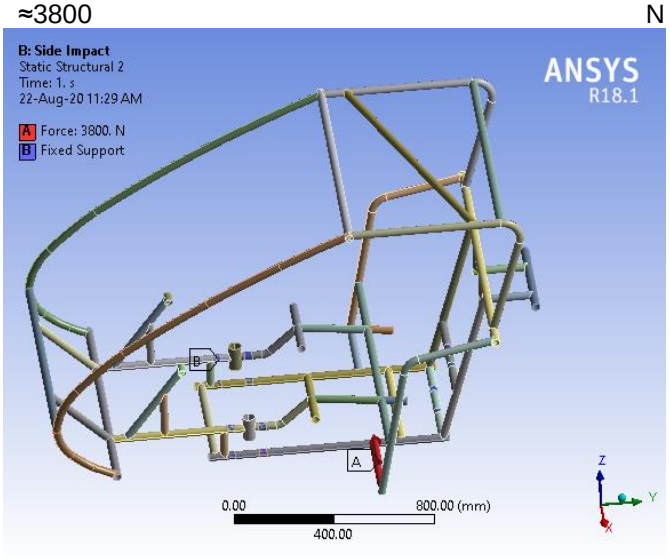
So,

F=W/S

=10166.5 /2.73

=3723.9 N

≈3800 N



d) Optimizations:

* Unnecessary members are removed

* T joints are preferred instead of corner joints

Material-4 (Steel AISI 4130, 1inx1.11inx1.65mm)

a) Assumption & Considerations:

Following assumptions & consideration were made for performing the analysis for frontal impact on frame/vehicle.
Impact force was applied on the foremost part of the roll cage.

Mounting points of suspension arms were fixed.

Initial Speed=9.114m/s

Final Speed=0m/s

Reaction time=0.30s

b) Calculation of Impact Forces:

Work Done= $(0.5*M*V_{final}^2 - 0.5*M*V_{initial}^2)$

$|W|=|-0.5*M*V_{initial}^2|$

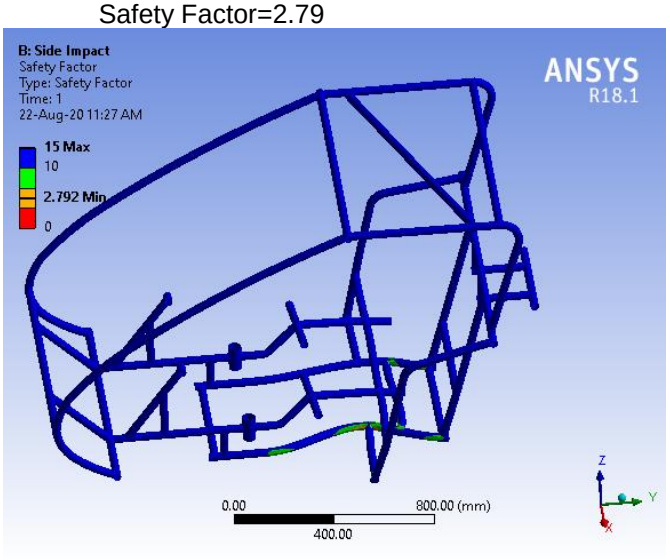
$=|-0.5*245*9.114^2|$

=10166.5 Nm

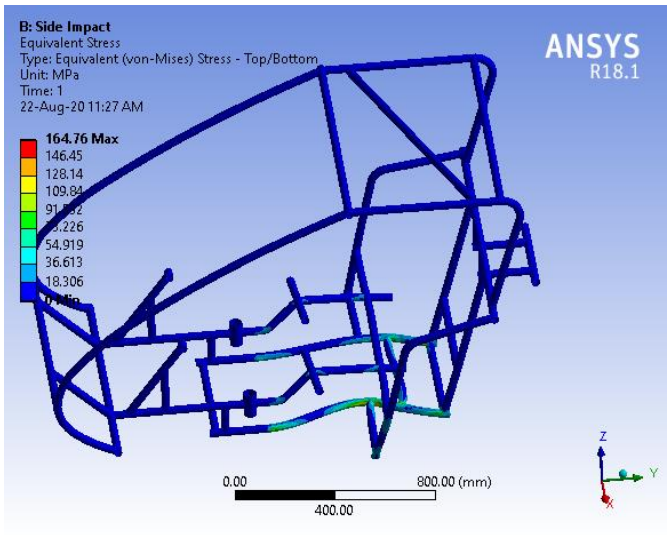
Work Done=Force * Displacement

c) Analysis Results

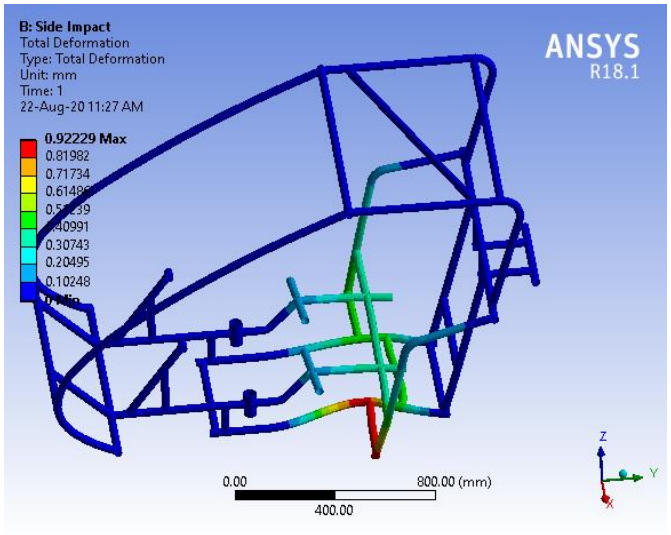
Safety Factor=2.79



Equivalent Stress=164.76MPa



Total Deformation = 0.92mm



Meshing Conditions- Relevance Centre = Fine
Relevance = 100
Element Size = 10mm

Reaction Time=0.13 sec

b) Calculation of Impact Forces:

$M * g * h = 0.5 * M * v^2$

$v = \sqrt{2 * 9.81 * 2}$

$= 6.2641 m/s$

(Now from work energy principal)

Work Done=Change in Kinetic Energy

$|W| = |-0.5 * M * v_{initial}^2|$

$= |0.5 * 245 * 6.2641^2|$

$= 4806.7 N$

$S = \text{Impact time} * v_{max}$

$= 0.13 * 6.2641$

$= 0.814333 m$

$F = W/S$

$= 4806.7/0.81433$

$= 5902.7 N$

$\approx 6000 N$

d) Optimizations:

* Unnecessary members are removed

* T joints are preferred instead of corner joints

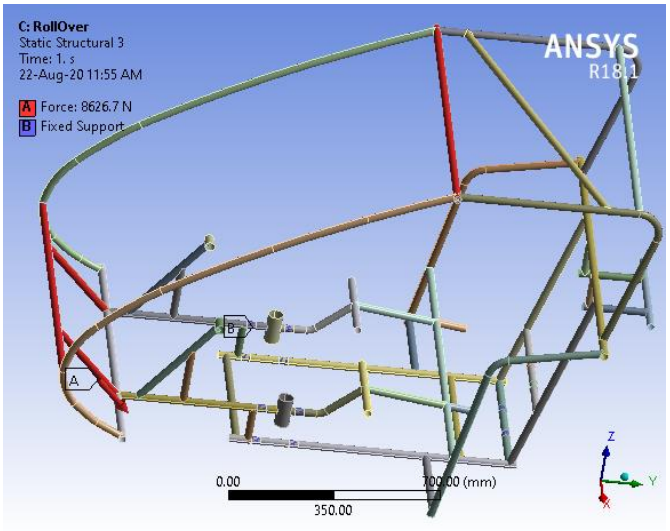
4.3. ROLLOVER ANALYSIS

Material-1 (Steel AISI 1018, 1inx0.84inx2mm)

a) Assumption & Considerations:

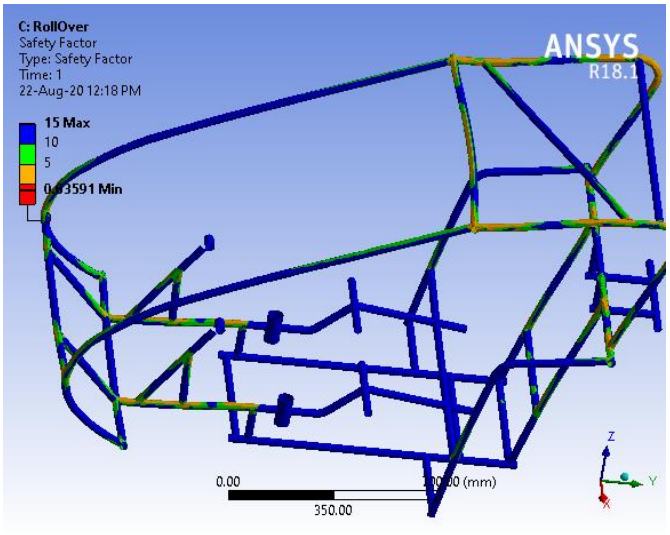
Following assumptions & considerations were made.
Lower most members were fixed performing the analysis for rollover on frame/vehicle.
Mounting points of suspension arms were fixed.

Impact force = G

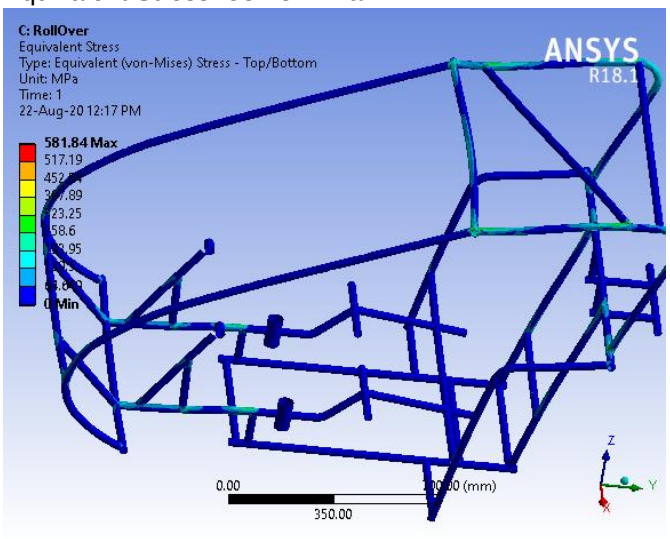


c) Analysis Results:

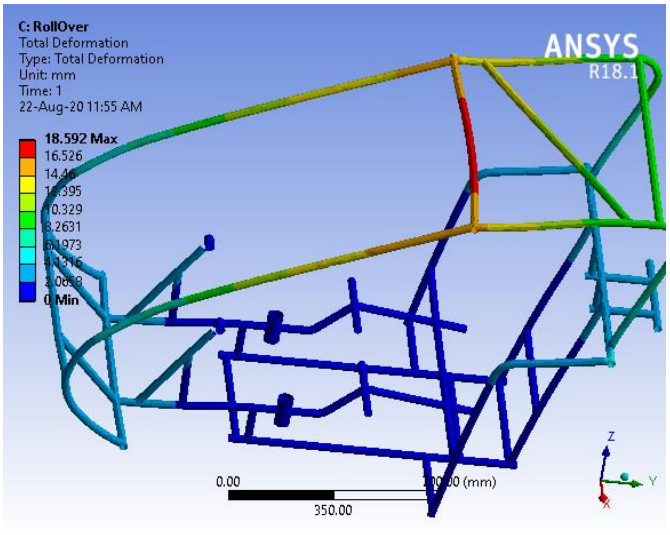
Safety Factor=0.63



Equivalent Stress=581.84MPa



Total Deformation = 18.59mm



d) Optimizations:

* Unnecessary members are removed
* T joints are preferred instead of corner joints

Material-2 (Steel AISI 4130, 1inx0.84inx2mm)

a) Assumption & Considerations:

Following assumptions & considerations were made.
Lower most members were fixed performing the analysis for rollover on frame/vehicle.
Mounting points of suspension arms were fixed.

Impact force = G

Meshing Conditions- Relevance Centre = Fine
Relevance = 100
Element Size = 10mm

Reaction Time=0.13 sec

b) Calculation of Impact Forces:

$M * g * h = 0.5 * M * v^2$

$v = \sqrt{2 * 9.81 * 2}$

$= 6.2641 m/s$

(Now from work energy principal)

Work Done=Change in Kinetic Energy

$|W| = |-0.5*M*v_{initial}^2|$

$= |0.5*245*6.2641^2|$

$= 4806.7 N$

$S = \text{Impact time} * v_{max}$

$= 0.13*6.2641$

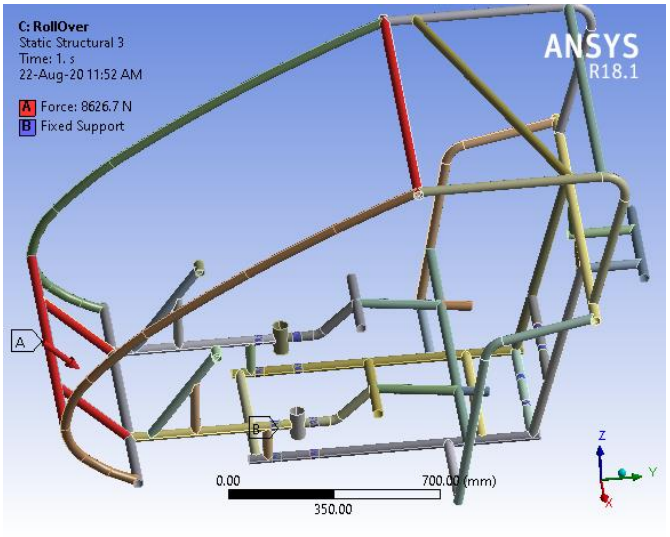
$= 0.814333 m$

$F = W/S$

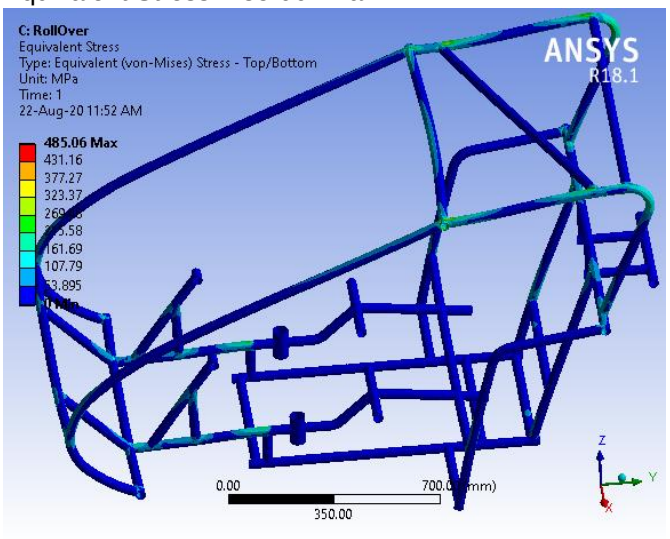
$= 4806.7/0.81433$

$= 5902.7 N$

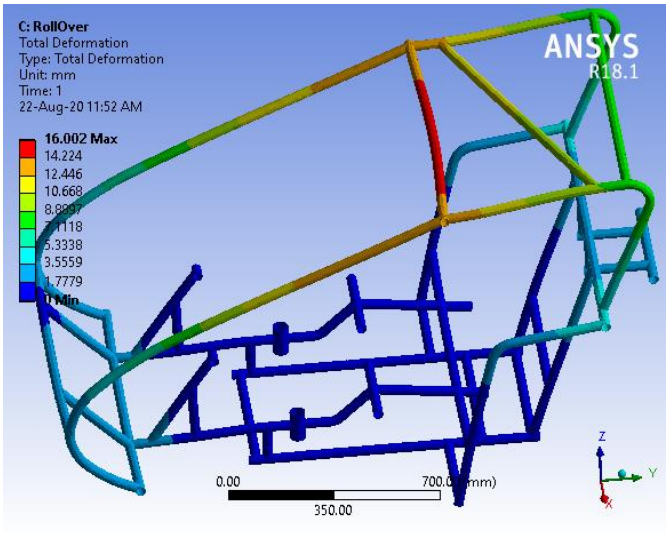
$\approx 6000 N$



Equivalent Stress=485.06MPa

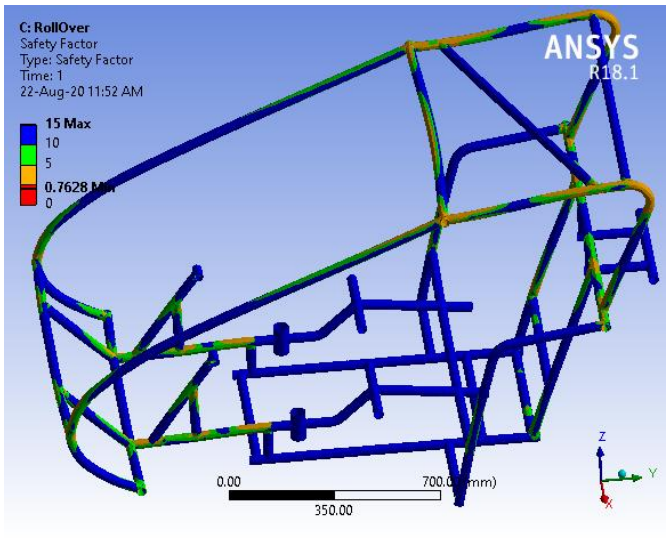


Total Deformation = 16.00mm



c) Analysis Results:

Safety Factor=0.76



d) Optimizations:

* Unnecessary members are removed

* T joints are preferred instead of corner joints

Material-3 (Steel AISI 1018, 1.25inx1.13inx1.5mm)

a) Assumption & Considerations:

Following assumptions & considerations were made.
Lower most members were fixed performing the analysis for rollover on frame/vehicle.
Mounting points of suspension arms were fixed.

Impact force = G

Meshing Conditions- Relevance Centre = Fine
Relevance = 100
Element Size = 10mm

Reaction Time=0.13 sec

b) Calculation of Impact Forces:

$M * g * h = 0.5 * M * v^2$

$v = \sqrt{2 * 9.81 * 2}$

$= 6.2641 m/s$

(Now from work energy principal)

Work Done=Change in Kinetic Energy

$|W| = |-0.5 * M * v_{initial}^2|$

$= |0.5 * 245 * 6.2641^2|$

$= 4806.7 N$

$S = \text{Impact time} * v_{max}$

$= 0.13 * 6.2641$

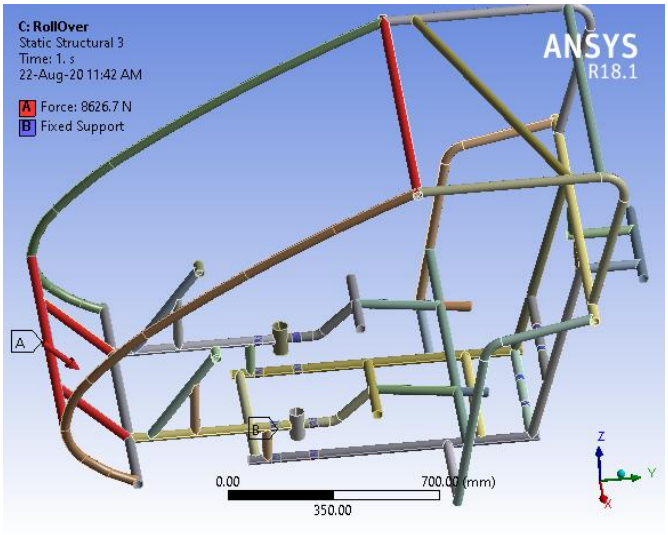
$= 0.814333 m$

$F = W/S$

$= 4806.7/0.81433$

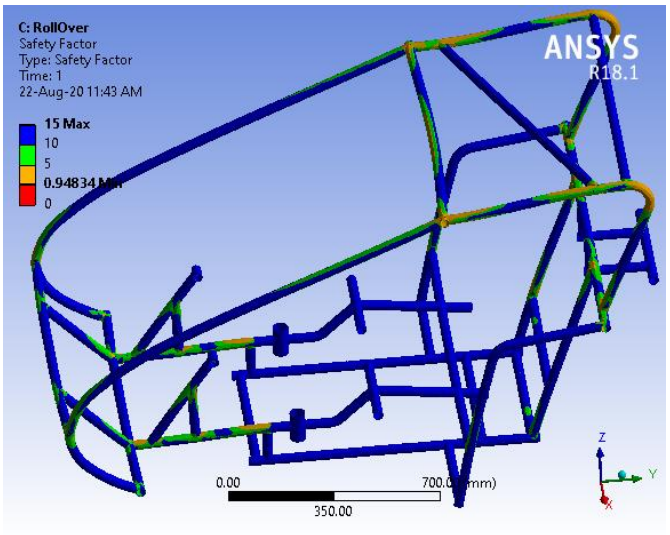
$= 5902.7 N$

$\approx 6000 N$

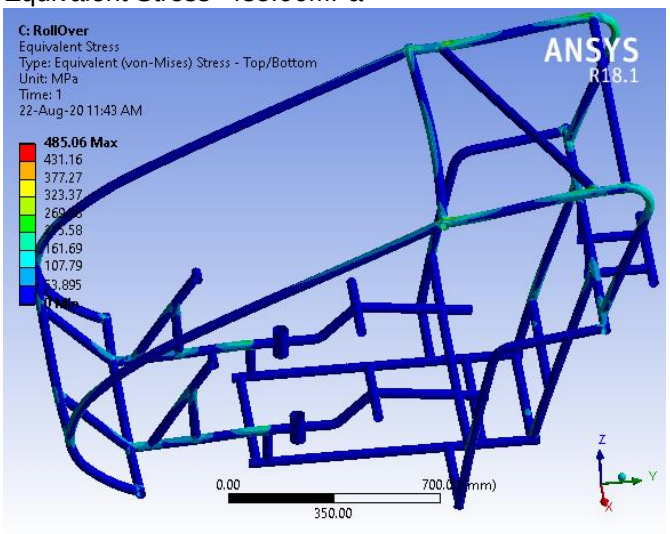


c) Analysis Results:

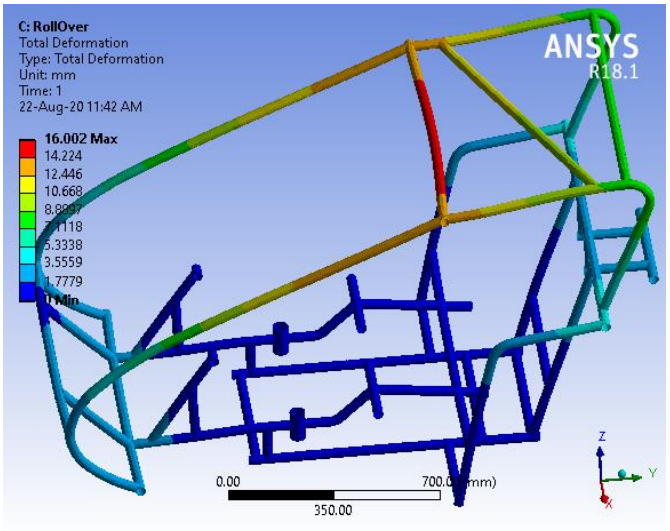
Safety Factor=0.94



Equivalent Stress=485.06MPa



Total Deformation = 16.00mm



d) Optimizations:

* Unnecessary members are removed

* T joints are preferred instead of corner joints

Material-4 (Steel AISI 4130, 1.25inx1.11inx1.65mm)

a) Assumption & Considerations:

Following assumptions & considerations were made.
Lower most members were fixed performing the analysis for rollover on frame/vehicle.
Mounting points of suspension arms were fixed.

Impact force = G

Meshing Conditions- Relevance Centre = Fine
Relevance = 100
Element Size = 10mm

Reaction Time=0.13 sec

b) Calculation of Impact Forces:

$M * g * h = 0.5 * M * v^2$

$v = \sqrt{2 * 9.81 * 2}$

$= 6.2641 m/s$

(Now from work energy principal)

Work Done=Change in Kinetic Energy

$|W| = |-0.5 * M * v_{initial}^2|$

$= |0.5 * 245 * 6.2641^2|$

$= 4806.7 N$

$S = \text{Impact time} * v_{max}$

$= 0.13 * 6.2641$

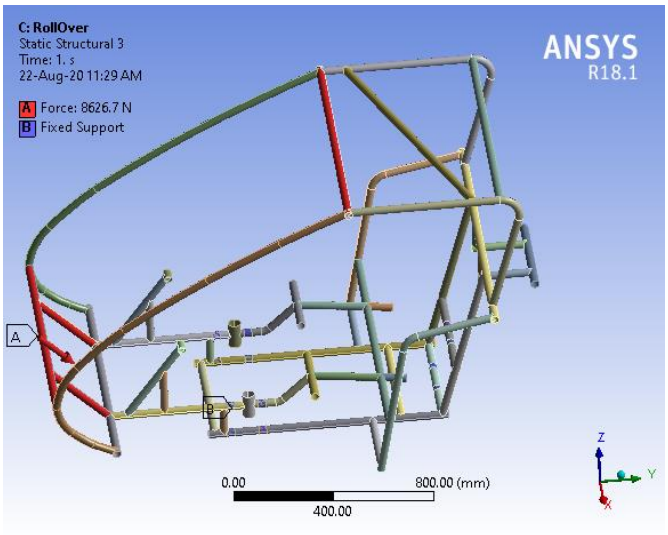
$= 0.814333 m$

$F = W/S$

$= 4806.7/0.81433$

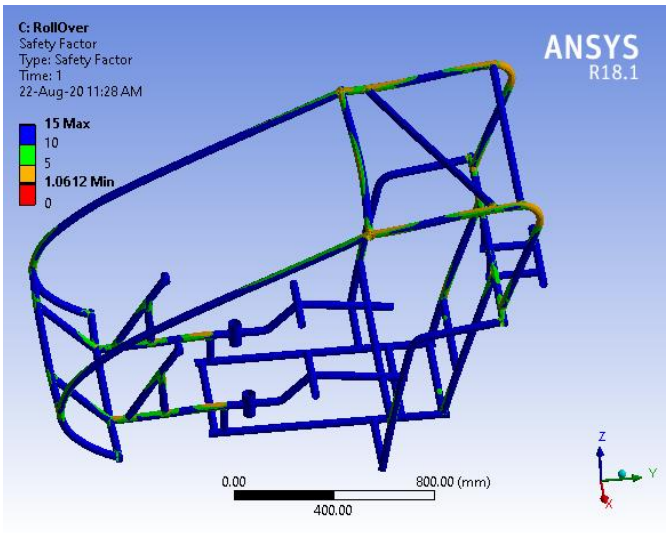
$= 5902.7 N$

$\approx 6000 N$

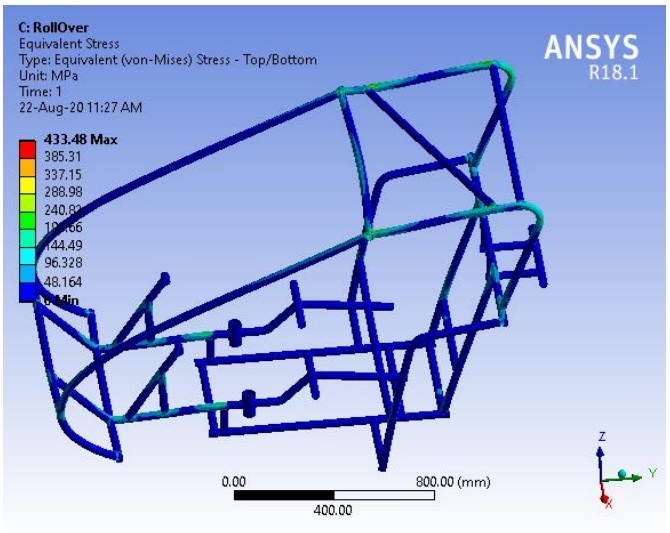


c) Analysis Results:

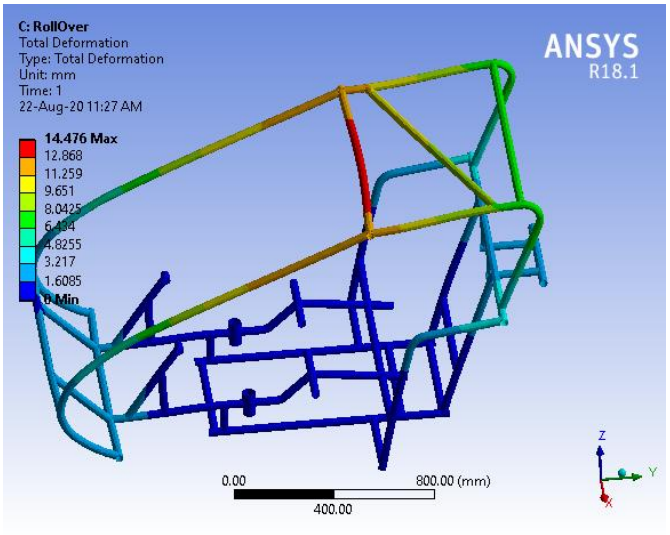
Safety Factor=1.06



Equivalent Stress=433.48MPa



Total Deformation = 14.47mm



d) Optimizations:

* Unnecessary members are removed
* T joints are preferred instead of corner joints

4.4. BENDING ANALYSIS

Material-1 (Steel AISI 1018, 1inx0.84inx2mm)

a) Assumption & Considerations:

Following assumptions & considerations were made.
Lower most members were fixed performing the analysis for bending on frame/vehicle.
Mounting points of rear suspension arms were fixed and force on mounting points of front suspension arms was applied.
Vehicle undergoes a bump of size 10in=0.254m

b) Calculation of Forces:

$m * g * h = 0.5 * m * v^2$

$v=2.23m/s$

(Now by work principle work done by Spring is equal to change in kinetic energy)

$0.5 * k * x^2 = 0.5 * m * v^2$

(Here k is spring constant and its value is 7883.8 N/m)

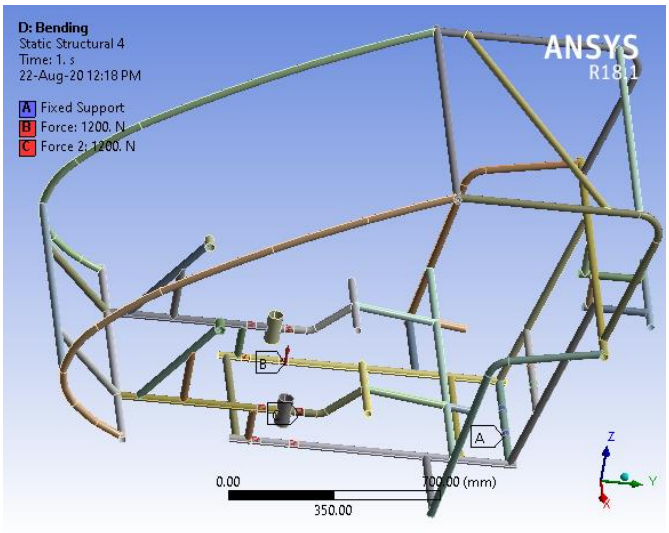
$7883.8 * x^2 = 240 * 2.23^2$

$x = 0.151$ m

Force applied by the spring on the frame is

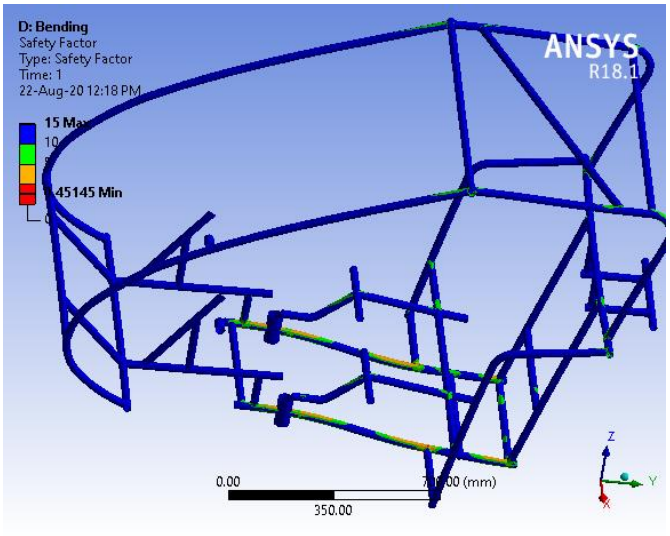
$k * x=1190.45$ N

≈1200 N

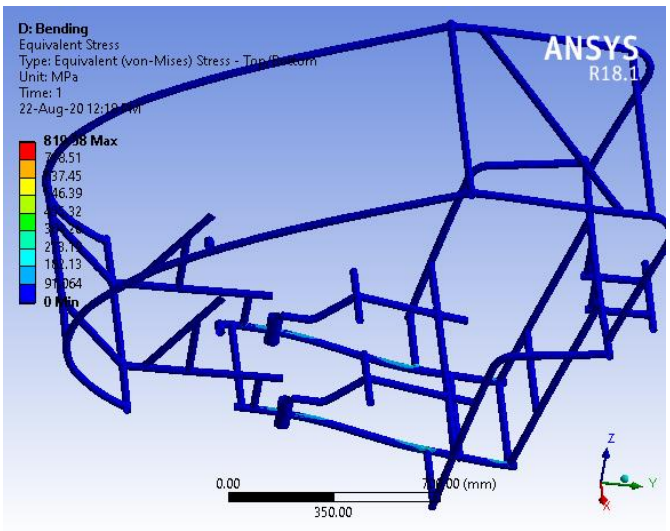


c) Analysis Results:

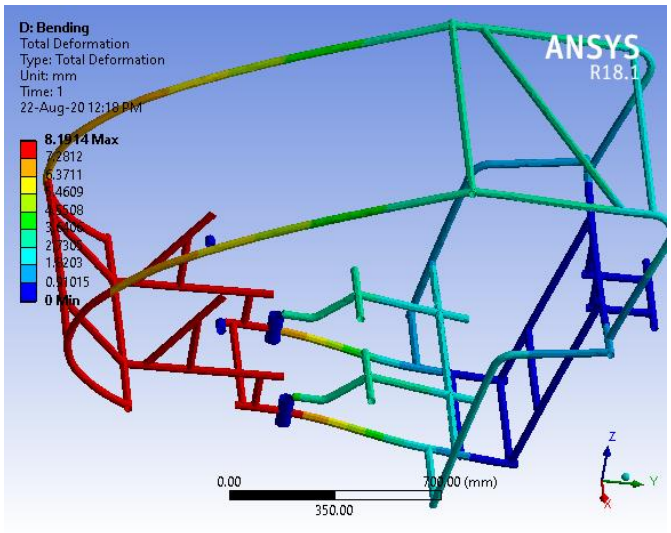
Safety Factor=0.45



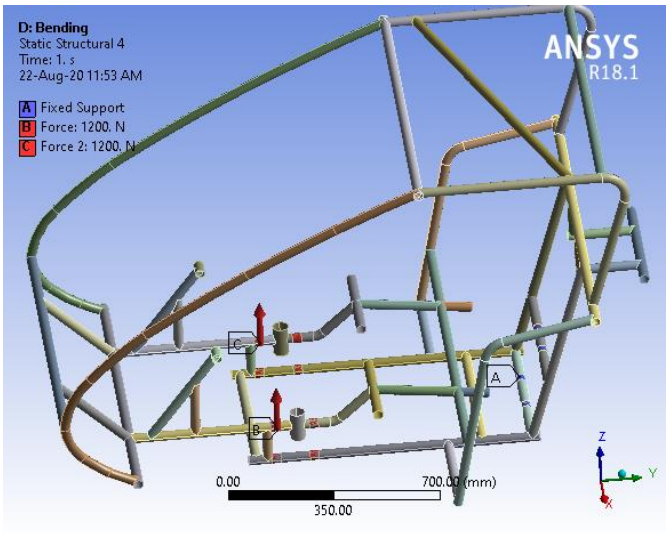
Equivalent Stress=819.58MPa



Total Deformation =8.19mm



≈1200 N



d) Optimizations:

* Unnecessary members are removed

* T joints are preferred instead of corner joints

Material-2 (Steel AISI 4130, 1inx0.84inx2mm)

a) Assumption & Considerations:

Following assumptions & considerations were made.
Lower most members were fixed performing the analysis for bending on frame/vehicle.
Mounting points of rear suspension arms were fixed and force on mounting points of front suspension arms was applied.
Vehicle undergoes a bump of size 10in=0.254m

b) Calculation of Forces:

$m * g * h = 0.5 * m * v^2$

$v=2.23m/s$

(Now by work principle work done by Spring is equal to change in kinetic energy)

$0.6 * k * x^2 = 0.5 * m * v^2$

(Here k is spring constant and its value is 7883.8 N/m)

$7883.8 * x^2 = 240 * 2.23^2$

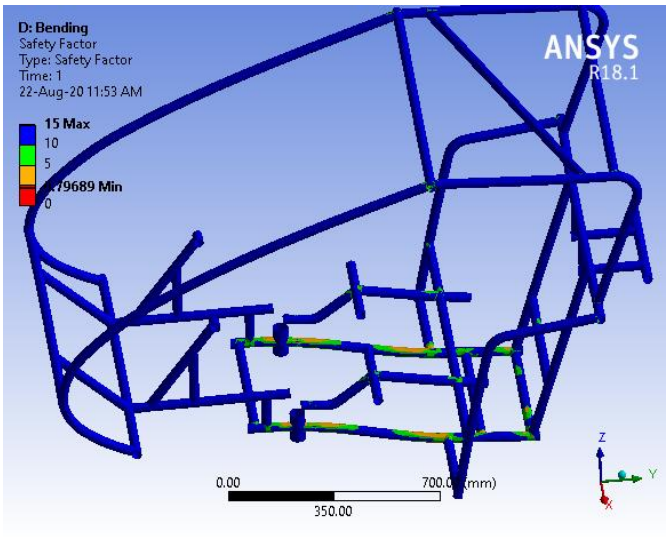
$x = 0.151$ m

Force applied by the spring on the frame is

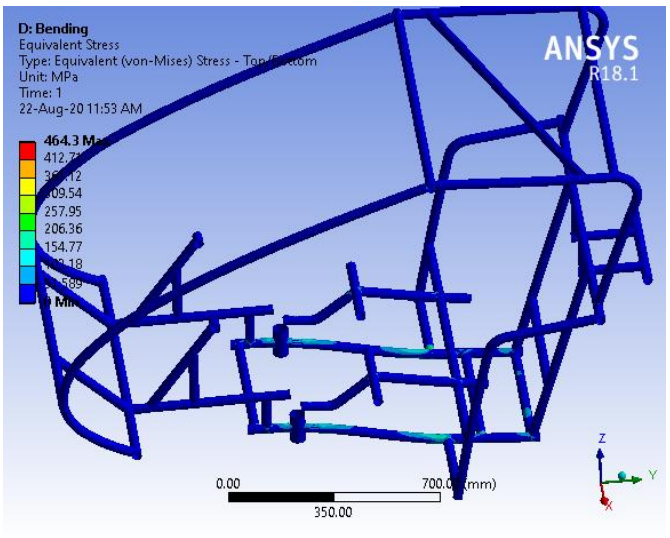
$k * x = 1190.45$ N

c) Analysis Results:

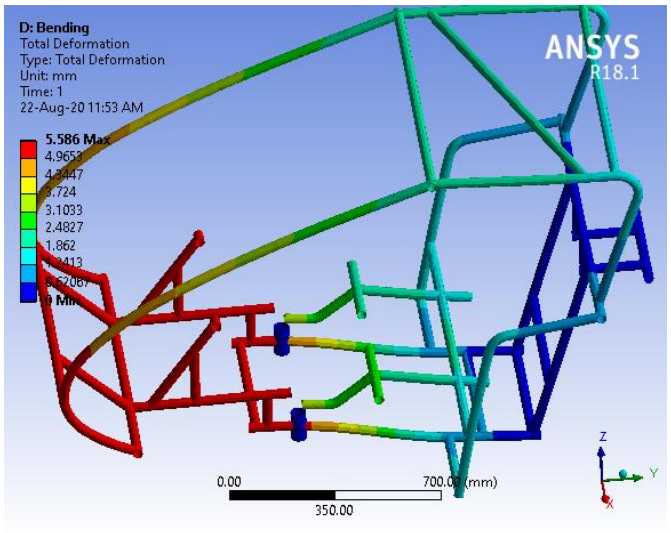
Safety Factor=0.79



Equivalent Stress=464.3MPa



Total Deformation =5.58mm



d) Optimizations:

* Unnecessary members are removed

* T joints are preferred instead of corner joints

Material-3 (Steel AISI 1018, 1.25inx1.13inx1.5mm)

a) Assumption & Considerations:

Following assumptions & considerations were made.
Lower most members were fixed performing the analysis for bending on frame/vehicle.
Mounting points of rear suspension arms were fixed and force on mounting points of front suspension arms was applied.
Vehicle undergoes a bump of size 10in=0.254m

b) Calculation of Forces:

$m * g * h = 0.5 * m * v^2$

v=2.23m/s

(Now by work principle work done by Spring is equal to change in kinetic energy)

$0.7 * k * x^2 = 0.5 * m * v^2$

(Here k is spring constant and its value is 7883.8 N/m)

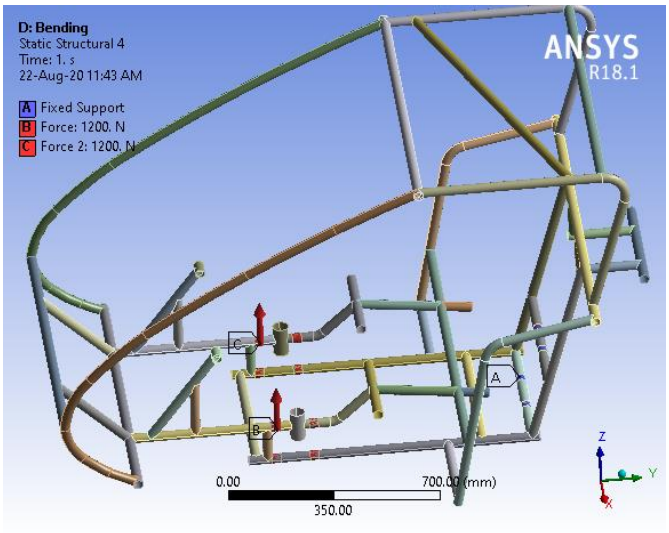
$7883.8 * x^2 = 240 * 2.23^2$

x = 0.151 m

Force applied by the spring on the frame is

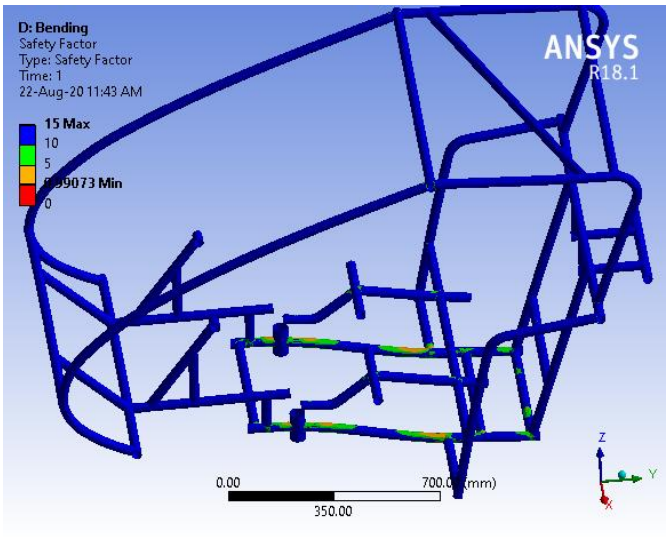
k * x=1190.45 N

≈1200 N

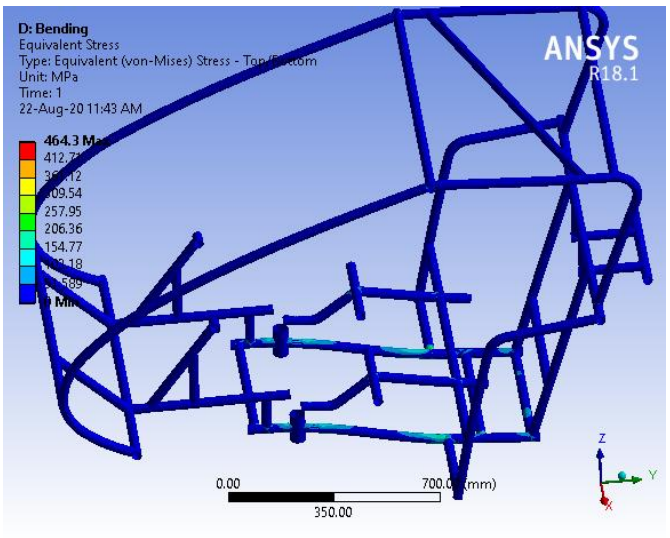


c) Analysis Results:

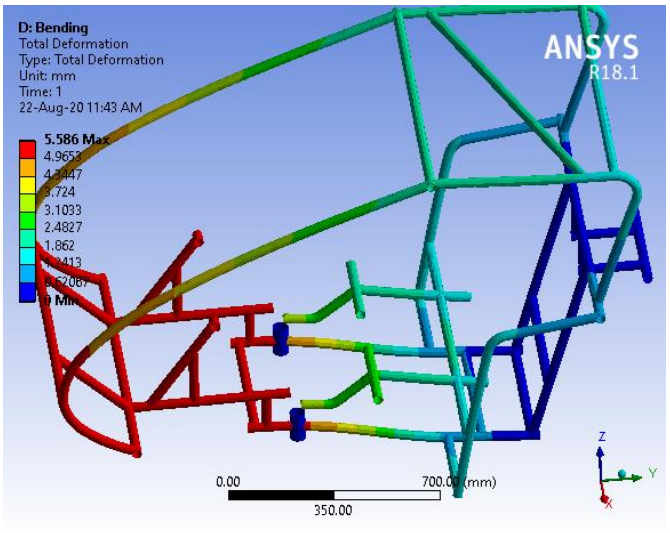
Safety Factor=0.99

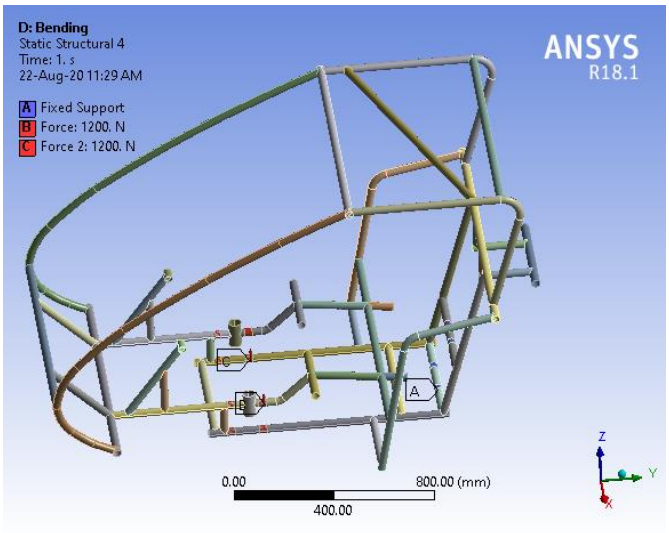


Equivalent Stress=464.3MPa



Total Deformation =5.58mm





d) Optimizations:

* Unnecessary members are removed

* T joints are preferred instead of corner joints

Material-4 (Steel AISI 4130, 1.225inx1.11inx1.65mm)

a) Assumption & Considerations:

Following assumptions & considerations were made.
Lower most members were fixed performing the analysis for bending on frame/vehicle.
Mounting points of rear suspension arms were fixed and force on mounting points of front suspension arms was applied.
Vehicle undergoes a bump of size 10in=0.254m

b) Calculation of Forces:

$m * g * h = 0.5 * m * v^2$

v=2.23m/s

(Now by work principle work done by Spring is equal to change in kinetic energy)

$0.8 * k * x^2 = 0.5 * m * v^2$

(Here k is spring constant and its value is 7883.8 N/m)

$7883.8 * x^2 = 240 * 2.23^2$

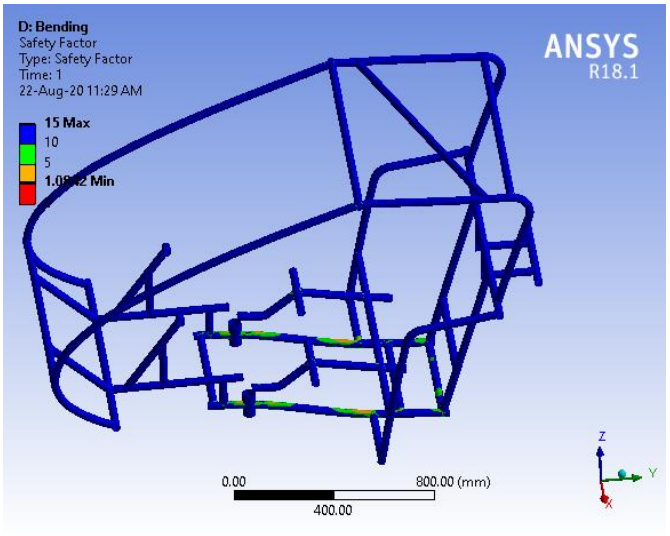
x = 0.151 m

Force applied by the spring on the frame is

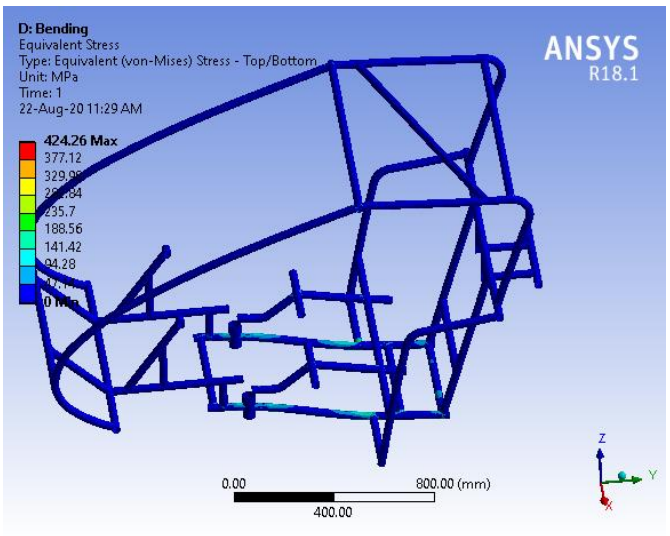
k * x=1190.45 N

c) Analysis Results:

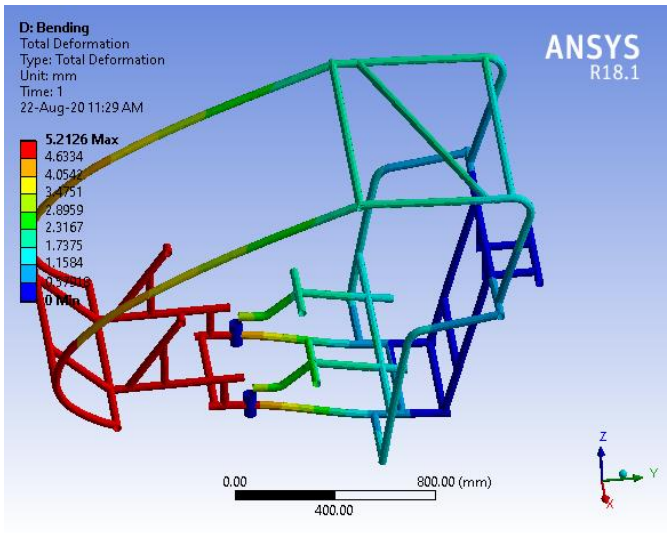
Safety Factor=1.08



Equivalent Stress=424.26MPa



Total Deformation =5.21mm



d) Optimizations:

* Unnecessary members are removed

* T joints are preferred instead of corner joints

4.5. TORSIONAL ANALYSIS

Material-1 (Steel AISI 1018, 1inx0.84inx2mm)

a) Assumption & Considerations:

Following assumptions & considerations were made.
Lower most members were fixed performing the analysis for bending on frame/vehicle.
Mounting points of rear suspension arms were fixed and force on mounting points of front suspension arms was applied.
Vehicle undergoes a bump of size 10in=0.254m

b) Calculation of Forces:

$m * g * h = 0.5 * m * v^2$

$v=2.23m/s$

(Now by work principle work done by Spring is equal to change in kinetic energy)

$0.9 * k * x^2 = 0.5 * m * v^2$

(Here k is spring constant and its value is 7883.8 N/m)

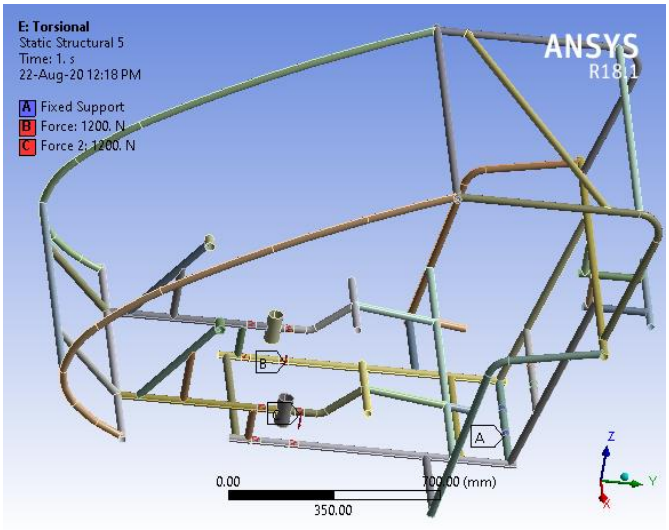
$7883.8 * x^2 = 240 * 2.23^2$

$x = 0.151$ m

Force applied by the spring on the frame is

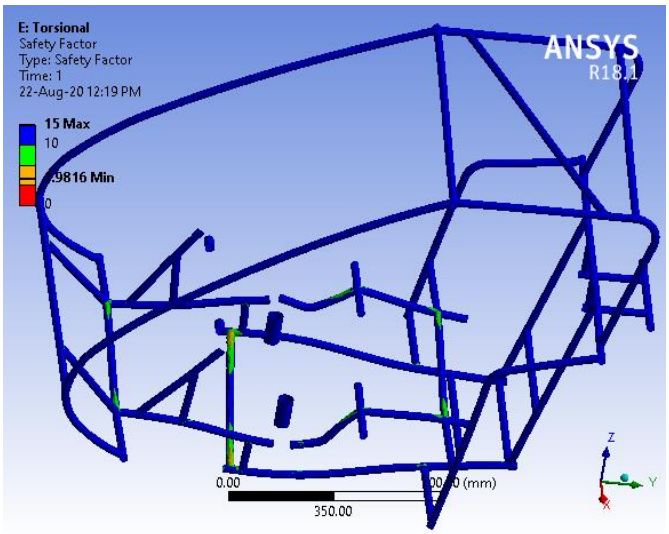
$k * x=1190.45$ N

≈1200 N

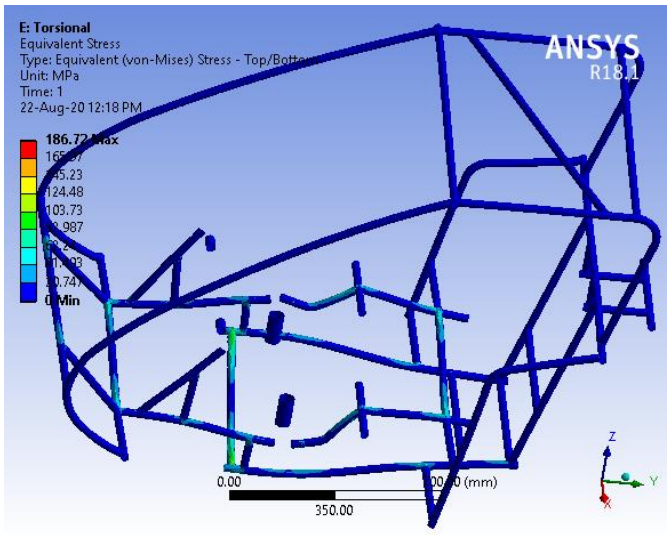


c) Analysis Results:

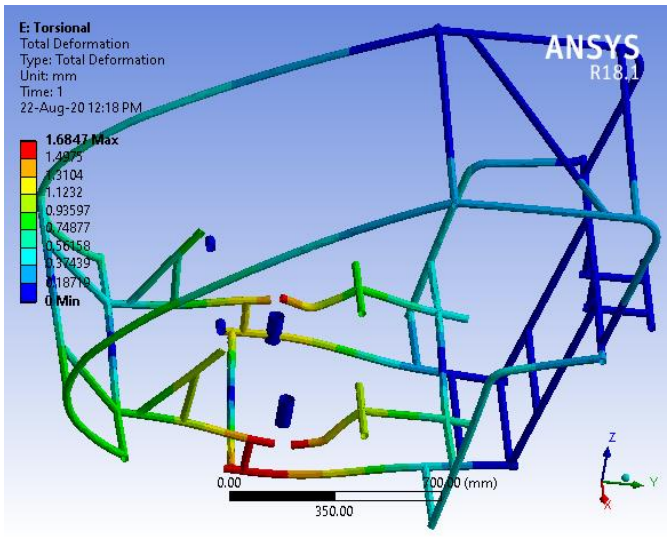
Safety Factor=1.98



Equivalent Stress=186.72MPa



Total Deformation =1.68mm



d) Optimizations:

* Unnecessary members are removed

* T joints are preferred instead of corner joints

Material-2 (Steel AISI 4130, 1inx0.84inx2mm)

a) Assumption & Considerations:

Following assumptions & considerations were made.
Lower most members were fixed performing the analysis for bending on frame/vehicle.
Mounting points of rear suspension arms were fixed and force on mounting points of front suspension arms was applied.
Vehicle undergoes a bump of size 10in=0.254m

b) Calculation of Forces:

$m * g * h = 0.5 * m * v^2$

$v=2.23m/s$

(Now by work principle work done by Spring is equal to change in kinetic energy)

$0.10 * k * x^2 = 0.5 * m * v^2$

(Here k is spring constant and its value is 7883.8 N/m)

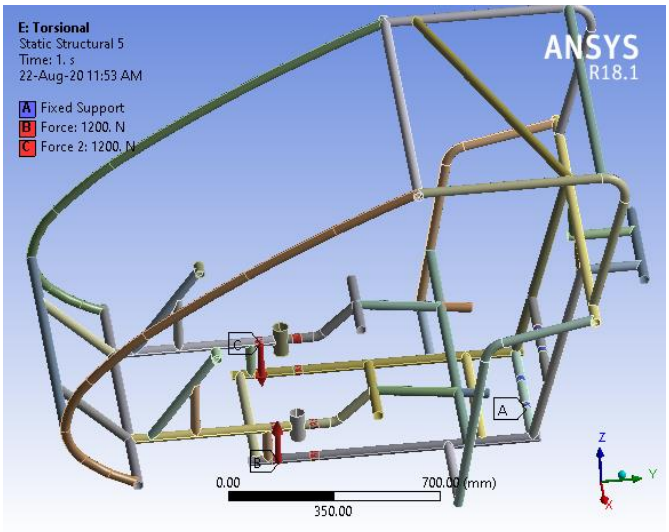
$7883.8 * x^2 = 240 * 2.23^2$

$x = 0.151$ m

Force applied by the spring on the frame is

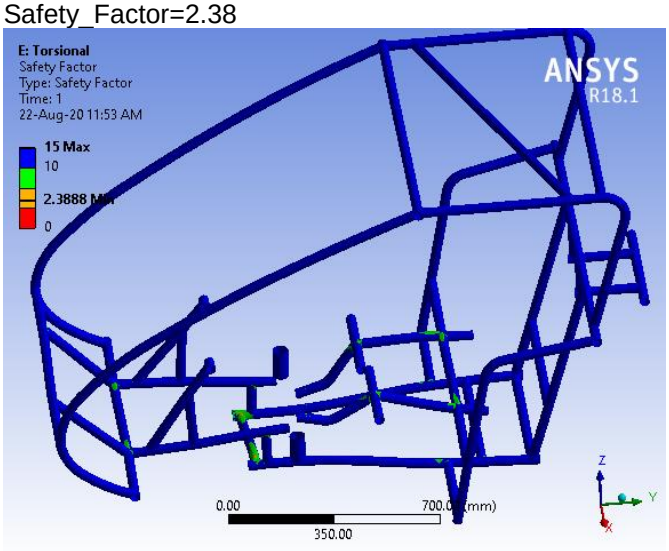
$k * x = 1190.45$ N

≈1200 N

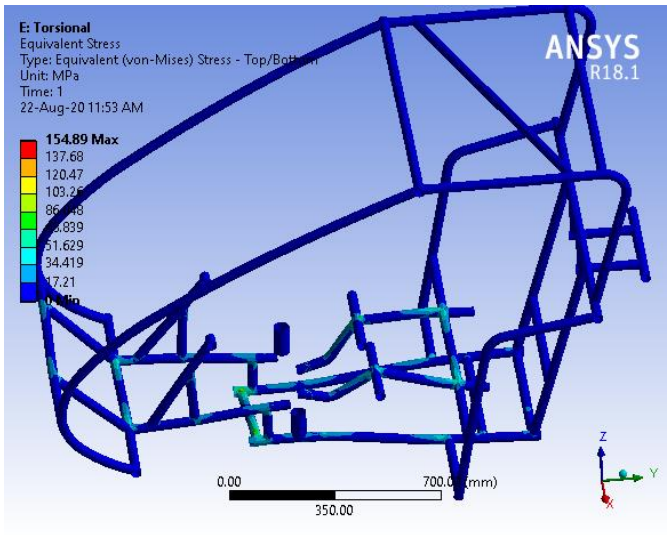


c) Analysis Results:

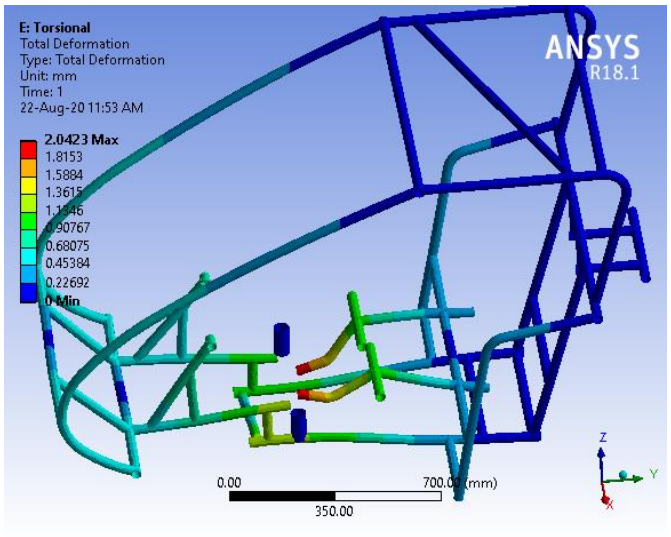
Safety_Factor=2.38



Equivalent Stress=154.89MPa



Total Deformation =2.04mm



d) Optimizations:

* Unnecessary members are removed

* T joints are preferred instead of corner joints

Material-3 (Steel AISI 1018, 1.25inx1.13inx1.5mm)

a) Assumption & Considerations:

Following assumptions & considerations were made.
Lower most members were fixed performing the analysis for bending on frame/vehicle.
Mounting points of rear suspension arms were fixed and force on mounting points of front suspension arms was applied.
Vehicle undergoes a bump of size 10in=0.254m

b) Calculation of Forces:

$m * g * h = 0.5 * m * v^2$

$v=2.23m/s$

(Now by work principle work done by Spring is equal to change in kinetic energy)

$0.11 * k * x^2 = 0.5 * m * v^2$

(Here k is spring constant and its value is 7883.8 N/m)

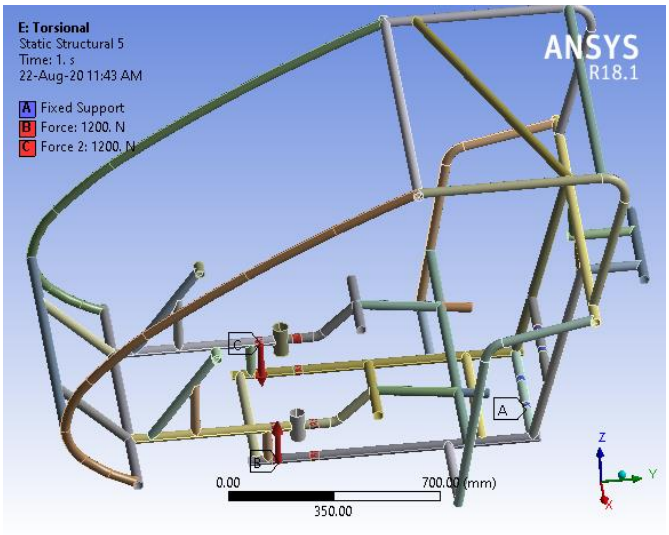
$7883.8 * x^2 = 240 * 2.23^2$

$x = 0.151$ m

Force applied by the spring on the frame is

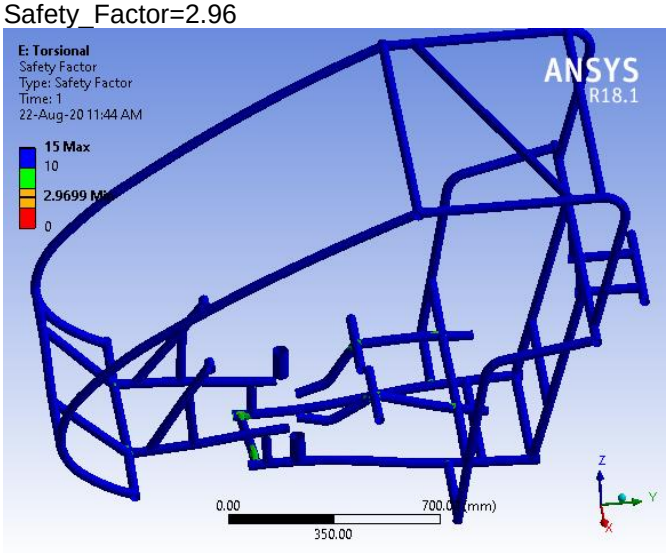
$k * x=1190.45$ N

≈1200 N

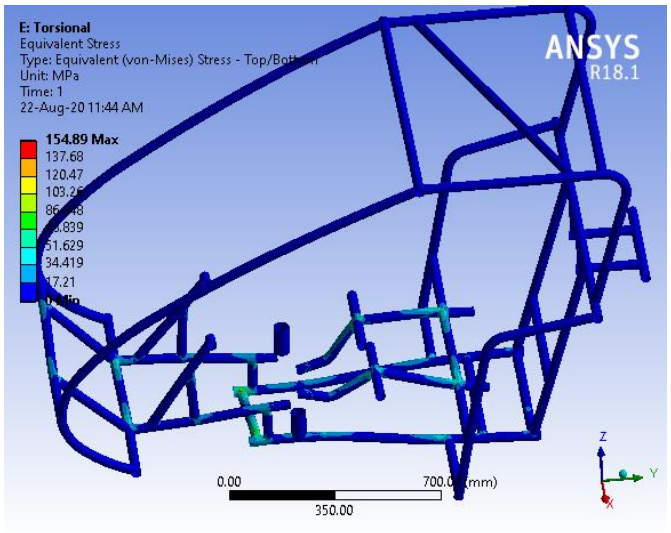


c) Analysis Results:

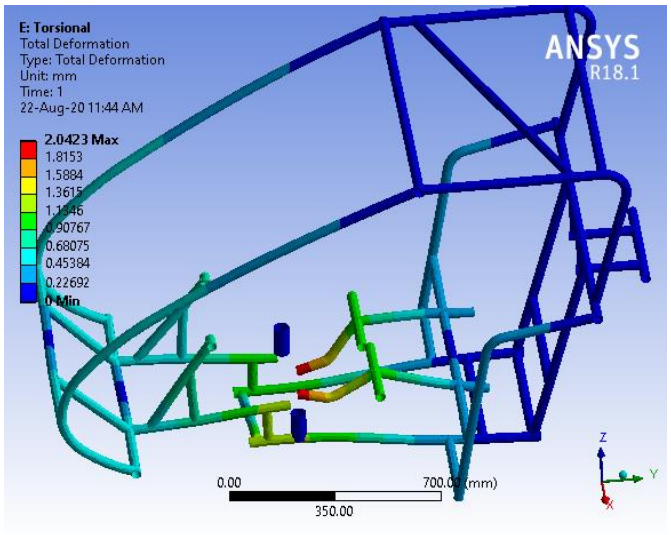
Safety_Factor=2.96



Equivalent Stress=154.89MPa



Total Deformation =2.04mm



d) Optimizations:

* Unnecessary members are removed

* T joints are preferred instead of corner joints

Material-4 (Steel AISI 4130, 1.225inx1.11inx1.65mm)

a) Assumption & Considerations:

Following assumptions & considerations were made.
Lower most members were fixed performing the analysis for bending on frame/vehicle.
Mounting points of rear suspension arms were fixed and force on mounting points of front suspension arms was applied.
Vehicle undergoes a bump of size 10in=0.254m

b) Calculation of Forces:

$m * g * h = 0.5 * m * v^2$

$v=2.23m/s$

(Now by work principle work done by Spring is equal to change in kinetic energy)

$0.12 * k * x^2 = 0.5 * m * v^2$

(Here k is spring constant and its value is 7883.8 N/m)

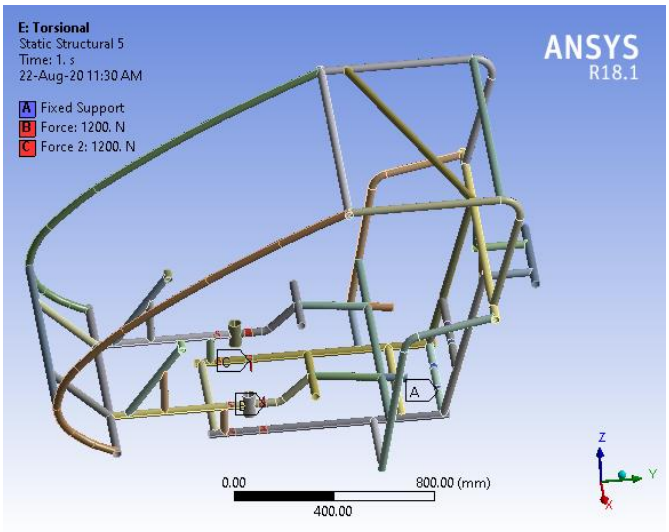
$7883.8 * x^2 = 240 * 2.23^2$

$x = 0.151$ m

Force applied by the spring on the frame is

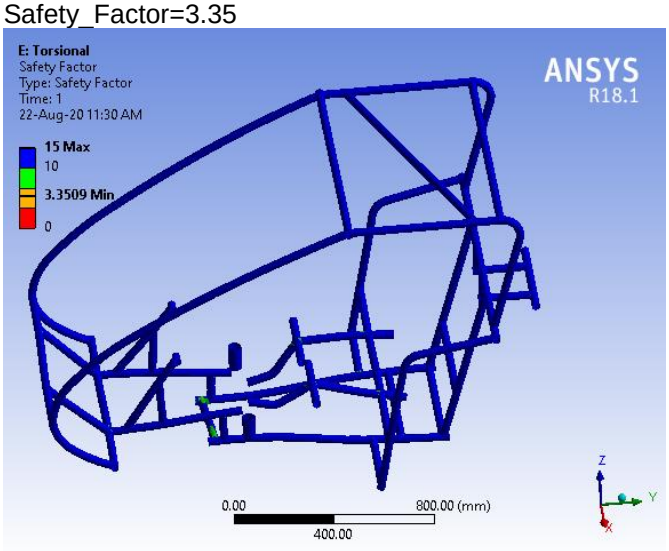
$k * x = 1190.45$ N

≈1200 N

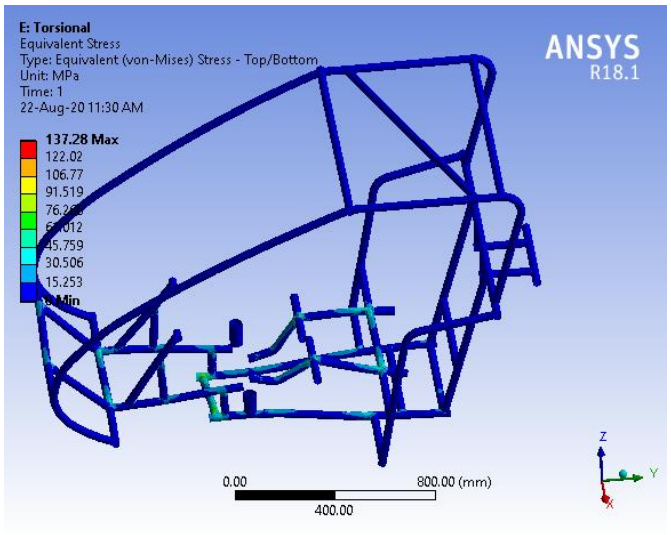


c) Analysis Results:

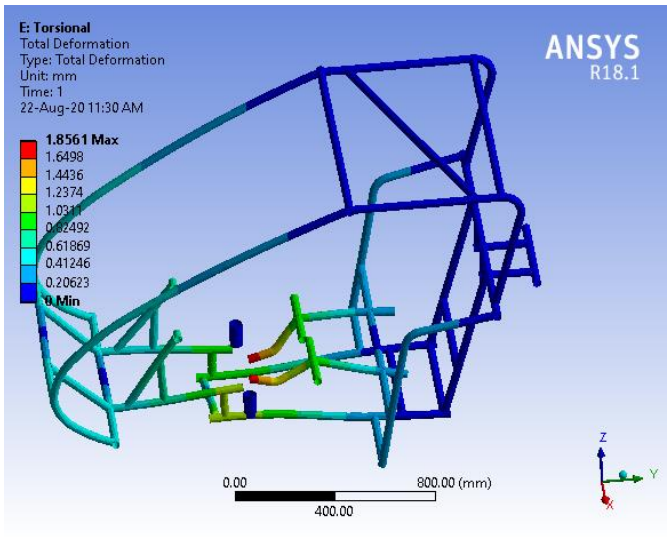
Safety_Factor=3.35



Equivalent Stress=137.28MPa



Total Deformation =1.85mm



d) Optimizations:

* Unnecessary members are removed

* T joints are preferred instead of corner joints

.

4.6. HARD POINT ANALYSIS

Material-1 (Steel AISI 1018, 1inx0.84inx2mm)

Analysis 1-Suspension Mountings

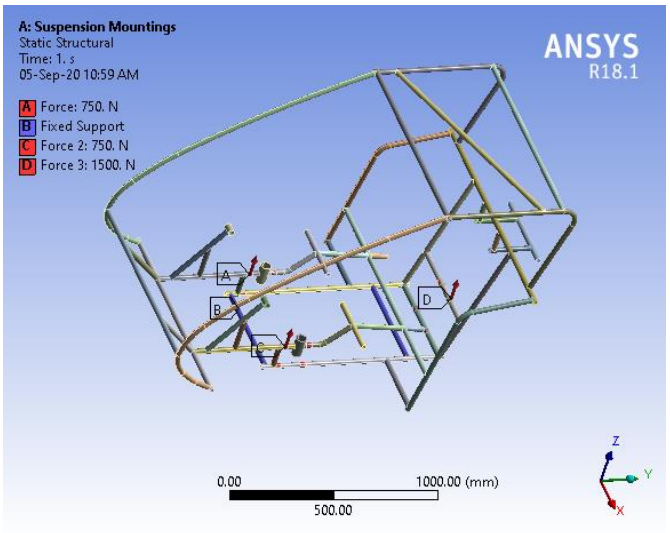
a) Assumption & Considerations:

Following assumptions & considerations were made.
Frame was fixed for the analysis of suspension mounting points and a force equal to

b) Calculation of Forces:

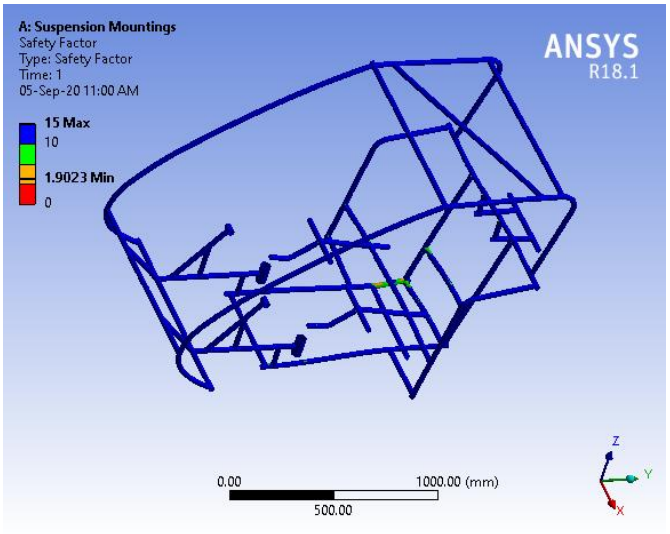
Max bump size=3.5in=8.89cm

v=√(2gh)=1.32 m/s
collision time=.54 s
Conservation of momentum
mv=-mv'
v'=-v
Change in momentum mv-(-mv)
F(bump force)=2mv/.54=2*245*1.32/.54
= 1197.77 N
≈1500N

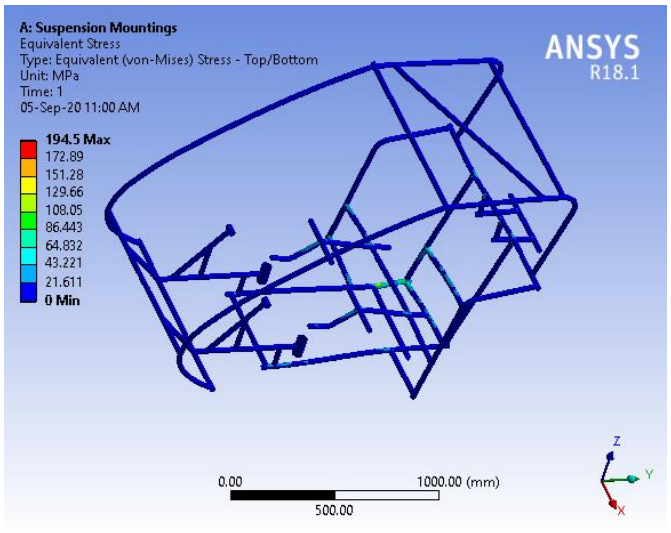


c) Analysis Results:

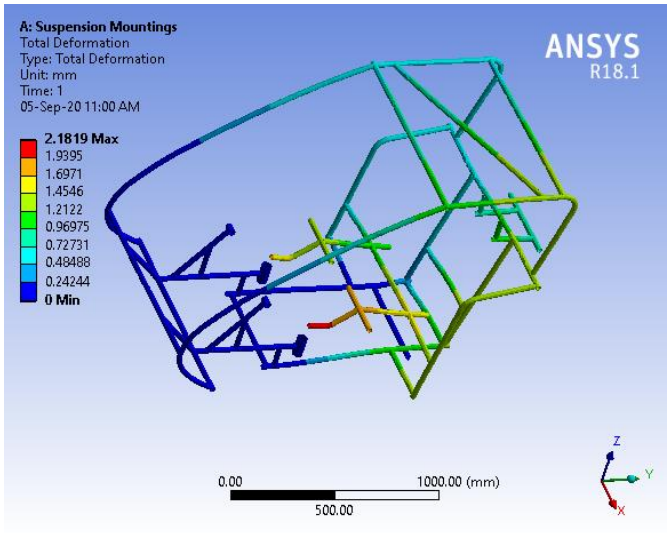
Factor of Safety= 1.90



Stress= 194.5MPa



Total Deformation= 2.18mm



d) Optimizations:

* Unnecessary members are removed

* T joints are preferred instead of corner joints

Analysis 2-Seat Mountings

a) Assumption & Considerations:

Following assumptions & considerations were made.

Suspension Mounting Points were fixed and weight of each driver was taken as 75 Kg. Acceleration due to gravity=9.8m/s^2

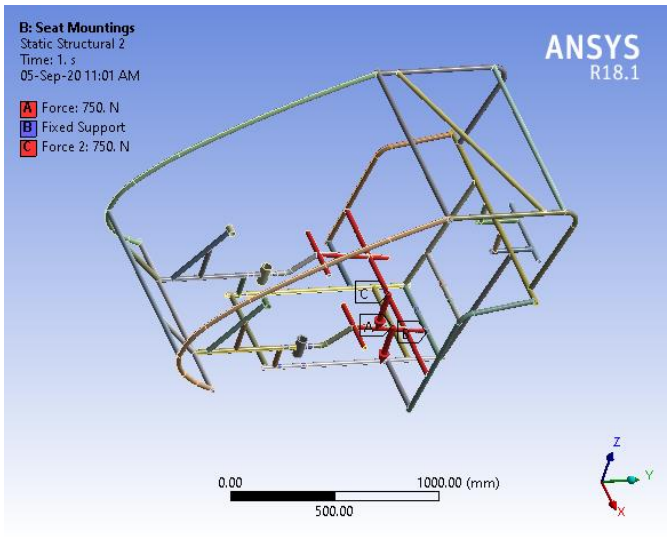
b) Calculation of Forces:

Force= Mass x Acceleration

Force= 75*9.8

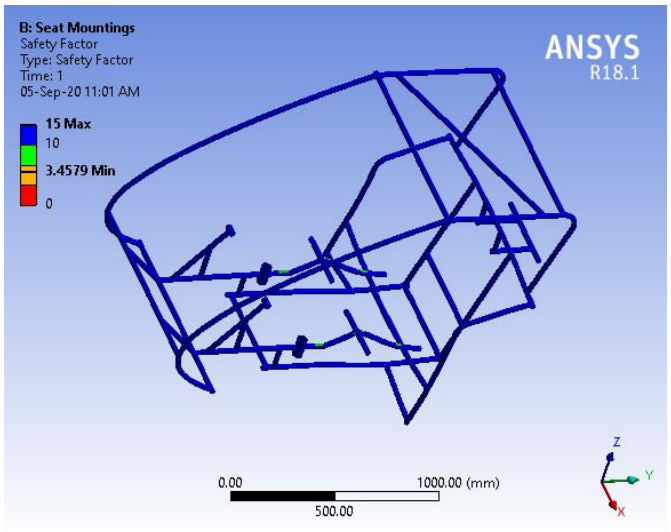
Force=735N

≈750N

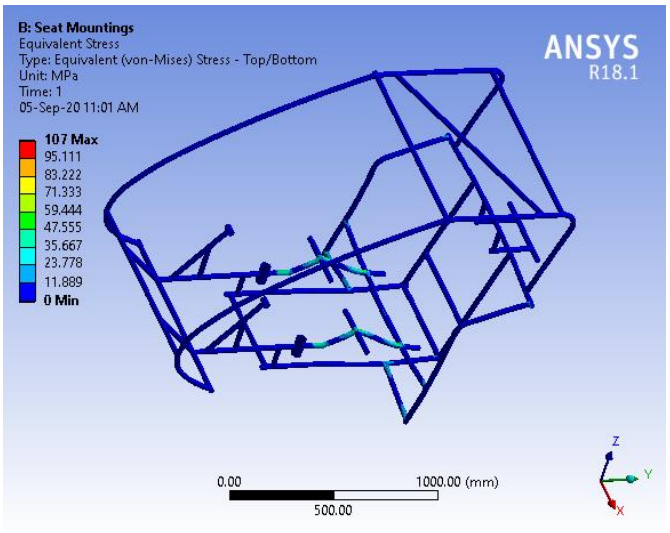


c) Analysis Results:

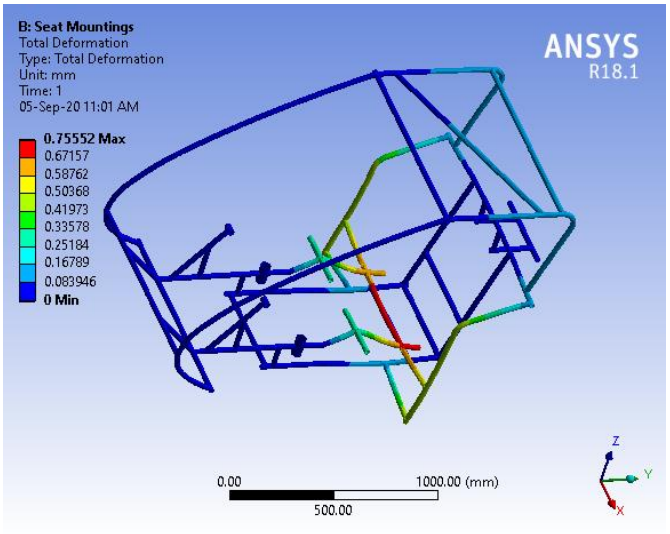
Factor of Safety= 3.45



Stress= 107.00MPa



Total Deformation= 0.75mm



d) Optimizations:

* Unnecessary members are removed

* T joints are preferred instead of corner joints

Analysis 3-Battery Mountings

a) Assumption & Considerations:

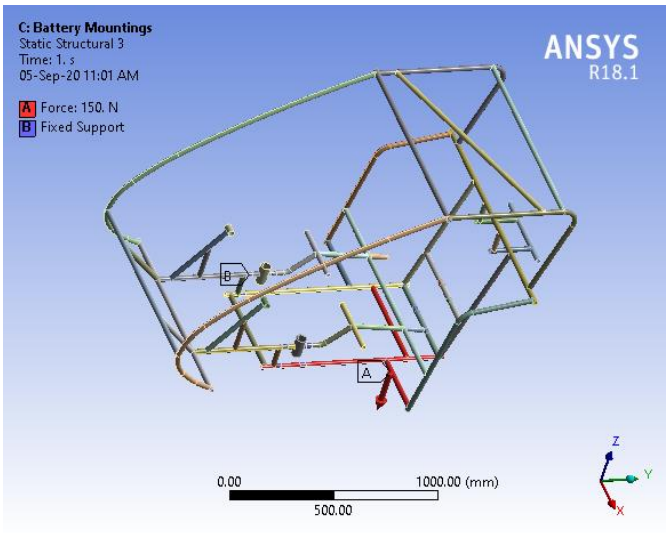
Following assumptions & considerations were made.
Suspension Mounting Points were fixed and weight of battery is 12 Kg.
Acceleration due to gravity=9.8m/s^2

b) Calculation of Forces:

Force= Mass x Acceleration

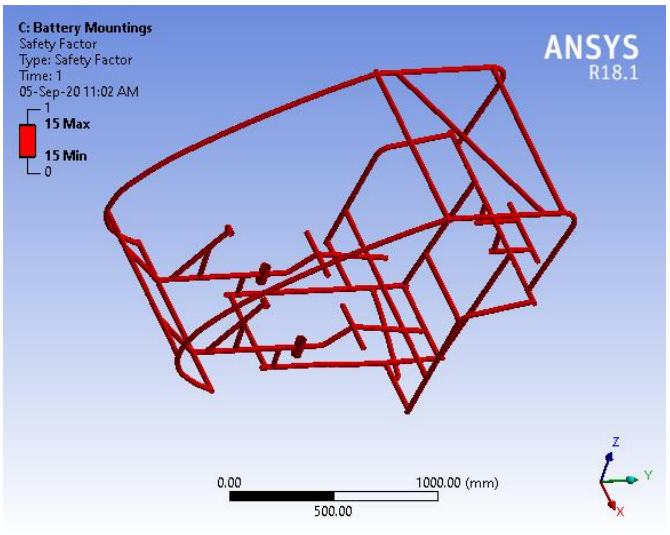
Force= 12*9.8

Force=117.6N

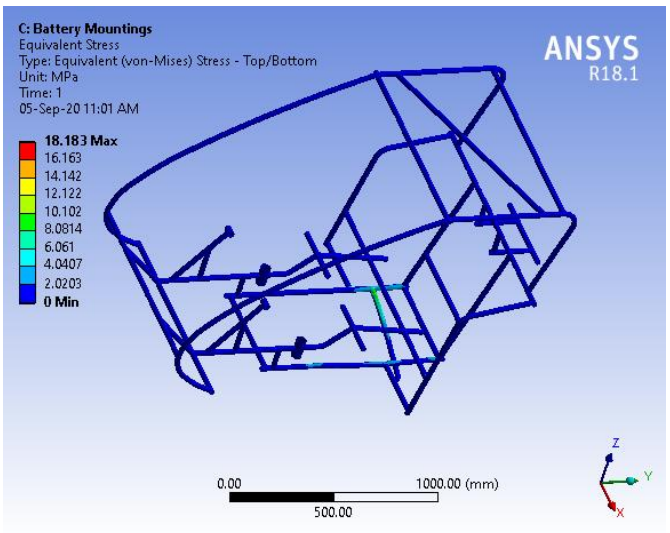


c) Analysis Results:

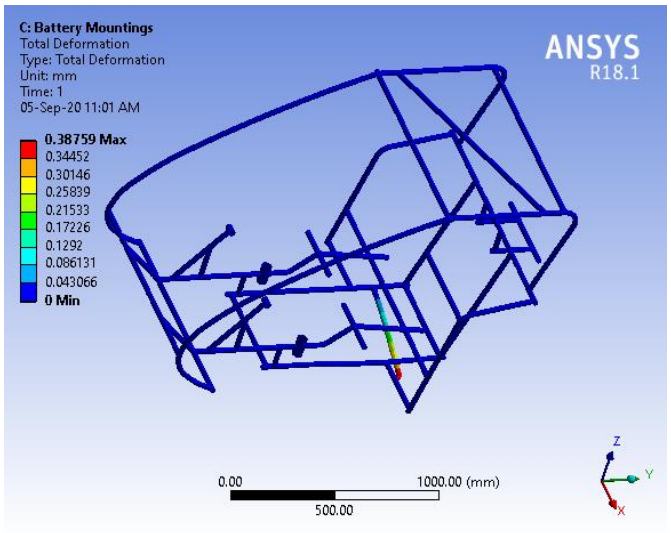
Factor of Safety= 15



Stress= 18.18MPa



Total Deformation= 0.38mm



d) Optimizations:

* Unnecessary members are removed

* T joints are preferred instead of corner joints

Analysis 4-Solar Panel Mountings

a) Assumption & Considerations:

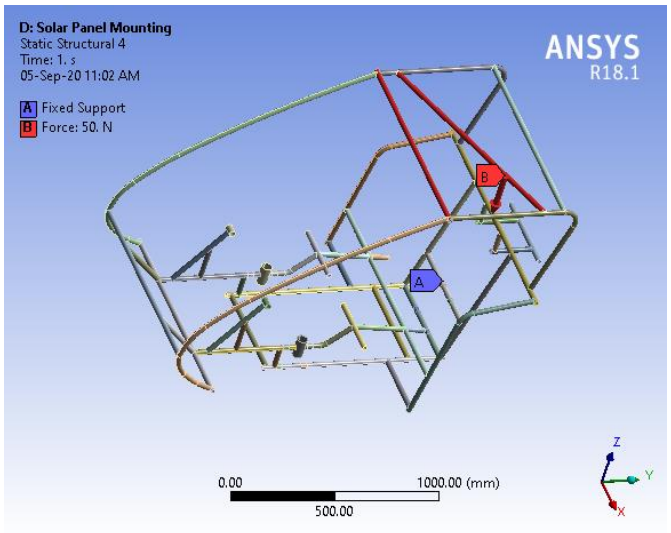
Following assumptions & considerations were made.
Suspension Mounting Points were fixed and weight of solar panel is 3 Kg.
Acceleration due to gravity=9.8m/s^2

b) Calculation of Forces:

Force= Mass x Acceleration

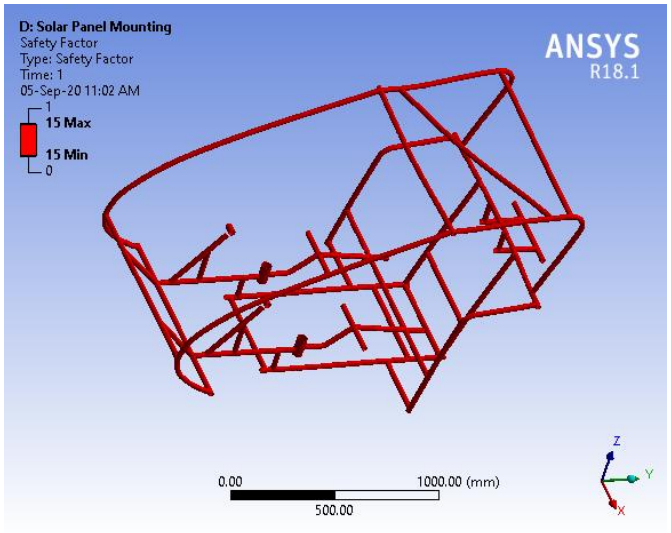
Force= 3*9.8

Force=29.4N

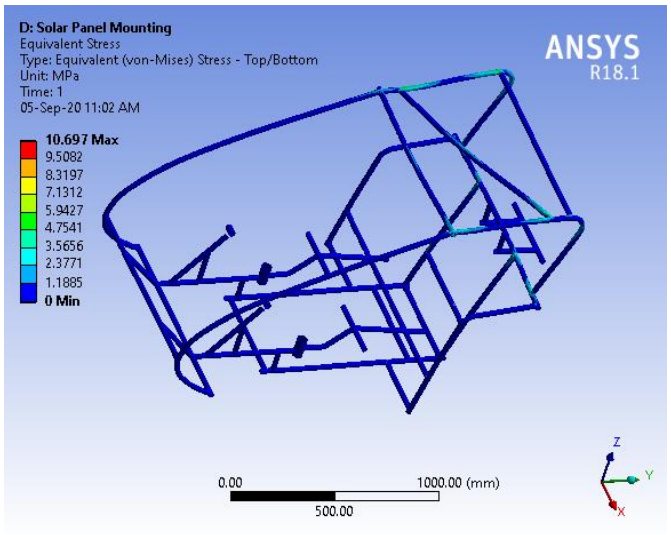


c) Analysis Results:

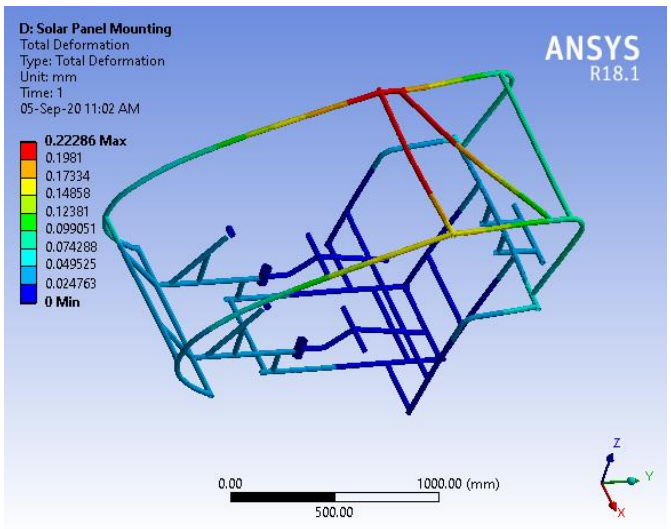
Factor of Safety= 15



Stress= 10.69MPa



Total Deformation= 0.22mm



d) Optimizations:

* Unnecessary members are removed

* T joints are preferred instead of corner joints

Material-2 (Steel AISI 1018,1.25inx1.13inx1.5mm)

Analysis 1-Suspension Mountings

a) Assumption & Considerations:

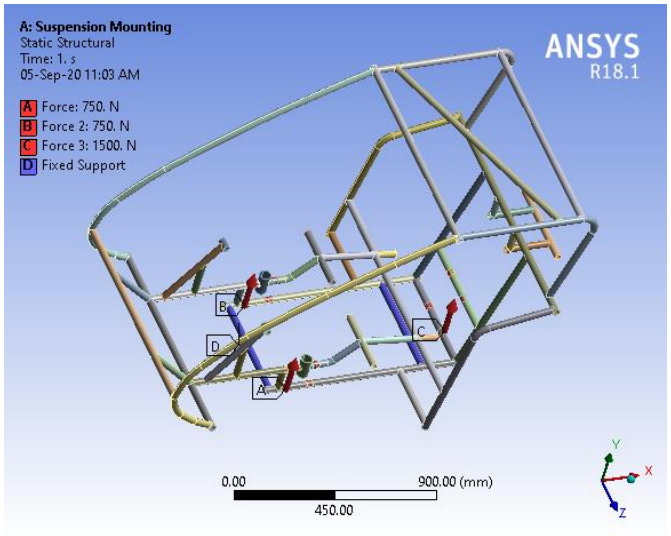
Following assumptions & considerations were made.

Frame was fixed for the analysis of suspension mounting points and a force equal to

b) Calculation of Forces:

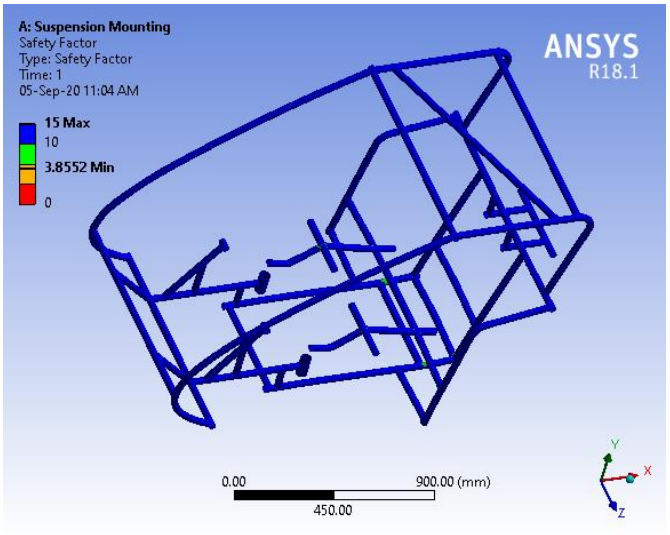
Max bump size=3.5in=8.89cm

v=√(2gh)=1.32 m/s
collision time=.54 s
Conservation of momentum
mv=-mv'
v'=-v
Change in momentum mv-(-mv)
F(bump force)=2mv/.54=2*245*1.32/.54
= 1197.77 N
≈1500N

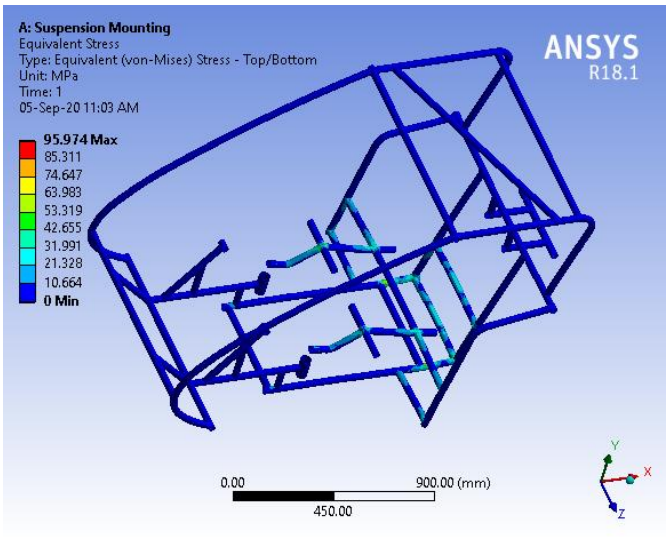


c) Analysis Results:

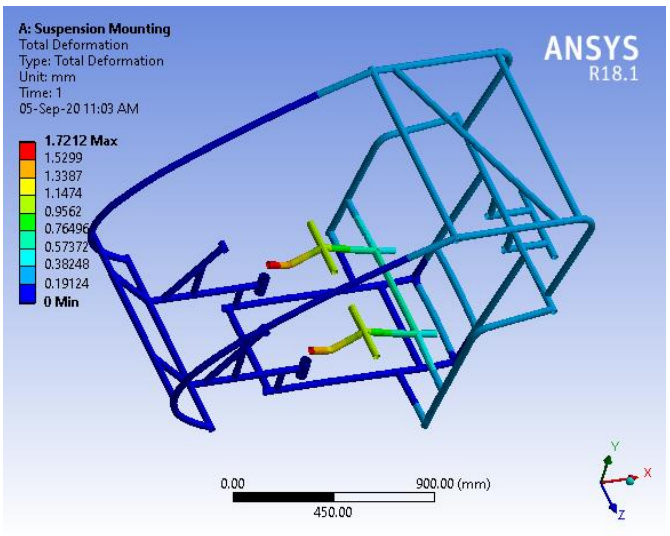
Factor of Safety= 3.85



Stress= 95.97MPa



Total Deformation= 1.72mm



d) Optimizations:

* Unnecessary members are removed

* T joints are preferred instead of corner joints

Analysis 2-Seat Mountings

a) Assumption & Considerations:

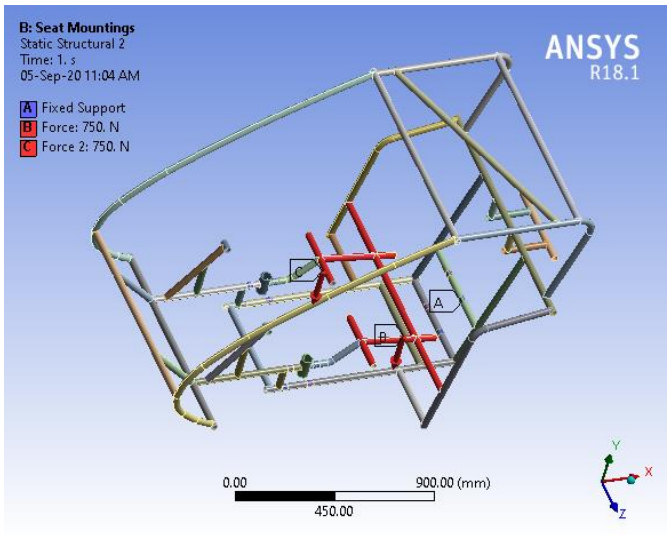
Following assumptions & considerations were made.
Suspension Mounting Points were fixed and weight of each driver was taken as 75 Kg.
Acceleration due to gravity=9.8m/s^2

b) Calculation of Forces:

Force= Mass x Acceleration

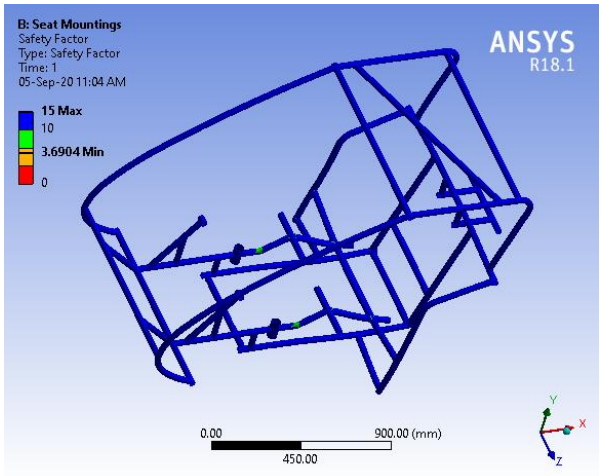
Force= 75*9.8

Force=735N

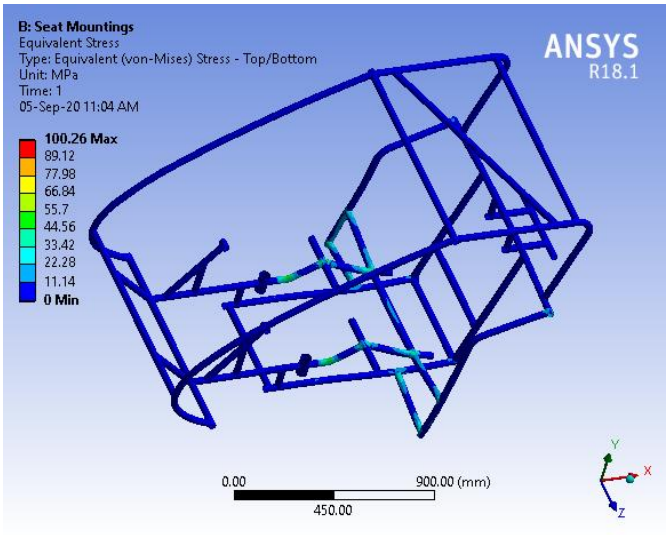


c) Analysis Results:

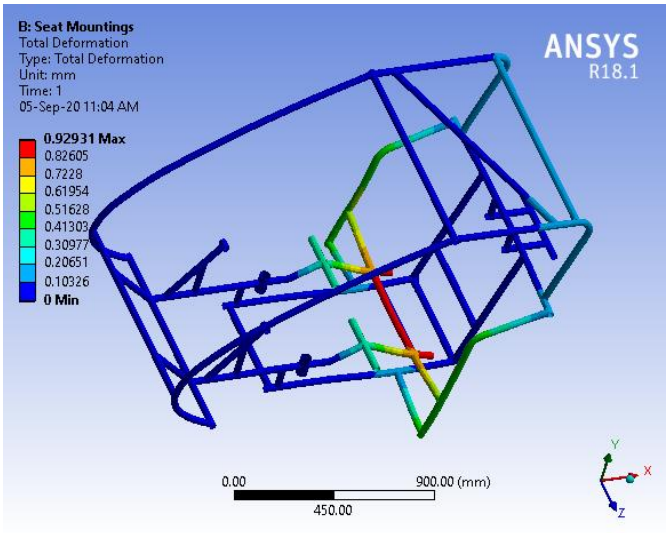
Factor of Safety= 3.69



Stress= 100.26MPa



Total Deformation= 0.92mm



d) Optimizations:

* Unnecessary members are removed

* T joints are preferred instead of corner joints

Analysis 3-Battery Mountings

a) Assumption & Considerations:

Following assumptions & considerations were made.
Suspension Mounting Points were fixed and weight of battery is 12 Kg.
Acceleration due to gravity=9.8m/s^2

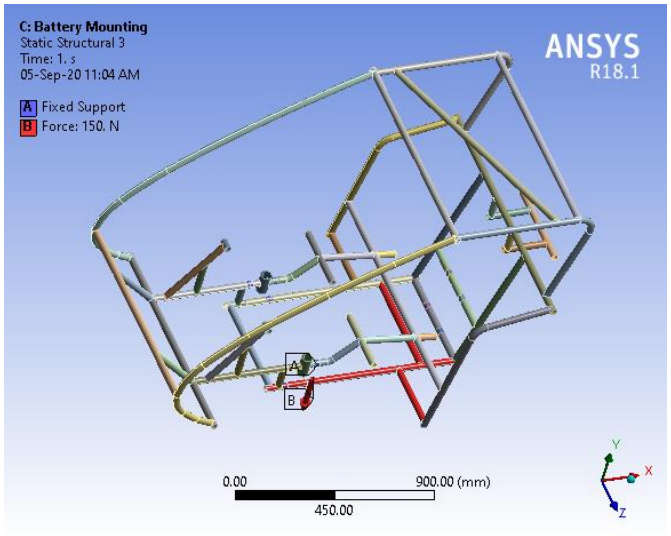
b) Calculation of Forces:

Force= Mass x Acceleration

Force= 12*9.8

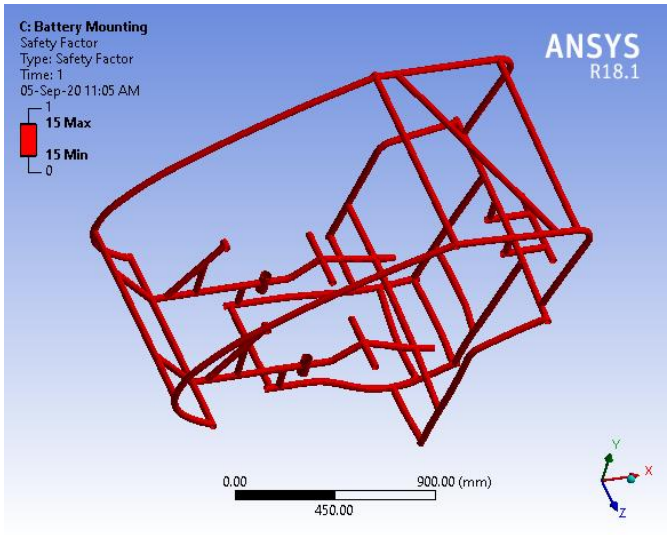
Force=117.6N

≈150N

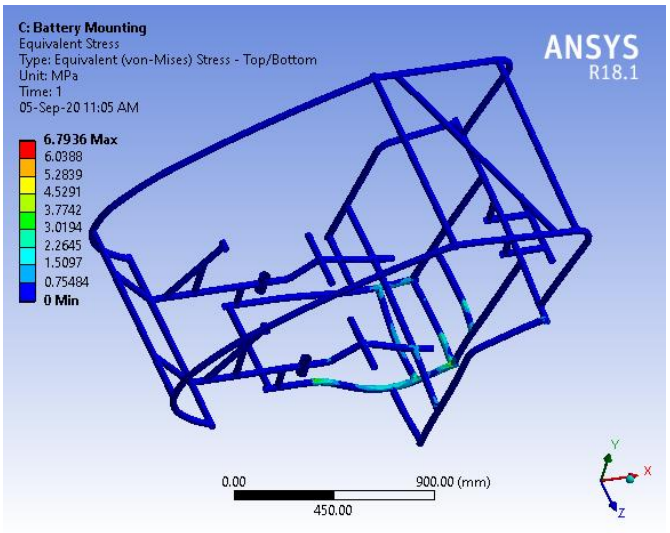


c) Analysis Results:

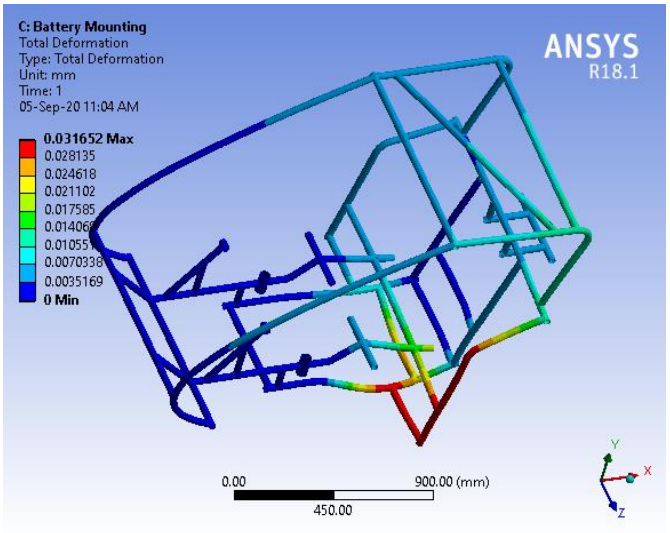
Factor of Safety= 15



Stress= 6.79MPa



Total Deformation= 0.03mm



d) Optimizations:

* Unnecessary members are removed

* T joints are preferred instead of corner joints

Analysis 2-Seat Mountings

a) Assumption & Considerations:

Following assumptions & considerations were made.
Suspension Mounting Points were fixed and weight of solar panel is 3 Kg.
Acceleration due to gravity=9.8m/s^2

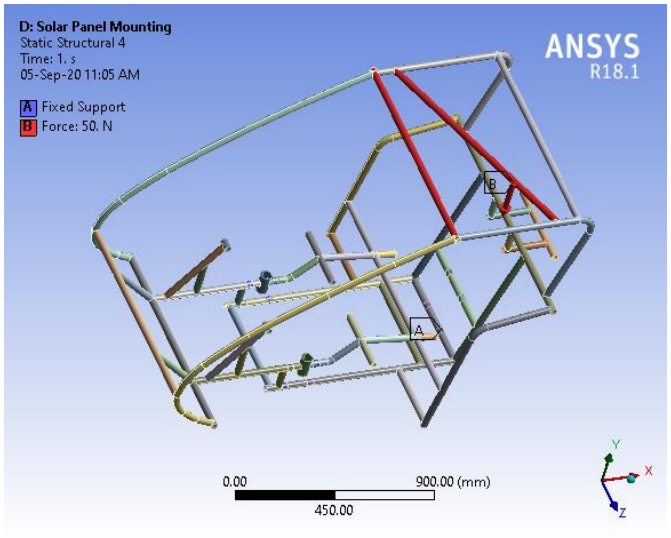
b) Calculation of Forces:

Force= Mass x Acceleration

Force= 3*9.8

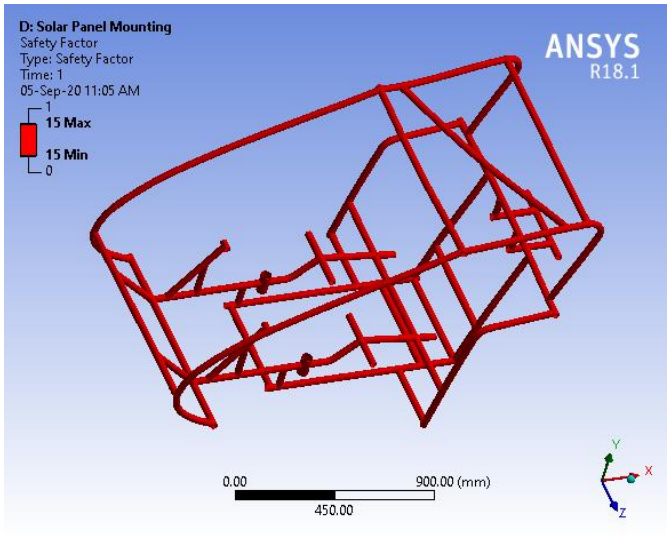
Force=29.4N

≈50N

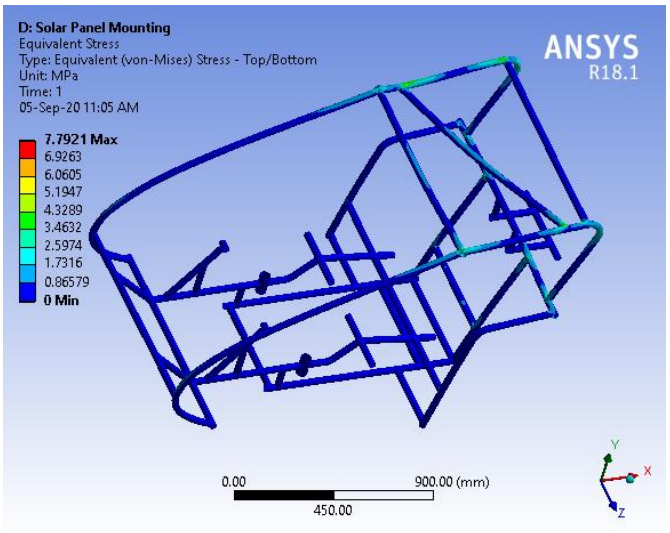


c) Analysis Results:

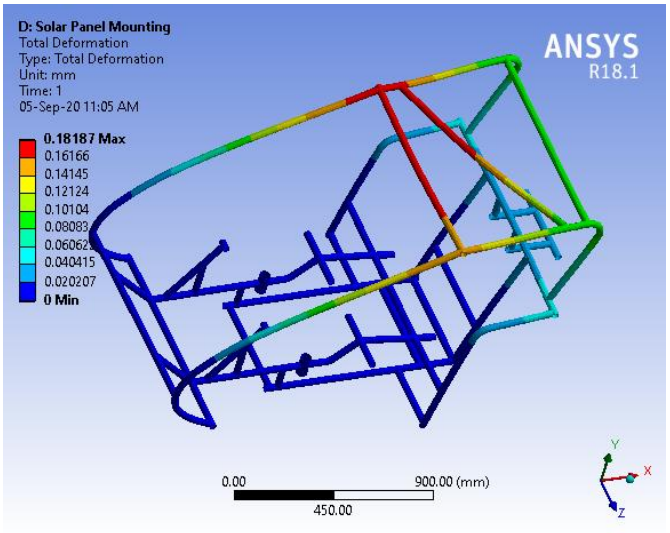
Factor of Safety= 15



Stress= 7.79MPa



Total Deformation= 0.18mm



d) Optimizations:

* Unnecessary members are removed

* T joints are preferred instead of corner joints

Material-3 (Steel AISI 4130,1.25inx1.13inx1.5mm)

Analysis 1-Suspension Mountings

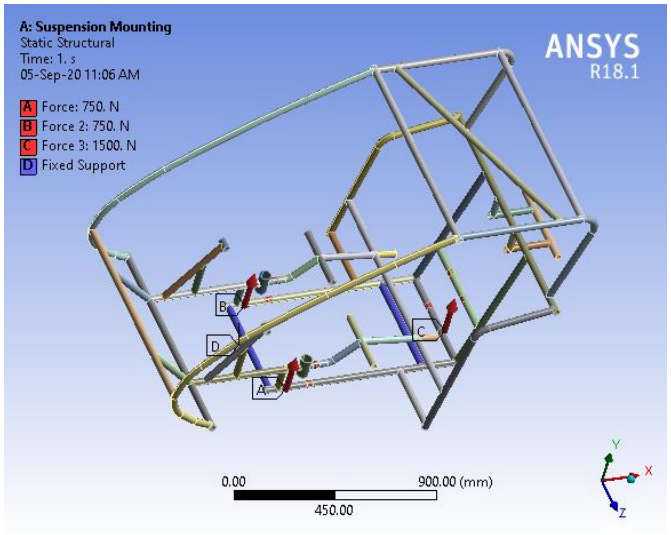
a) Assumption & Considerations:

Following assumptions & considerations were made.
Frame was fixed for the analysis of suspension mounting points and a force equal to

b) Calculation of Forces:

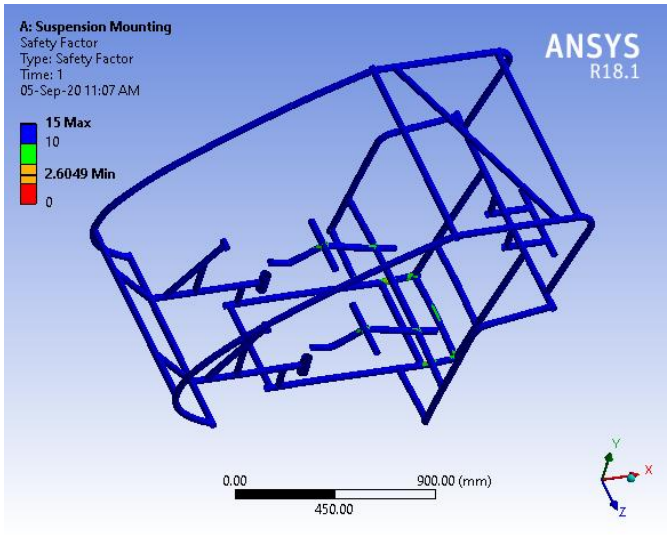
Max bump size=3.5in=8.89cm

v=√(2gh)=1.32 m/s
collision time=.54 s
Conservation of momentum
mv=-mv'
v'=-v
Change in momentum mv-(-mv)
F(bump force)=2mv/.54=2*245*1.32/.54
= 1197.77 N
≈1500N

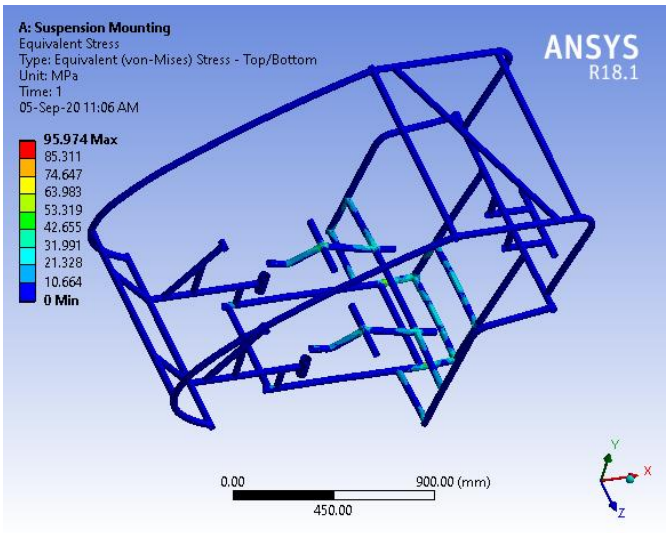


c) Analysis Results:

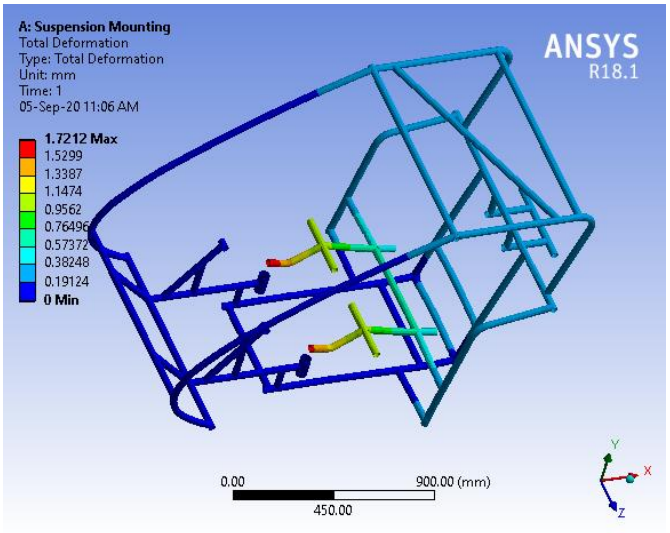
Factor of Safety= 2.60



Stress= 95.97MPa



Total Deformation= 1.72mm



d) Optimizations:

* Unnecessary members are removed

* T joints are preferred instead of corner joints

Analysis 2-Seat Mountings

a) Assumption & Considerations:

Following assumptions & considerations were made.

Suspension Mounting Points were fixed and weight of each driver was taken as 75 Kg.
Acceleration due to gravity=9.8m/s^2

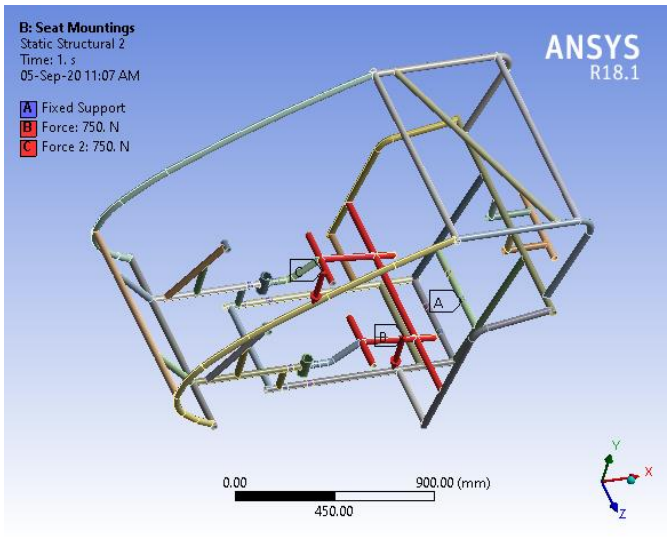
b) Calculation of Forces:

Force= Mass x Acceleration

Force= 75*9.8

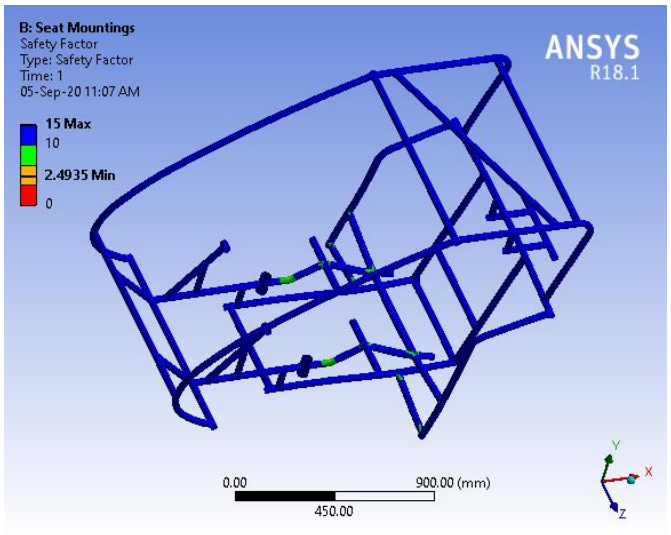
Force=735N

≈750N

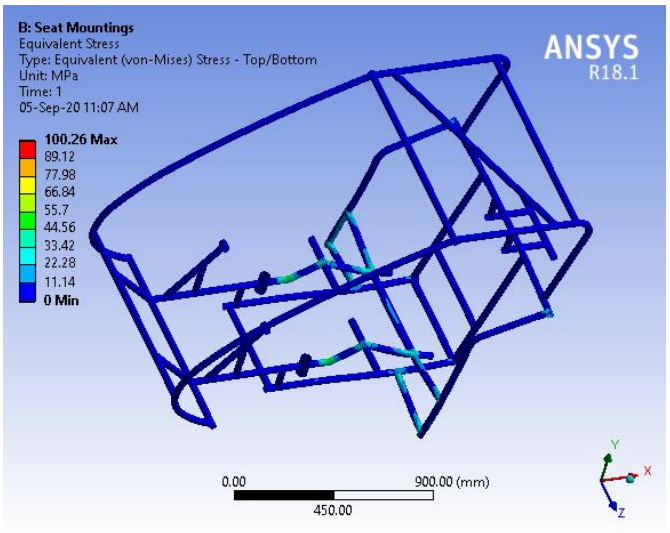


c) Analysis Results:

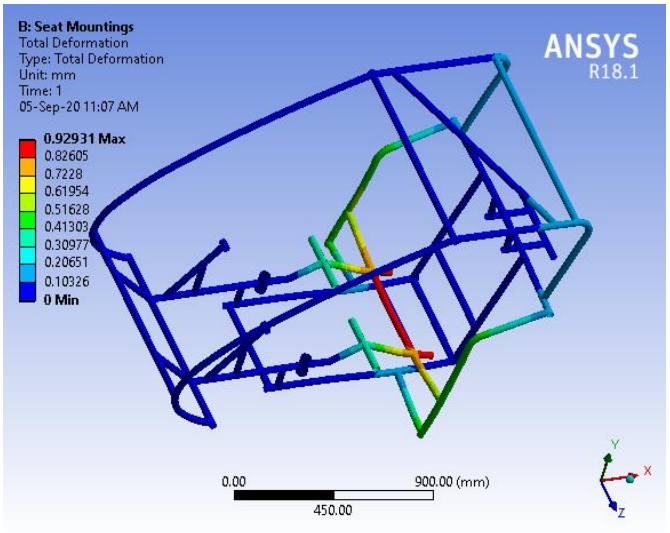
Factor of Safety= 2.49



Stress= 100.26MPa



Total Deformation= 0.92mm



d) Optimizations:

* Unnecessary members are removed

* T joints are preferred instead of corner joints

Analysis 3-Battery Mountings

a) Assumption & Considerations:

Following assumptions & considerations were made.
Suspension Mounting Points were fixed and weight of battery is 12 Kg.
Acceleration due to gravity=9.8m/s^2

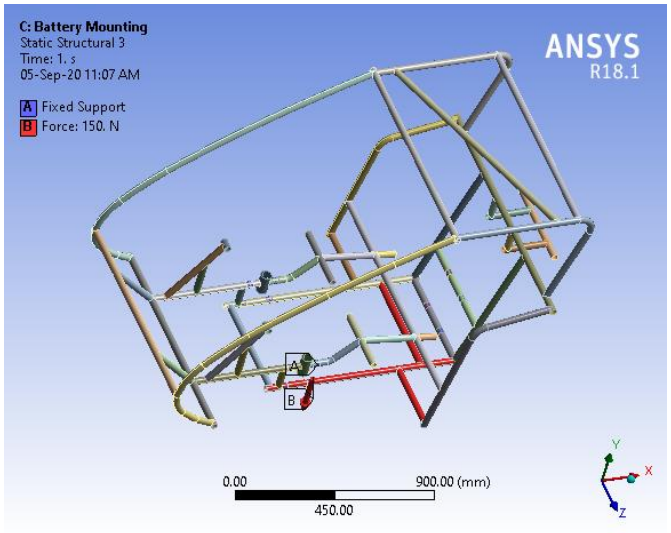
b) Calculation of Forces:

Force= Mass x Acceleration

Force= 12*9.8

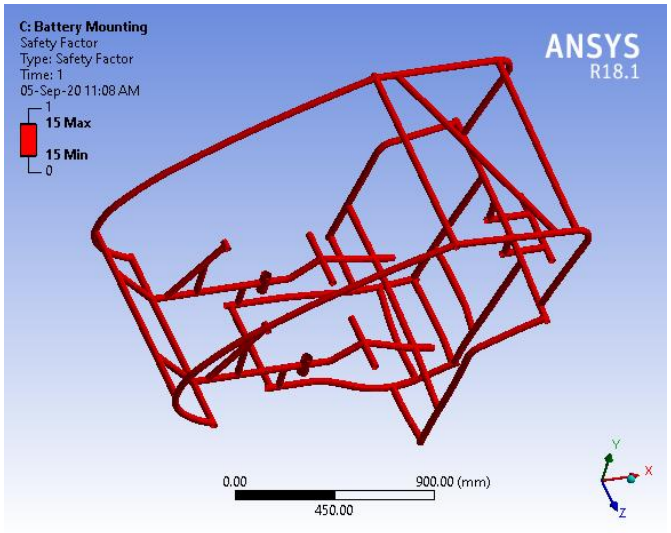
Force=117.6N

≈150N

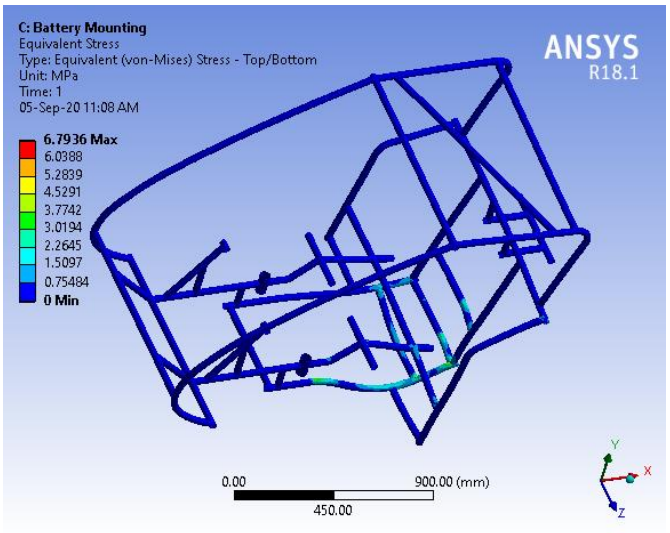


c) Analysis Results:

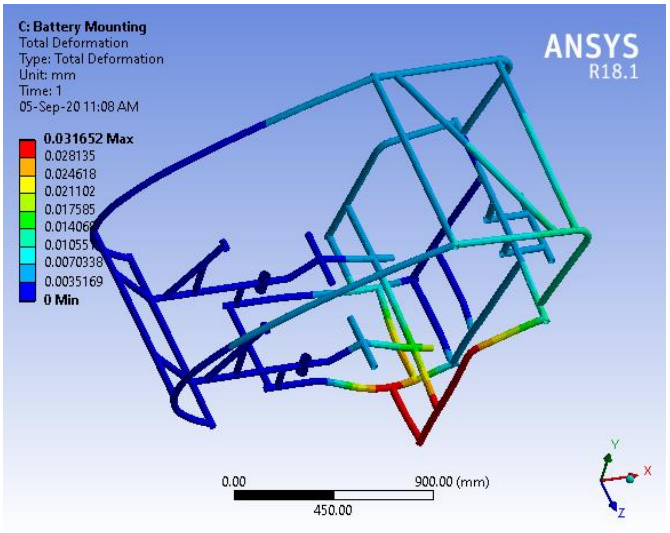
Factor of Safety= 15



Stress= 6.79MPa



Total Deformation= 0.03mm



d) Optimizations:

* Unnecessary members are removed

* T joints are preferred instead of corner joints

Analysis 2-Seat Mountings

a) Assumption & Considerations:

Following assumptions & considerations were made.
Suspension Mounting Points were fixed and weight of solar panel is 3 Kg.
Acceleration due to gravity=9.8m/s^2

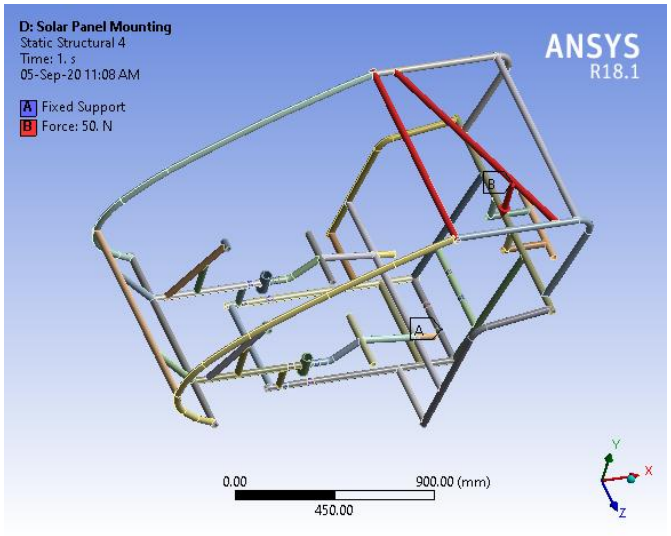
b) Calculation of Forces:

Force= Mass x Acceleration

Force= 3*9.8

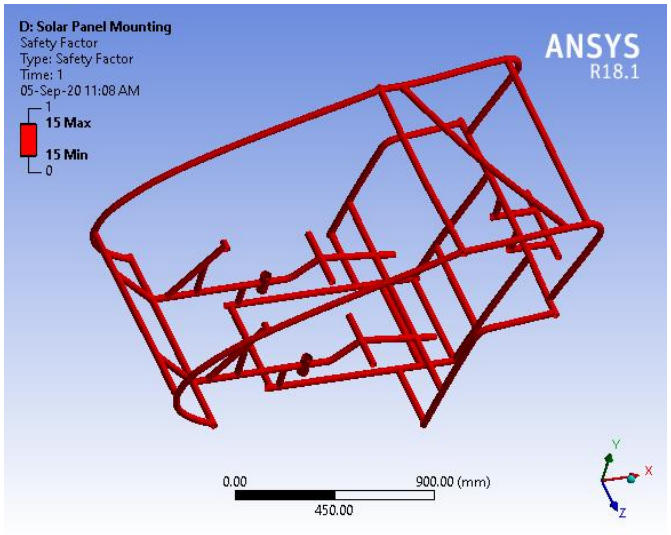
Force=29.4N

≈50N

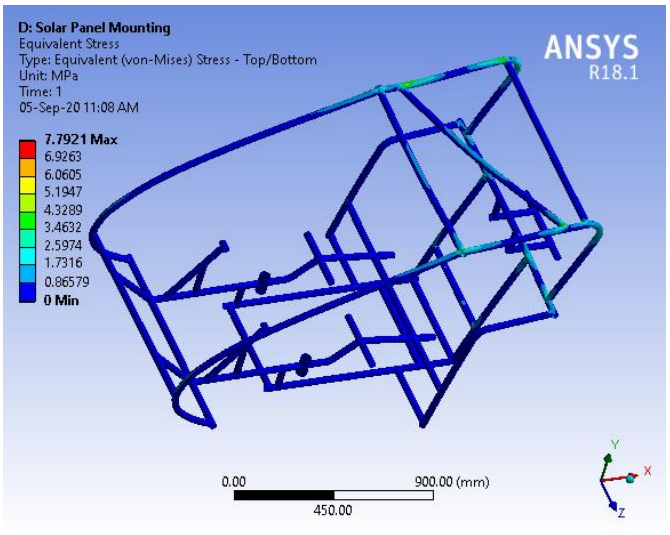


c) Analysis Results:

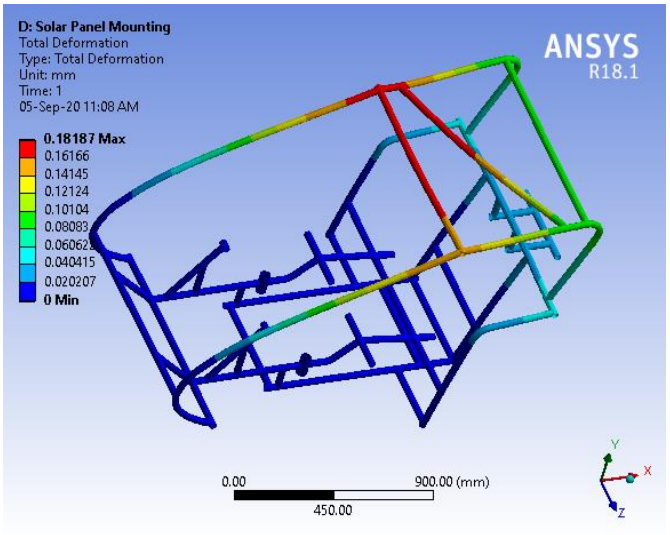
Factor of Safety= 15



Stress= 7.79MPa



Total Deformation= 0.18mm



d) Optimizations:

* Unnecessary members are removed

* T joints are preferred instead of corner joints

Material-4 (Steel AISI 4130, 1.225inx1.11inx1.65mm)

Analysis 1-Suspension Mountings

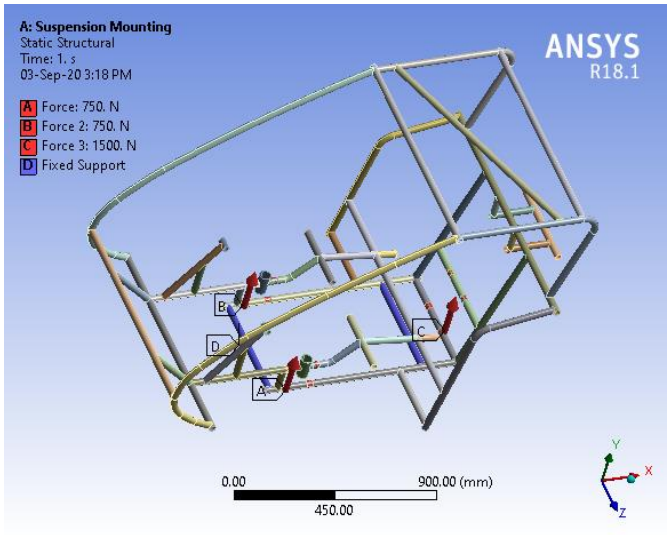
a) Assumption & Considerations:

Following assumptions & considerations were made.
Frame was fixed for the analysis of suspension mounting points and a force equal to

b) Calculation of Forces:

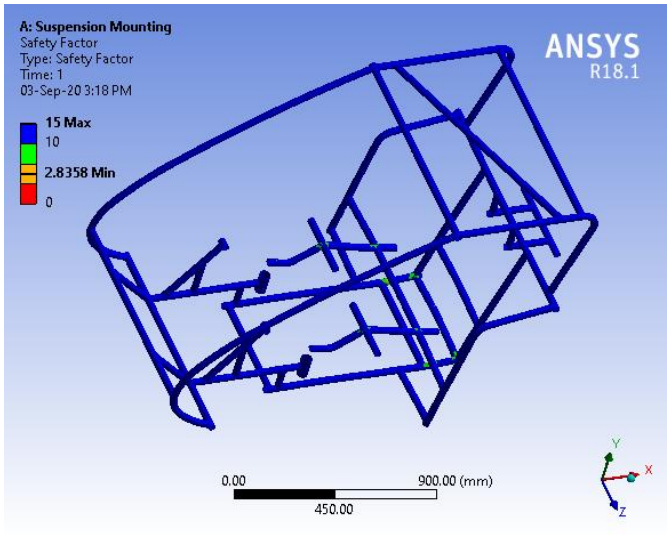
Max bump size=3.5in=8.89cm

v=√(2gh)=1.32 m/s
collision time=.54 s
Conservation of momentum
mv=-mv'
v'=-v
Change in momentum mv-(-mv)
F(bump force)=2mv/.54=2*245*1.32/.54
= 1197.77 N
≈1500N

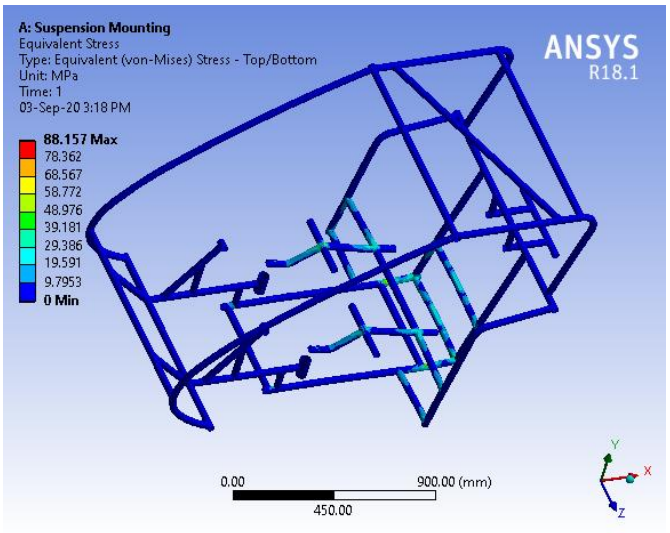


c) Analysis Results:

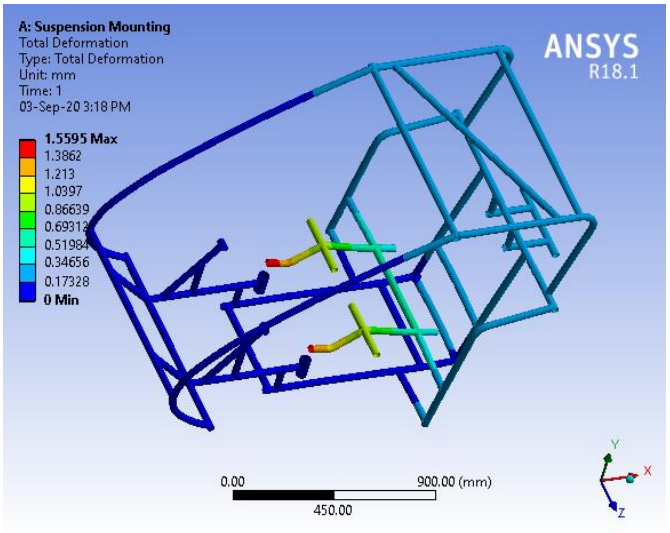
Factor of Safety= 2.83



Stress= 88.15MPa



Total Deformation= 1.55mm



d) Optimizations:

* Unnecessary members are removed

* T joints are preferred instead of corner joints

Analysis 2-Seat Mountings

a) Assumption & Considerations:

Following assumptions & considerations were made.

Suspension Mounting Points were fixed and weight of each driver was taken as 75 Kg.
Acceleration due to gravity=9.8m/s^2

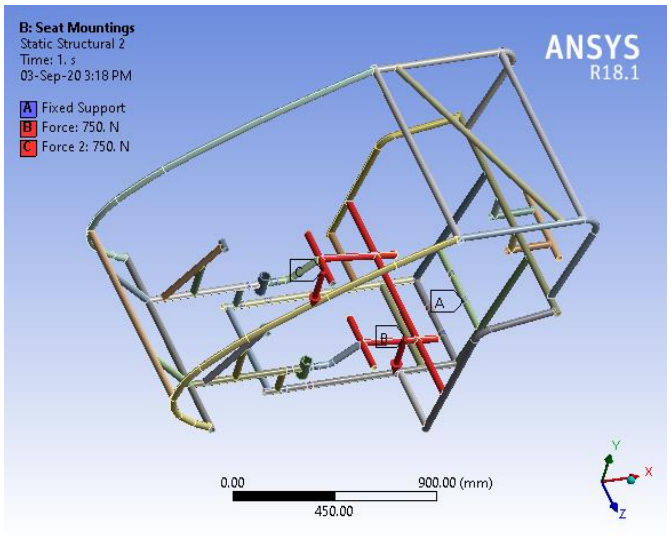
b) Calculation of Forces:

Force= Mass x Acceleration

Force= 75*9.8

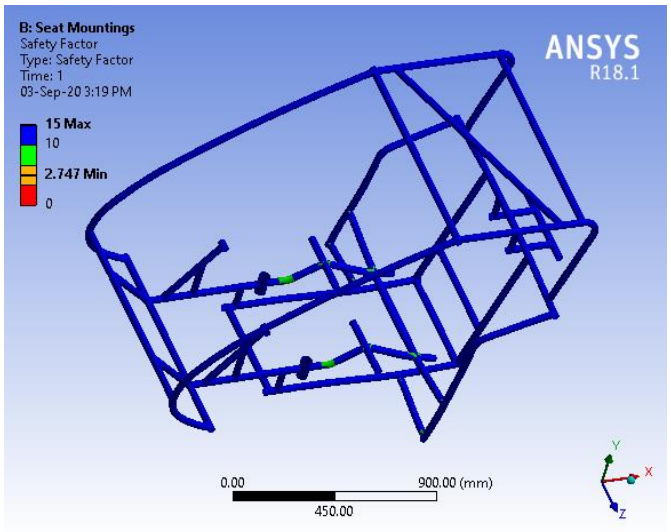
Force=735N

≈750N

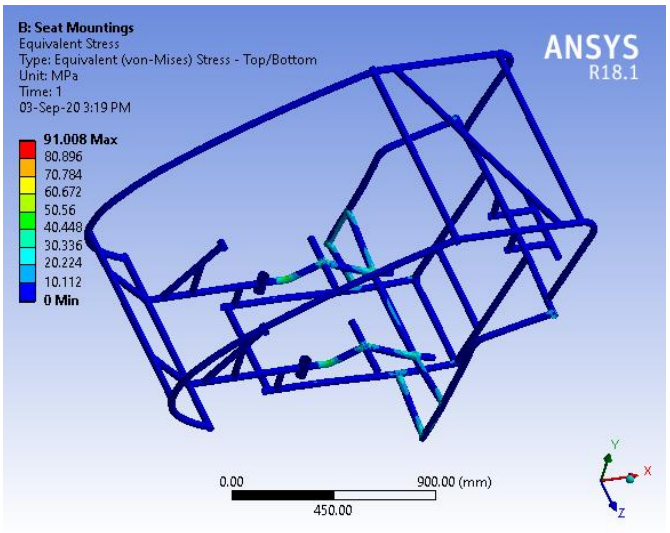


c) Analysis Results:

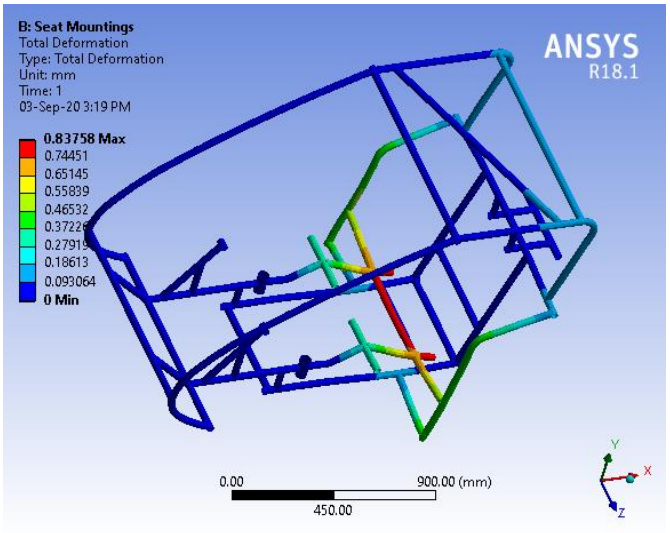
Factor of Safety= 2.74



Stress= 91.00MPa



Total Deformation= 0.83mm



d) Optimizations:

* Unnecessary members are removed

* T joints are preferred instead of corner joints

Analysis 3-Battery Mountings

a) Assumption & Considerations:

Following assumptions & considerations were made.
Suspension Mounting Points were fixed and weight of battery is 12 Kg.
Acceleration due to gravity=9.8m/s^2

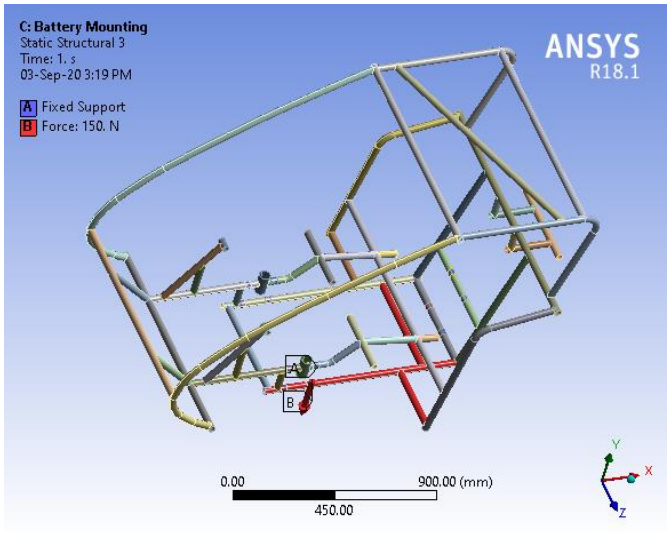
b) Calculation of Forces:

Force= Mass x Acceleration

Force= 12*9.8

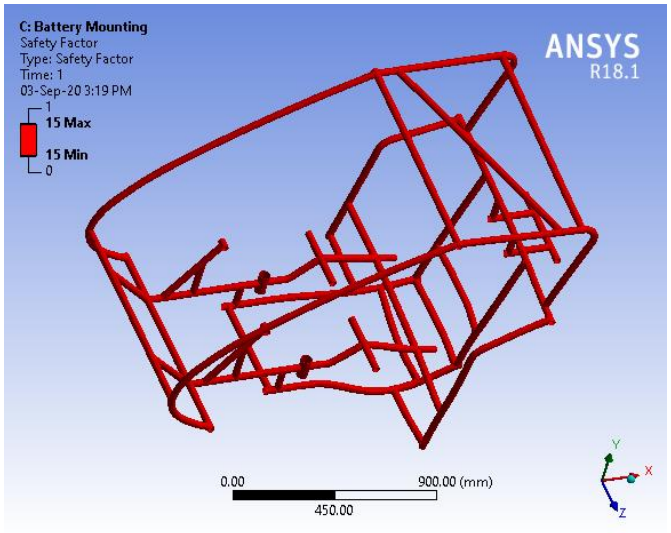
Force=117.6N

≈150N

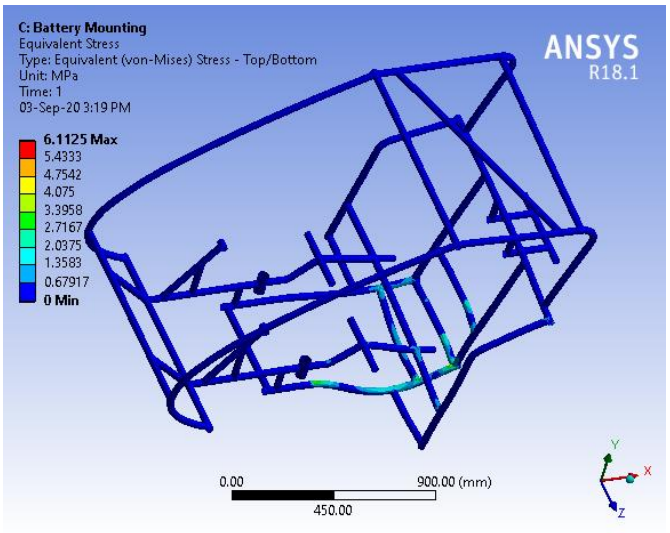


c) Analysis Results:

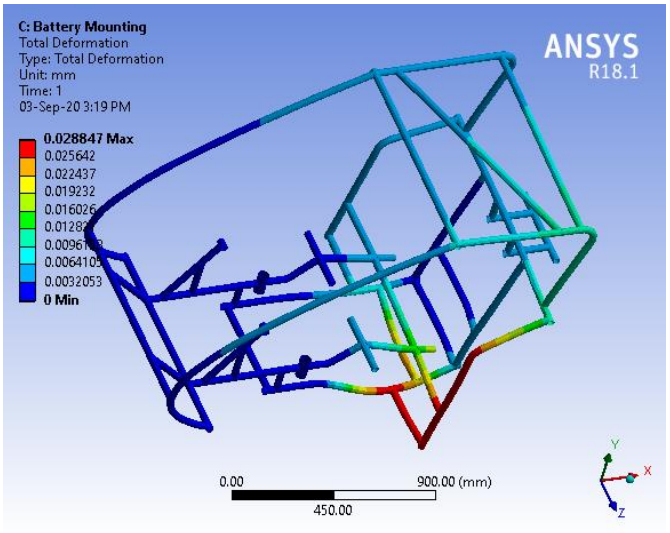
Factor of Safety= 15



Stress= 6.11MPa



Total Deformation= 0.02mm



d) Optimizations:

* Unnecessary members are removed

* T joints are preferred instead of corner joints

Analysis 2-Seat Mountings

a) Assumption & Considerations:

Following assumptions & considerations were made.
Suspension Mounting Points were fixed and weight of solar panel is 3 Kg.
Acceleration due to gravity=9.8m/s^2

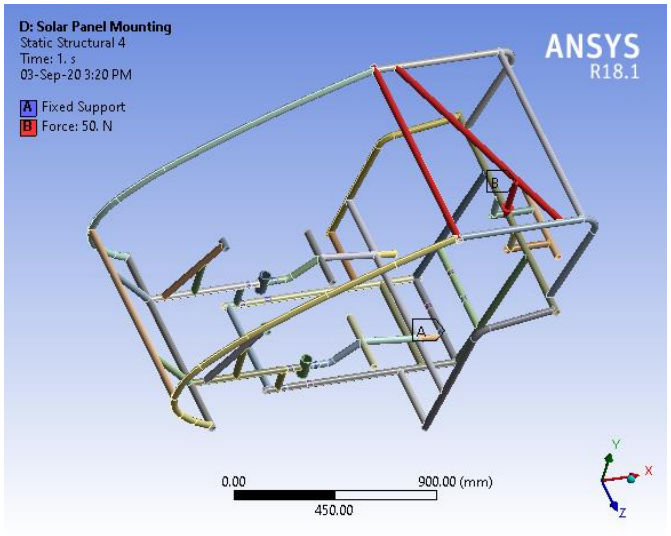
b) Calculation of Forces:

Force= Mass x Acceleration

Force= 3*9.8

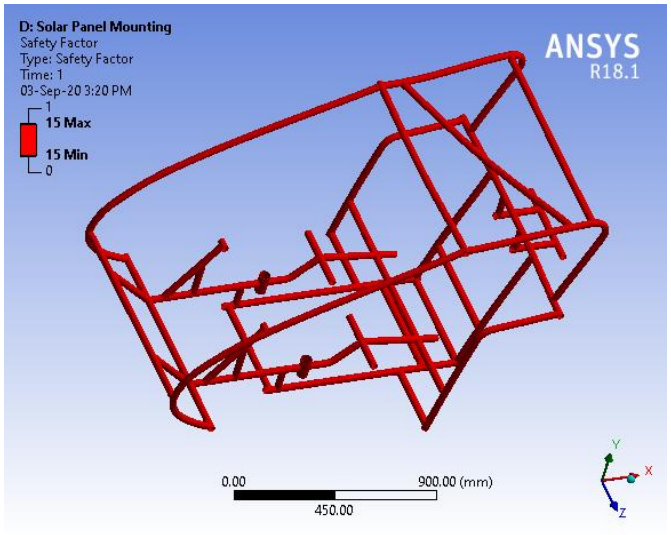
Force=29.4N

≈50N

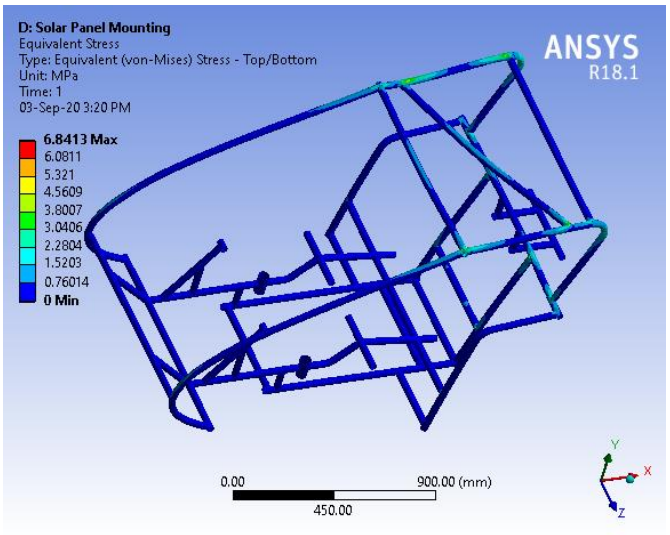


c) Analysis Results:

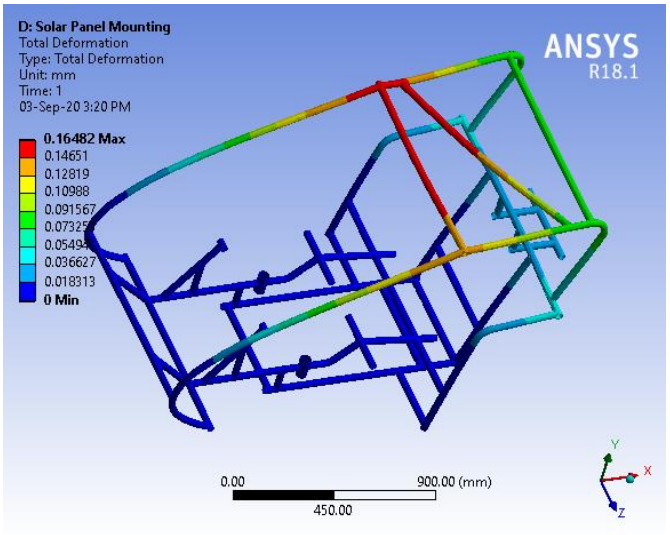
Factor of Safety= 15



Stress= 6.84MPa



Total Deformation= 0.16mm



d) Optimizations:

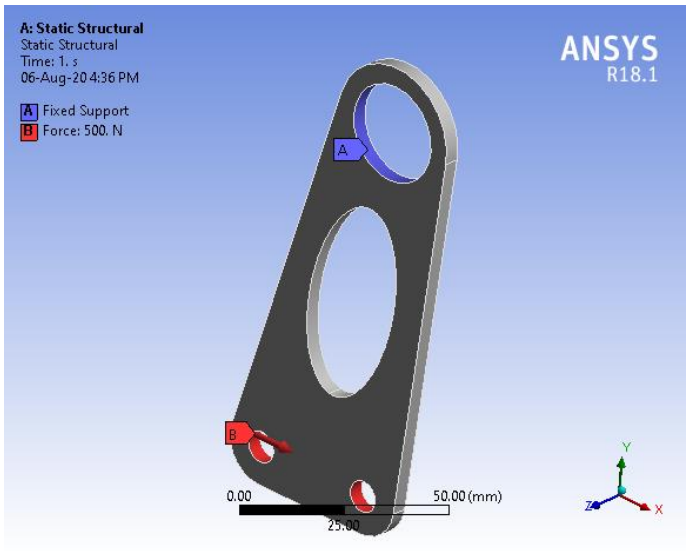
* Unnecessary members are removed

* T joints are preferred instead of corner joints

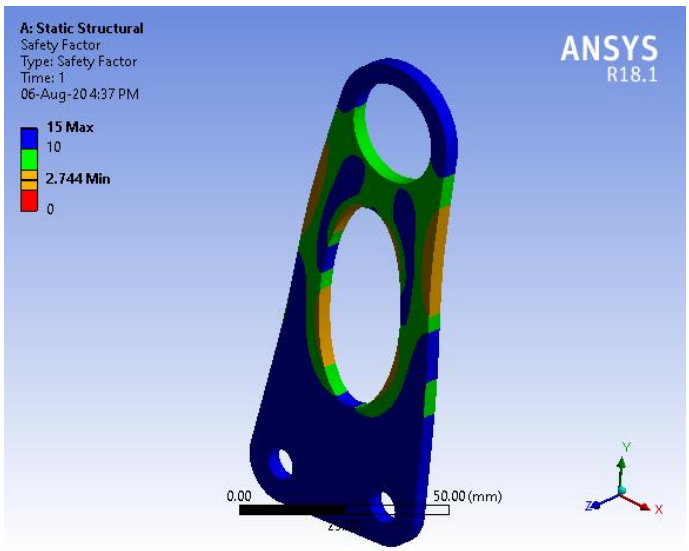
5. CAE ANALYSIS OF OTHER PARTS

a) CAE analysis : Steering Crank

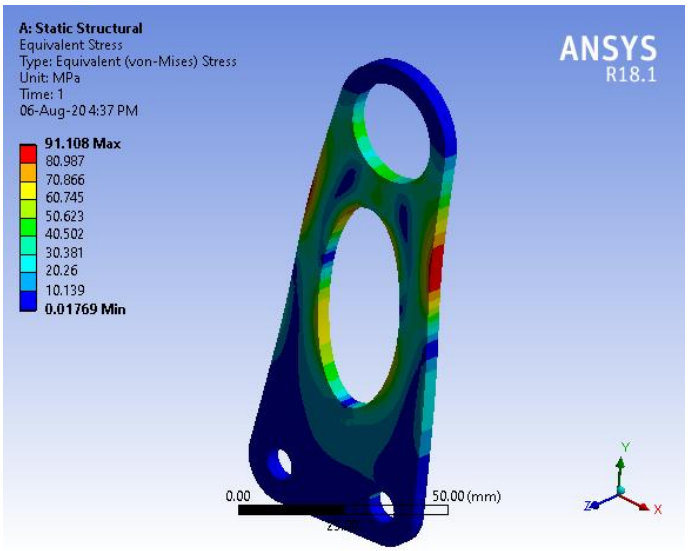
Force applied by tie rod = 500 N



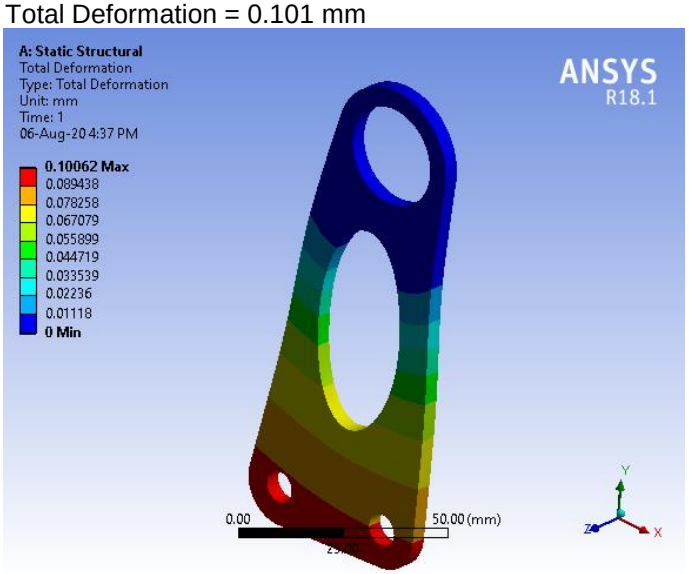
Safety Factor=2.74



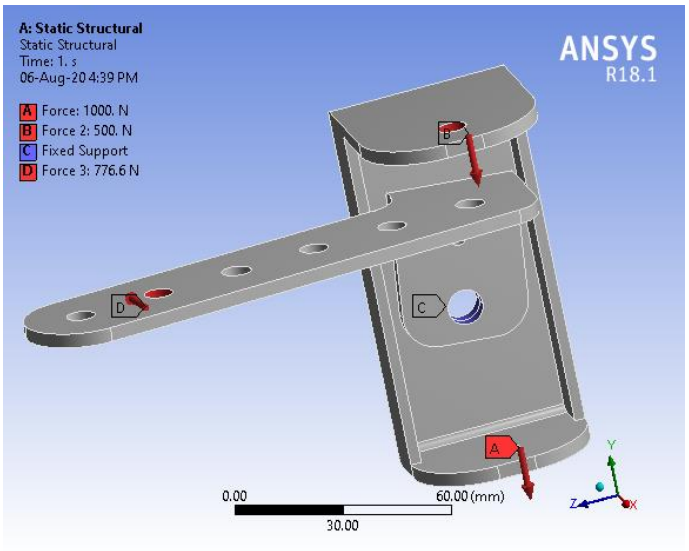
Equivalent Stress=91.11 MPa



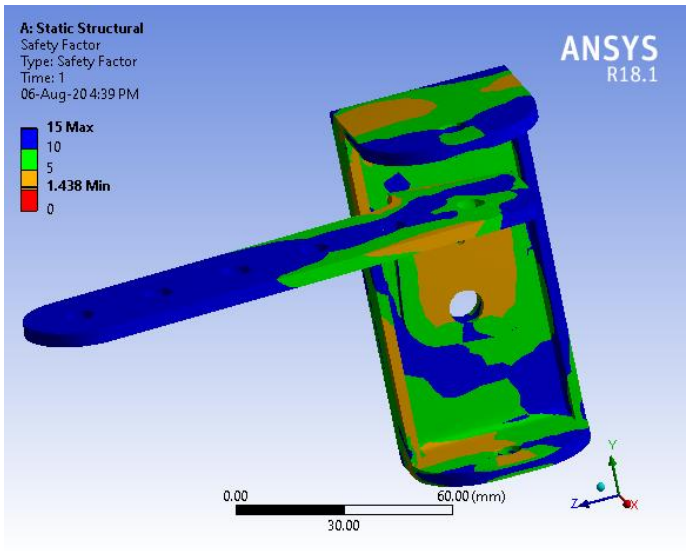
Total Deformation = 0.101 mm



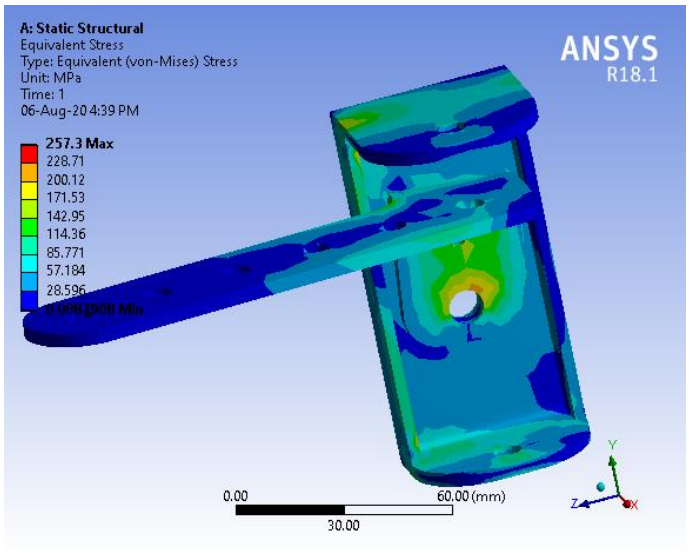
b) CAE analysis : Knuckle + Steering arm



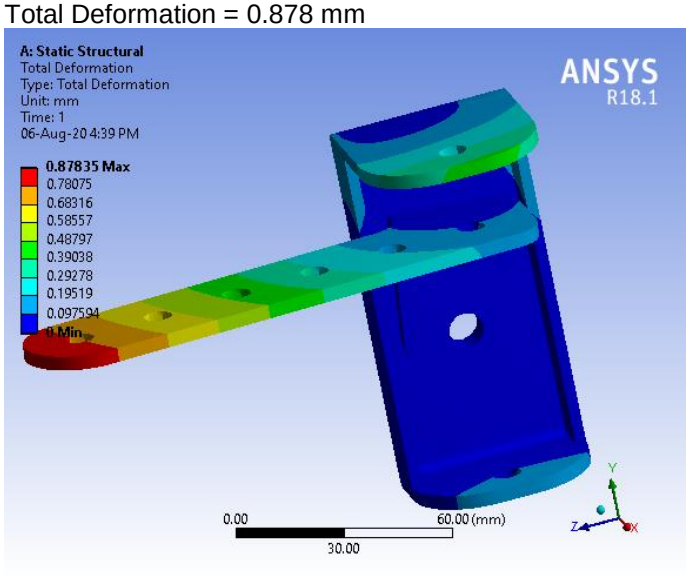
Safety Factor=1.43



Equivalent Stress=257.3 MPa

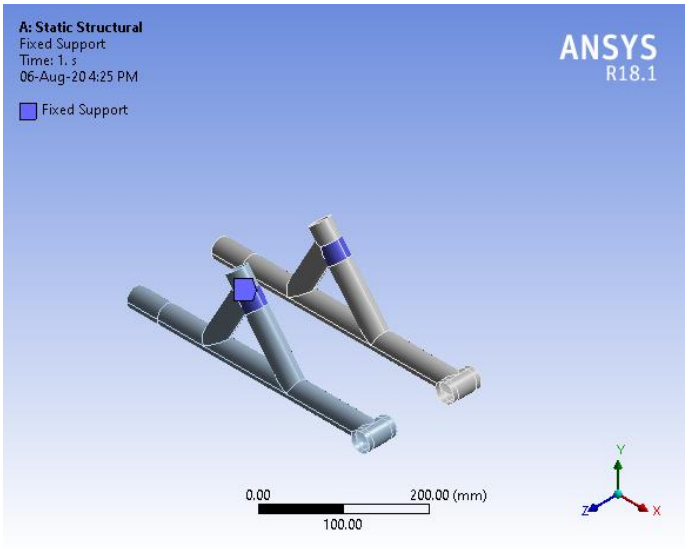


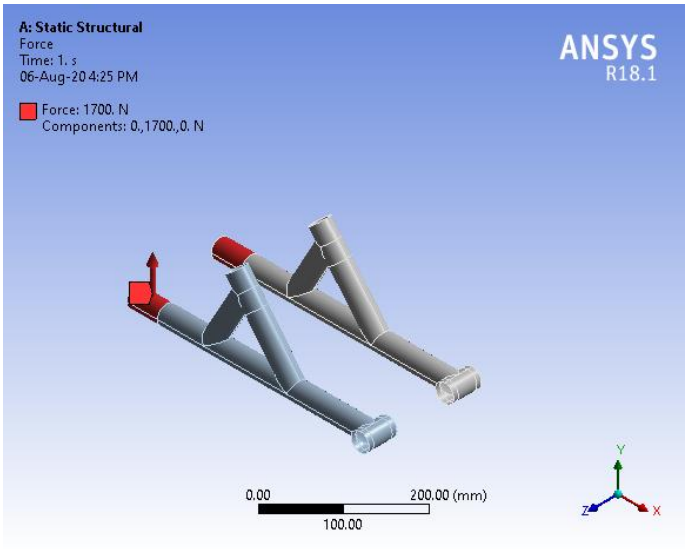
Total Deformation = 0.878 mm

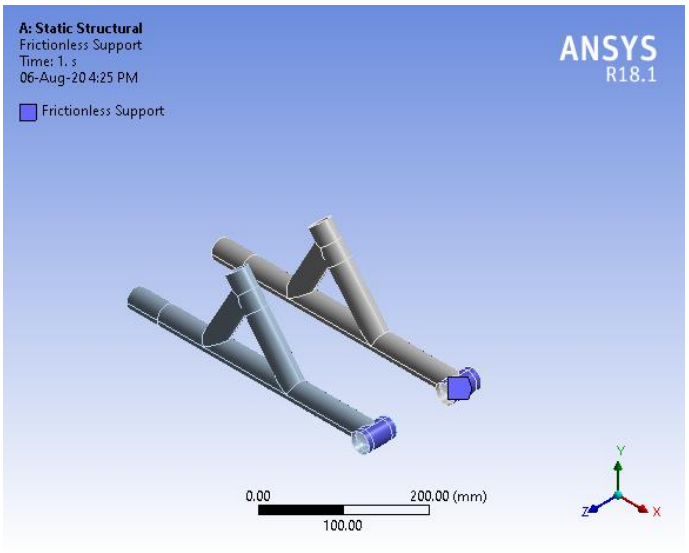


c) CAE analysis: Trailing arm

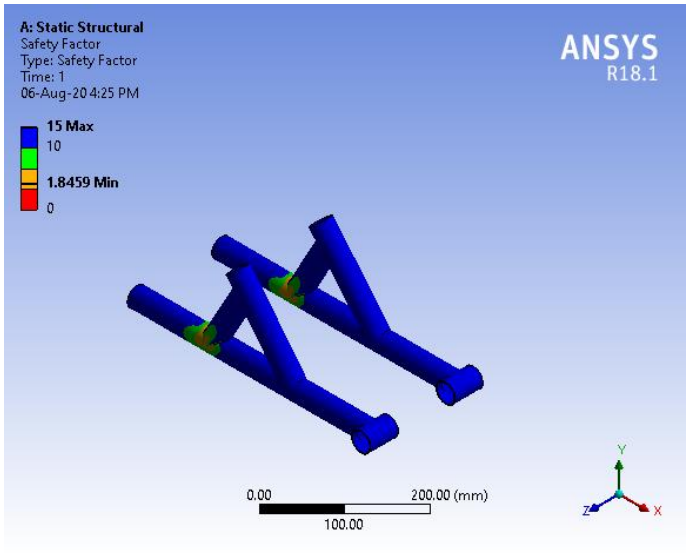
Trailing arm is subjected to a Maximum Force of 1500 N



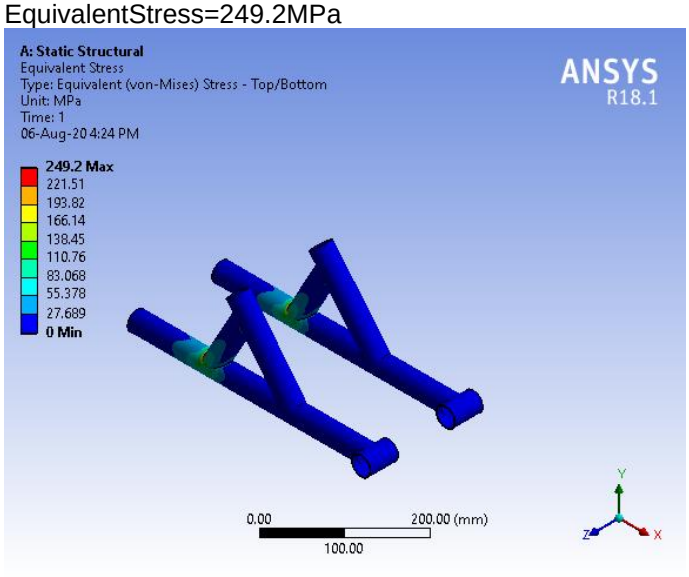




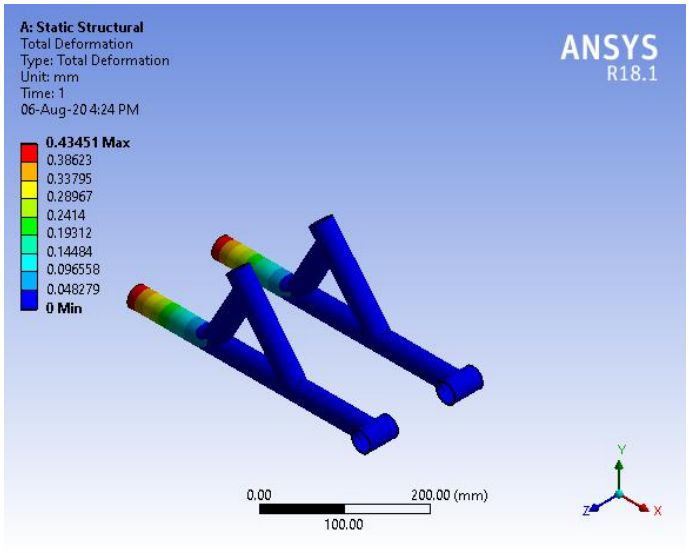
Safety Factor=1.8459



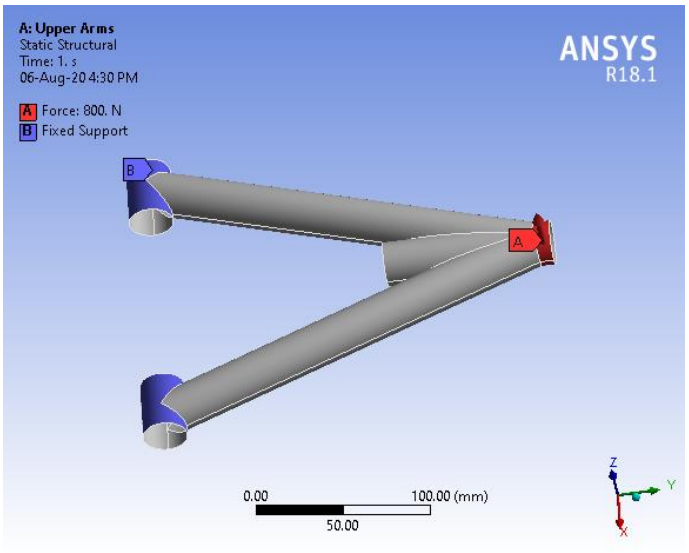
EquivalentStress=249.2MPa



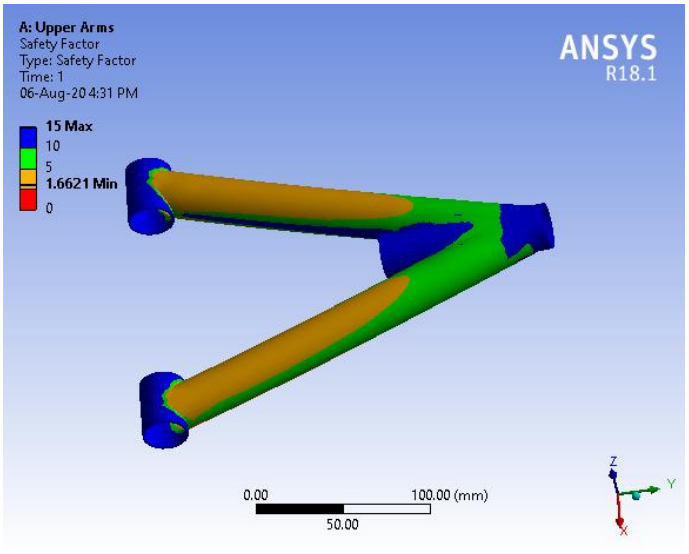
Total Deformation = 0.43451 mm



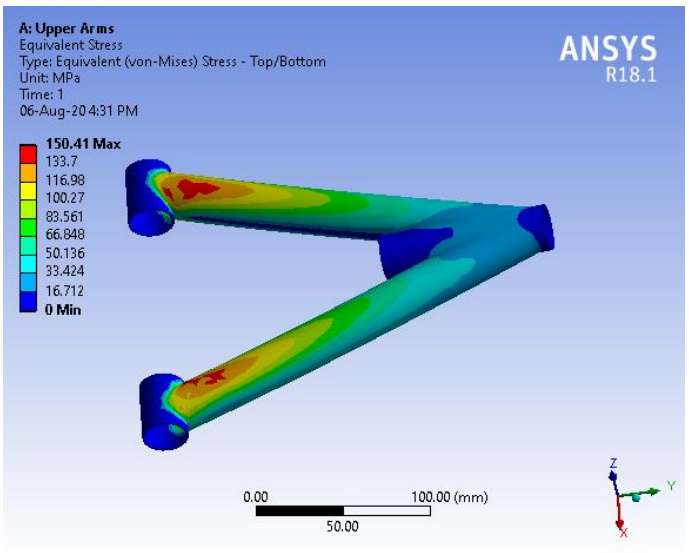
d) CAE analysis: Upper A - arm



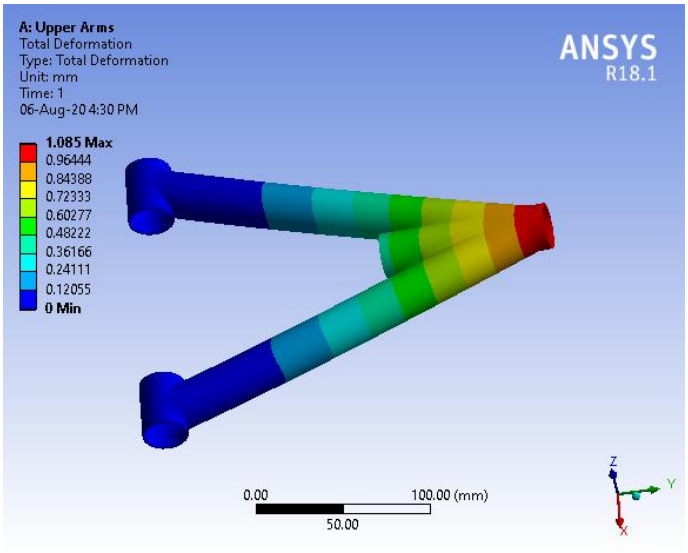
Safety Factor=1.6621



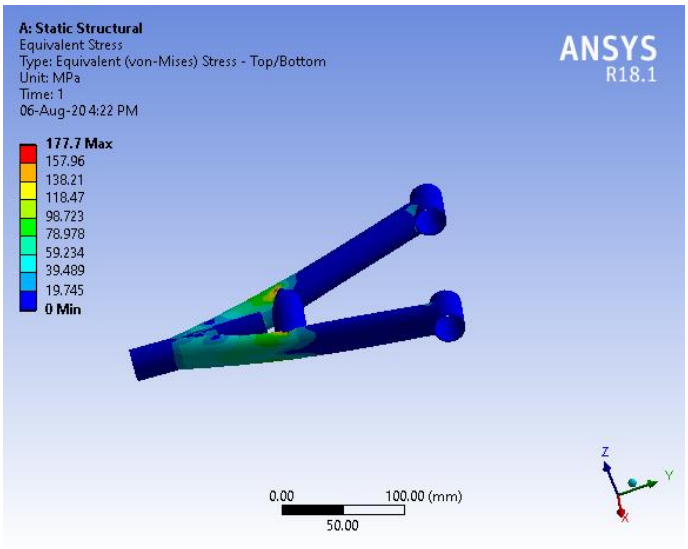
Equivalent Stress=150.41 MPa



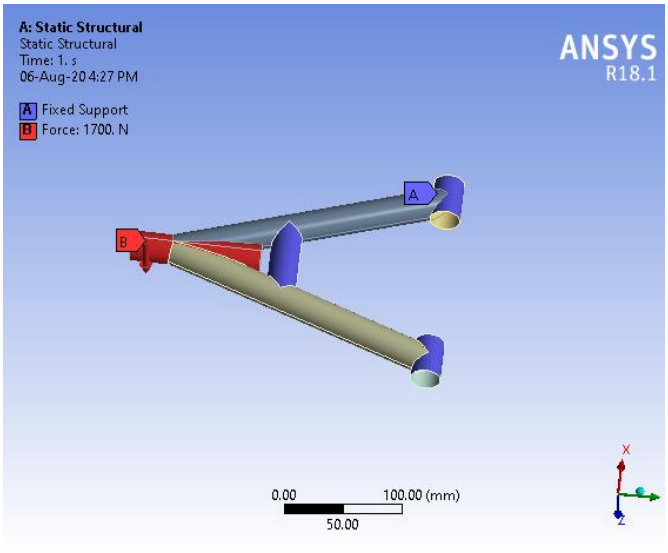
Total Deformation = 1.085 mm



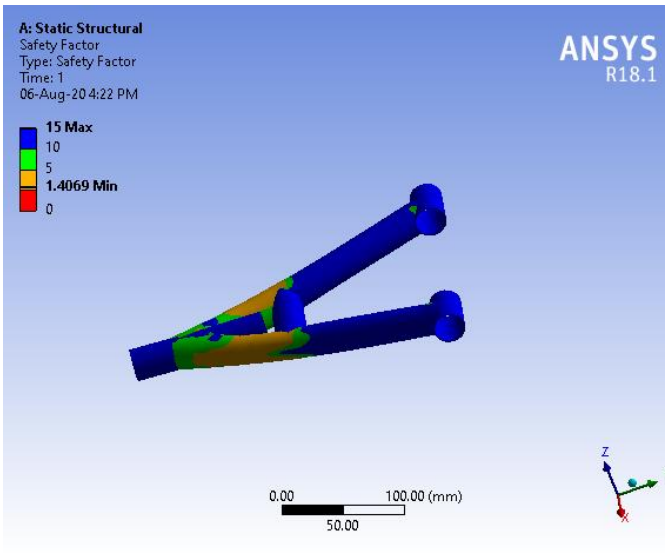
Equivalent Stress=177.7 MPa



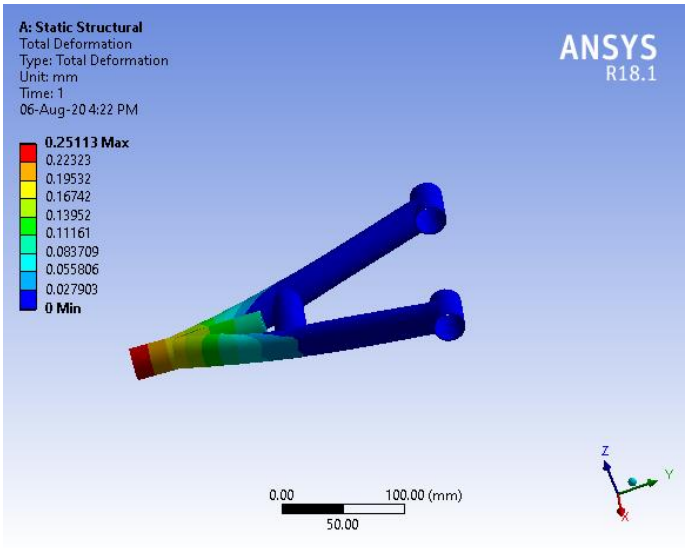
e) CAE analysis: Lower A- arm



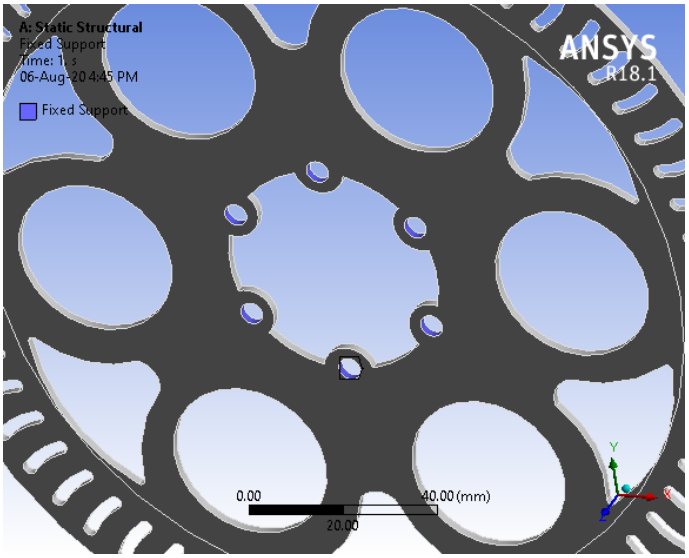
Safety Factor=1.4069

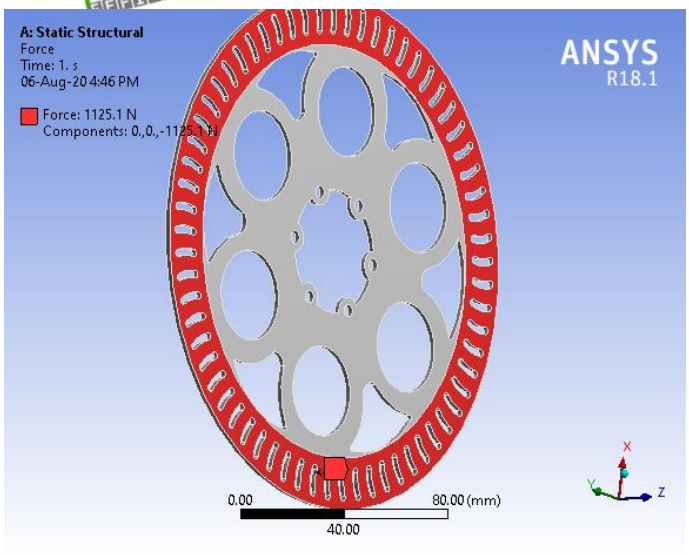


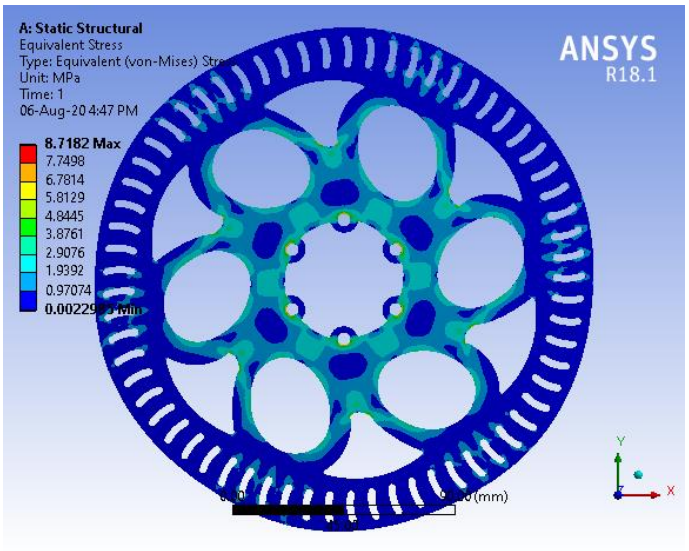
Total Deformation = 0.25113 mm



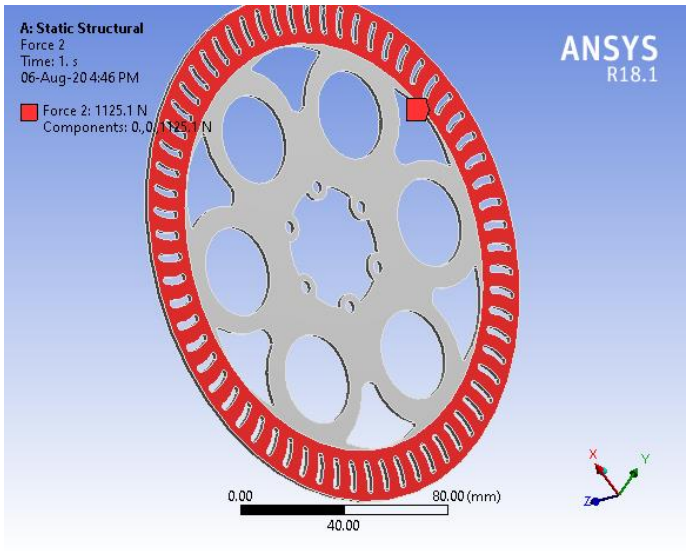
f) CAE analysis: Brake disc

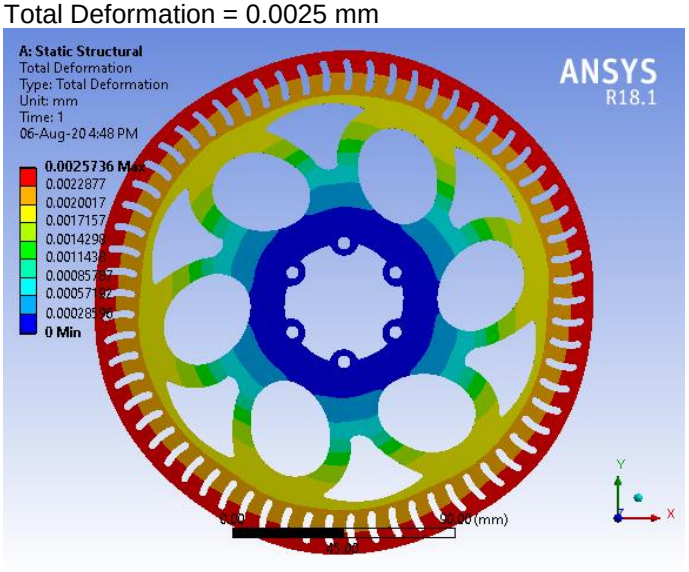




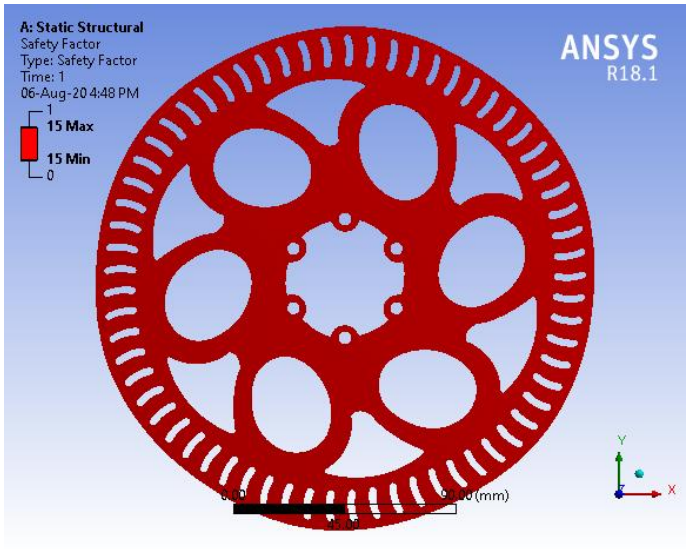


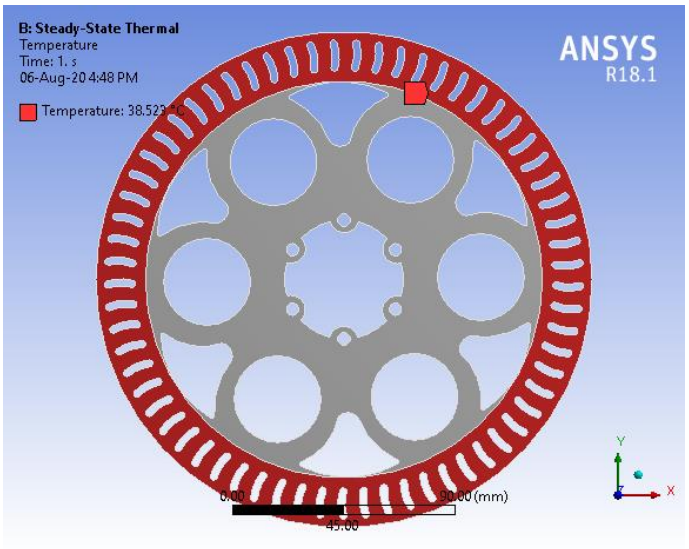
Total Deformation = 0.0025 mm



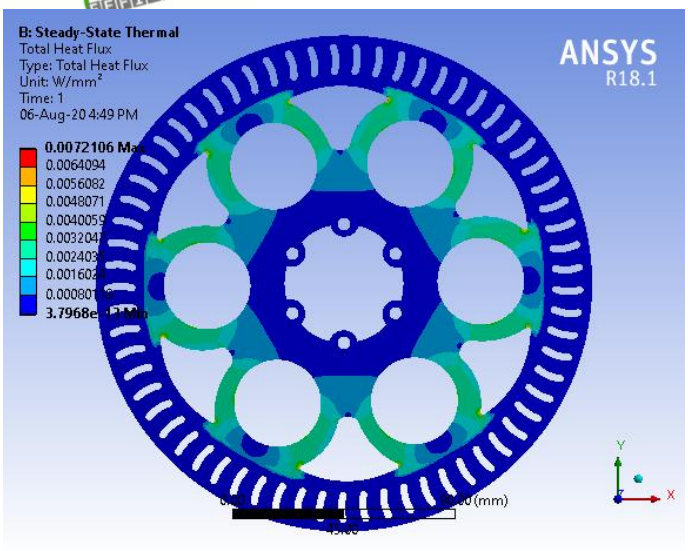


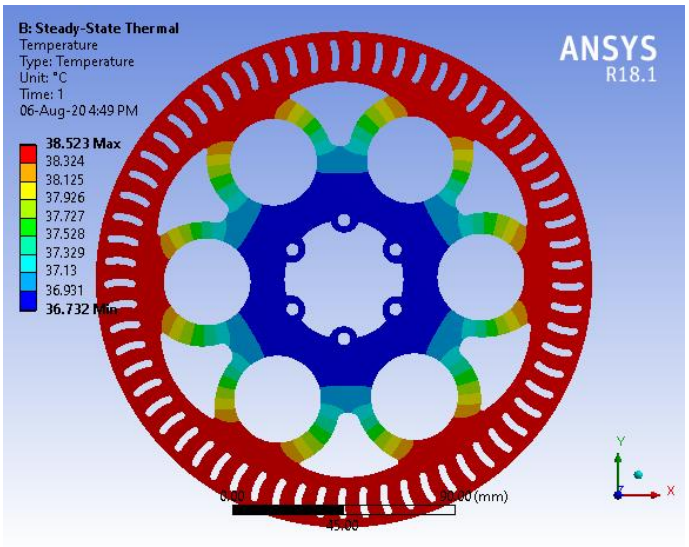
Safety Factor=15

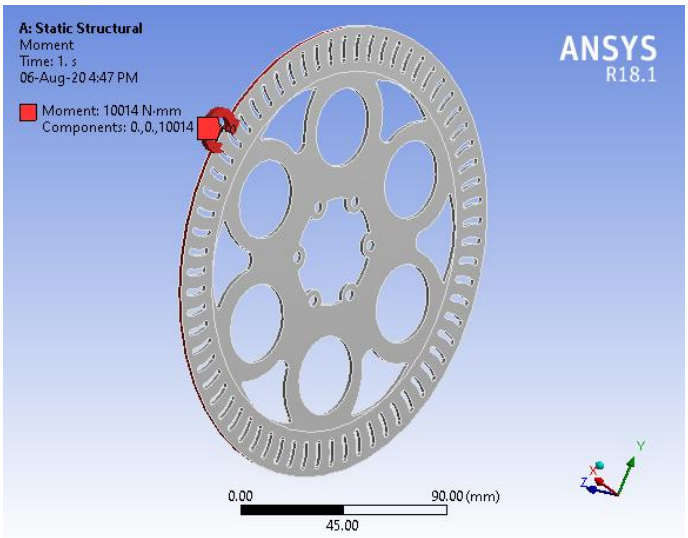




Equivalent Stress=8.7182 MPa

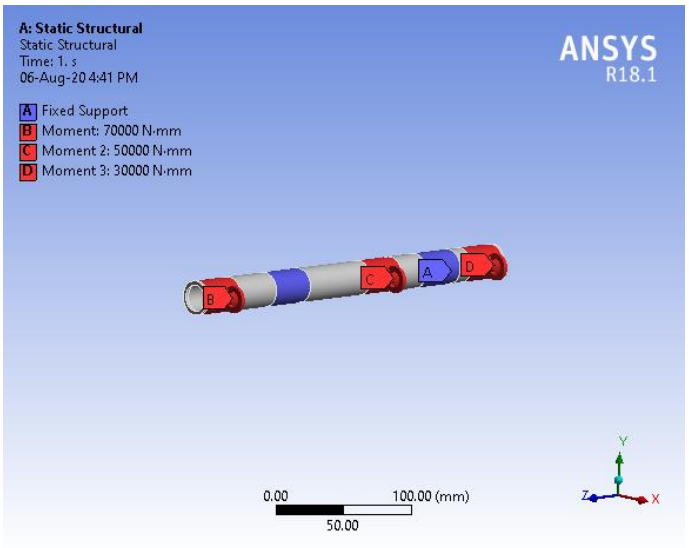


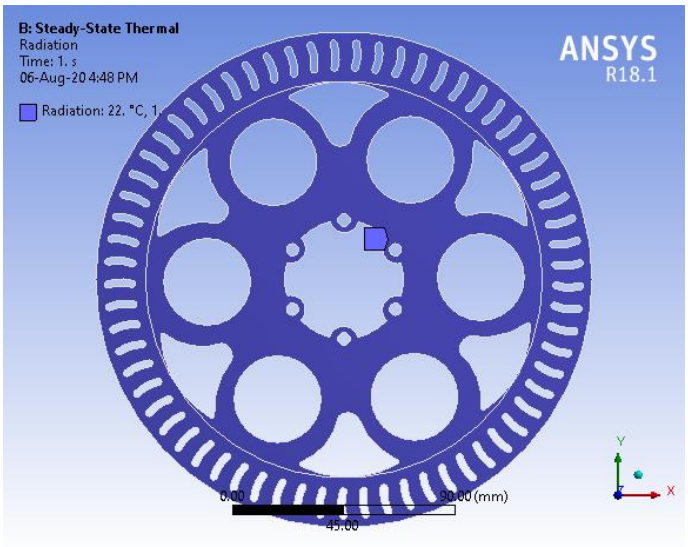




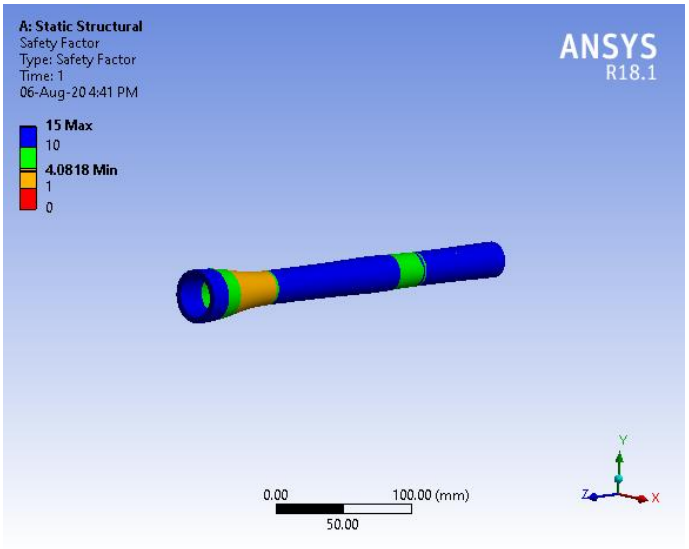
g) CAE analysis: Shaft 1

Maximum Moment= 70000 N-mm

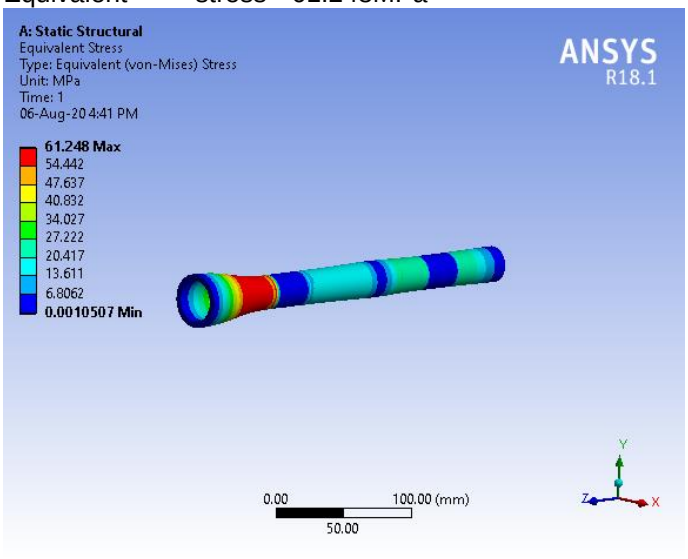




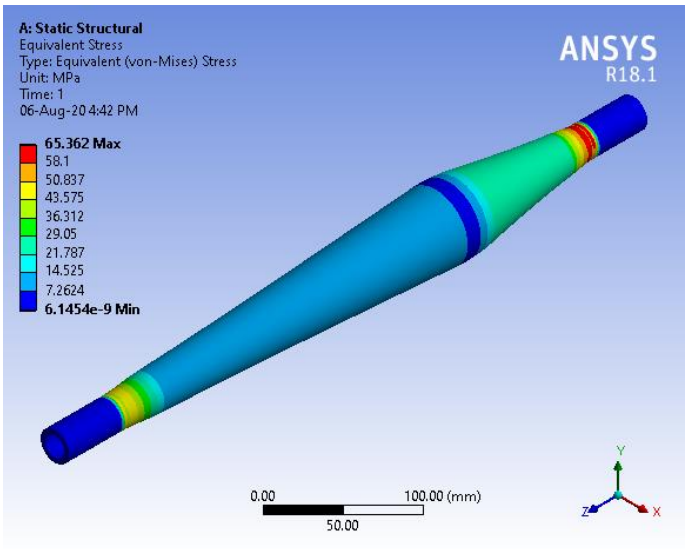
Factor of safety =4.0818



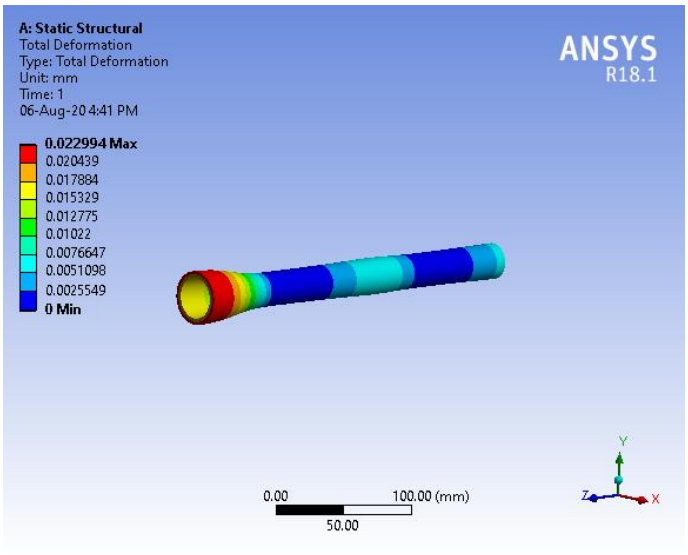
Equivalent stress= 61.248MPa



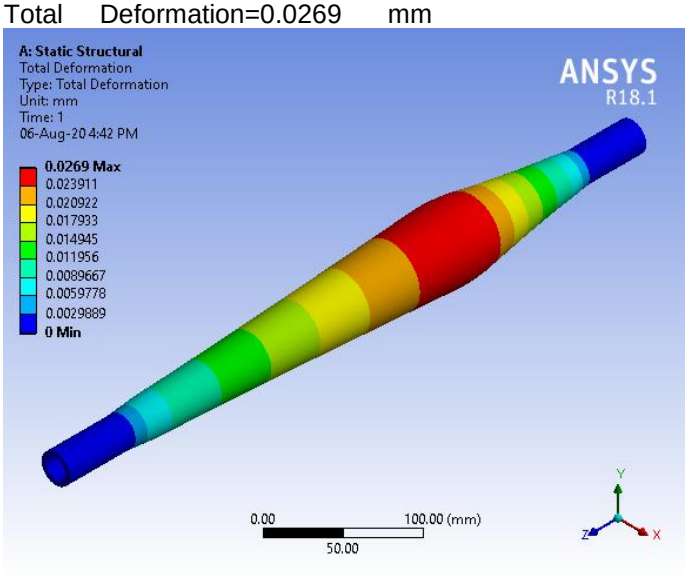
Equivalent stress = 65.362 MPa



Total deformation=0.022994mm

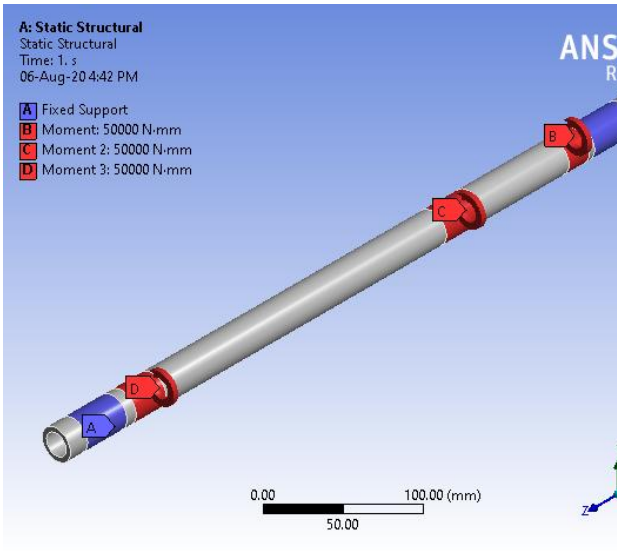


Total Deformation=0.0269 mm

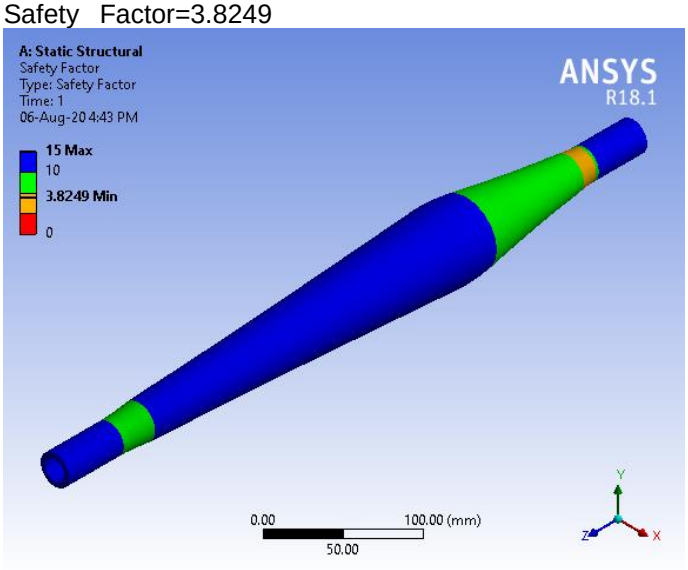


h) CAE analysis: Shaft 2

Maximum moment = 50000N



Safety Factor=3.8249



C) VEHICLE VIEWS

Vehicle views are included at the **Appendix-1** with all dimensions as asked (all views given at Appendix-1 are mandatory). Complete CAD model with the placement of all components are shown.

6. ALL HAND SKETCHES, 2D DRAWINGSVEHICLE VIEWS

Vehicle views should be included at the **Appendix-1** with all dimensions as asked (all views given at Appendix-1 are mandatory). Complete CAD model with the placement of all components should be shown.

If required more pictures of the CAD model may be inserted at Appendix-1 (e.g. Both side views if the sitting height for both drivers is different in case of adjacent seats, detailed view of subsystems etc.). All the pictures must be full page pictures at Appendix-1 and can be rotated for better presentation.

APPENDIX-1: Vehicle View

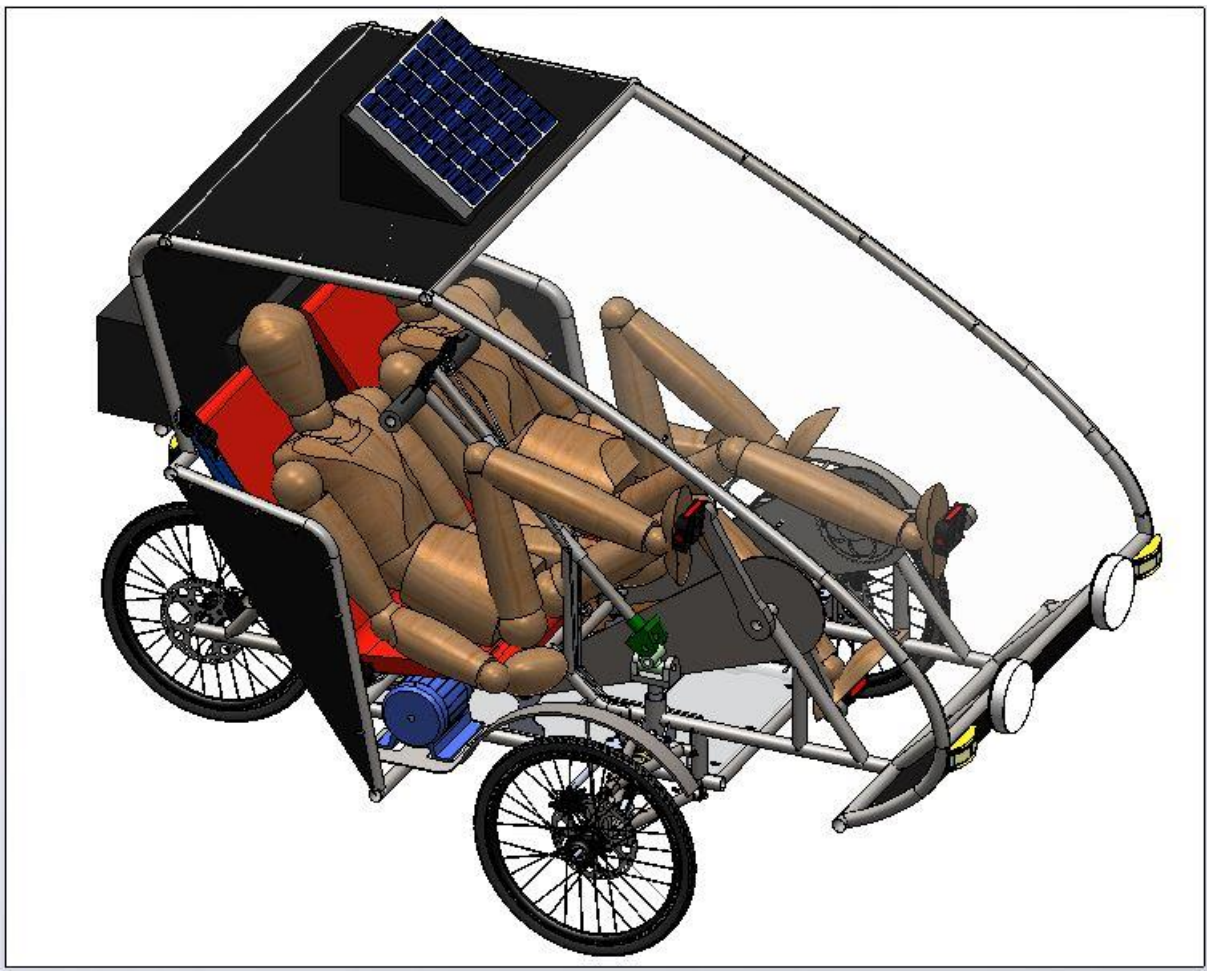


Figure-1 (Isometric View of Vehicle)

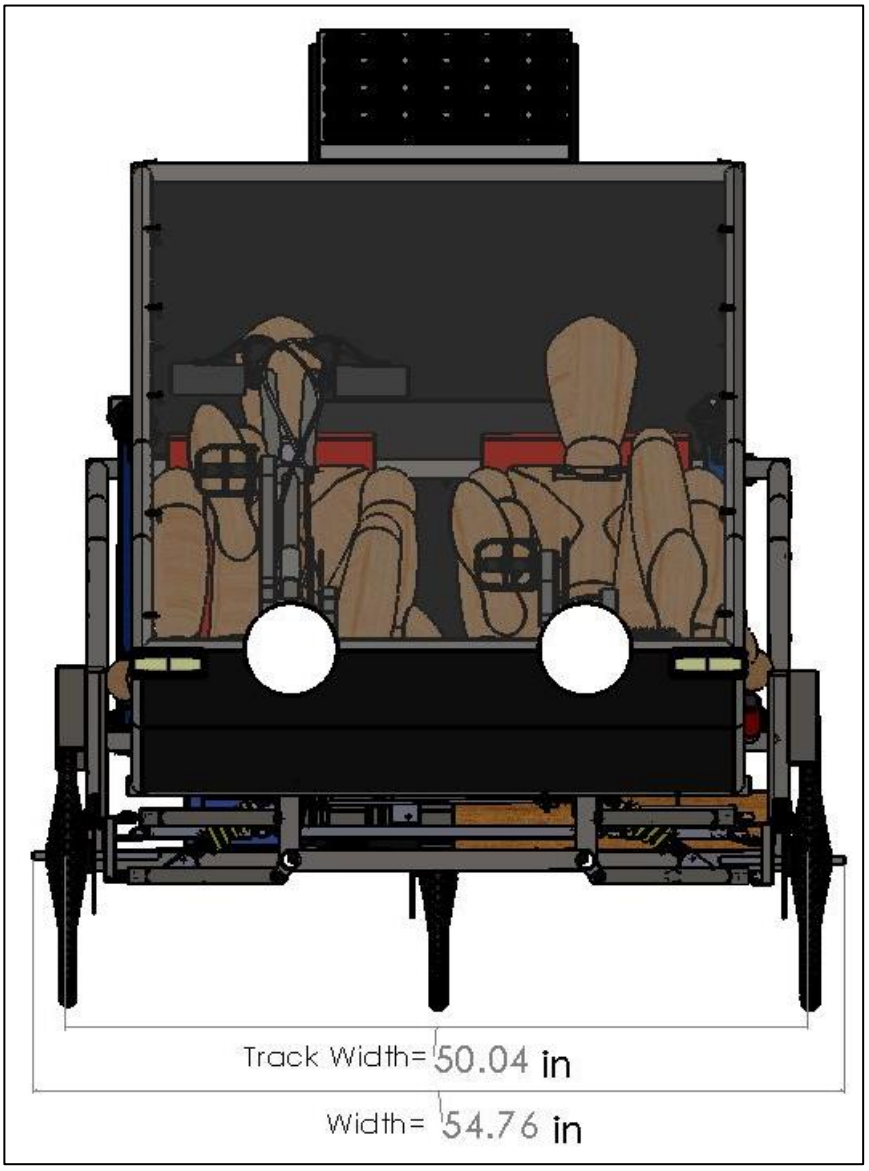


Figure-2 (Front View of Vehicle)

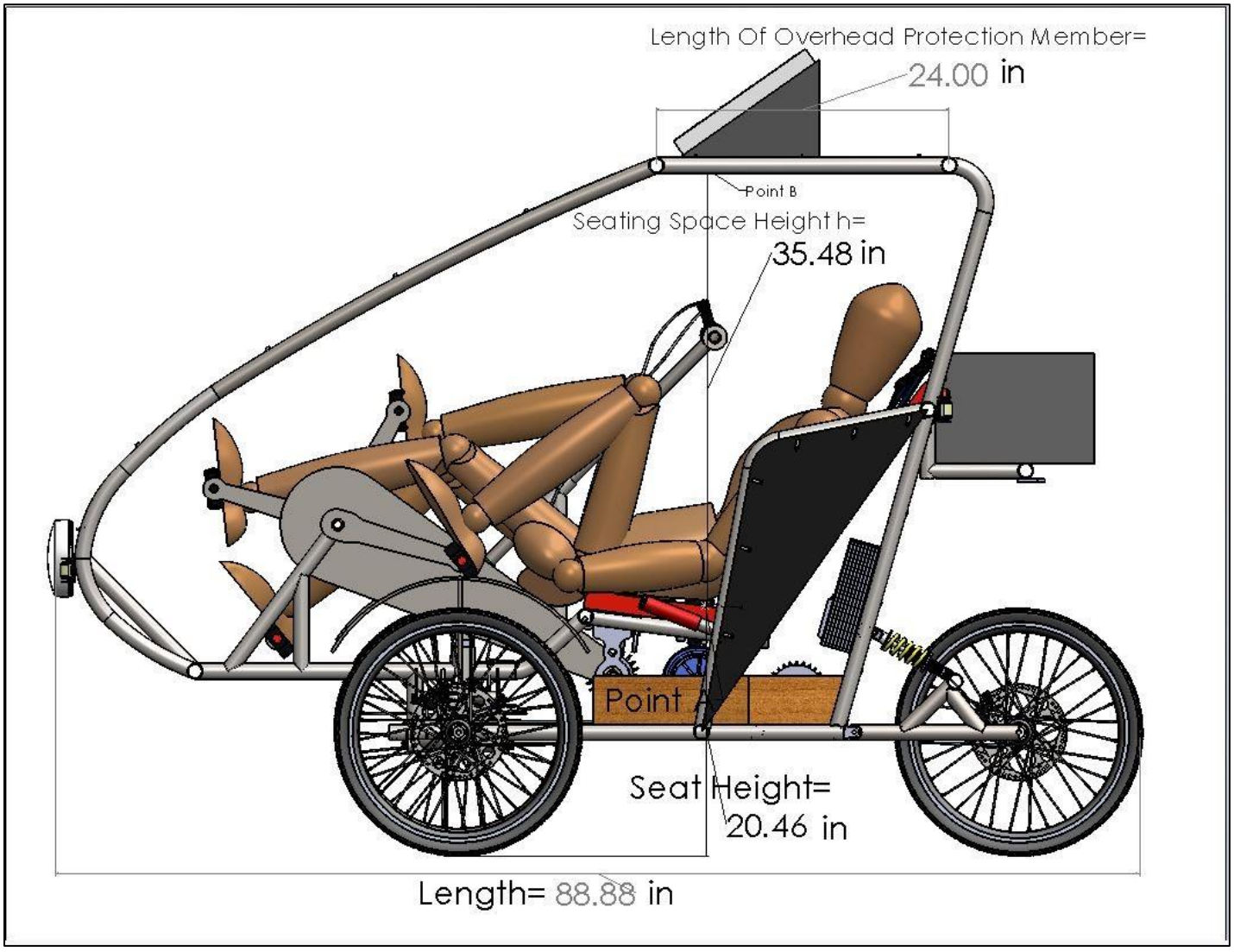


Figure-3 (Side View of Vehicle)

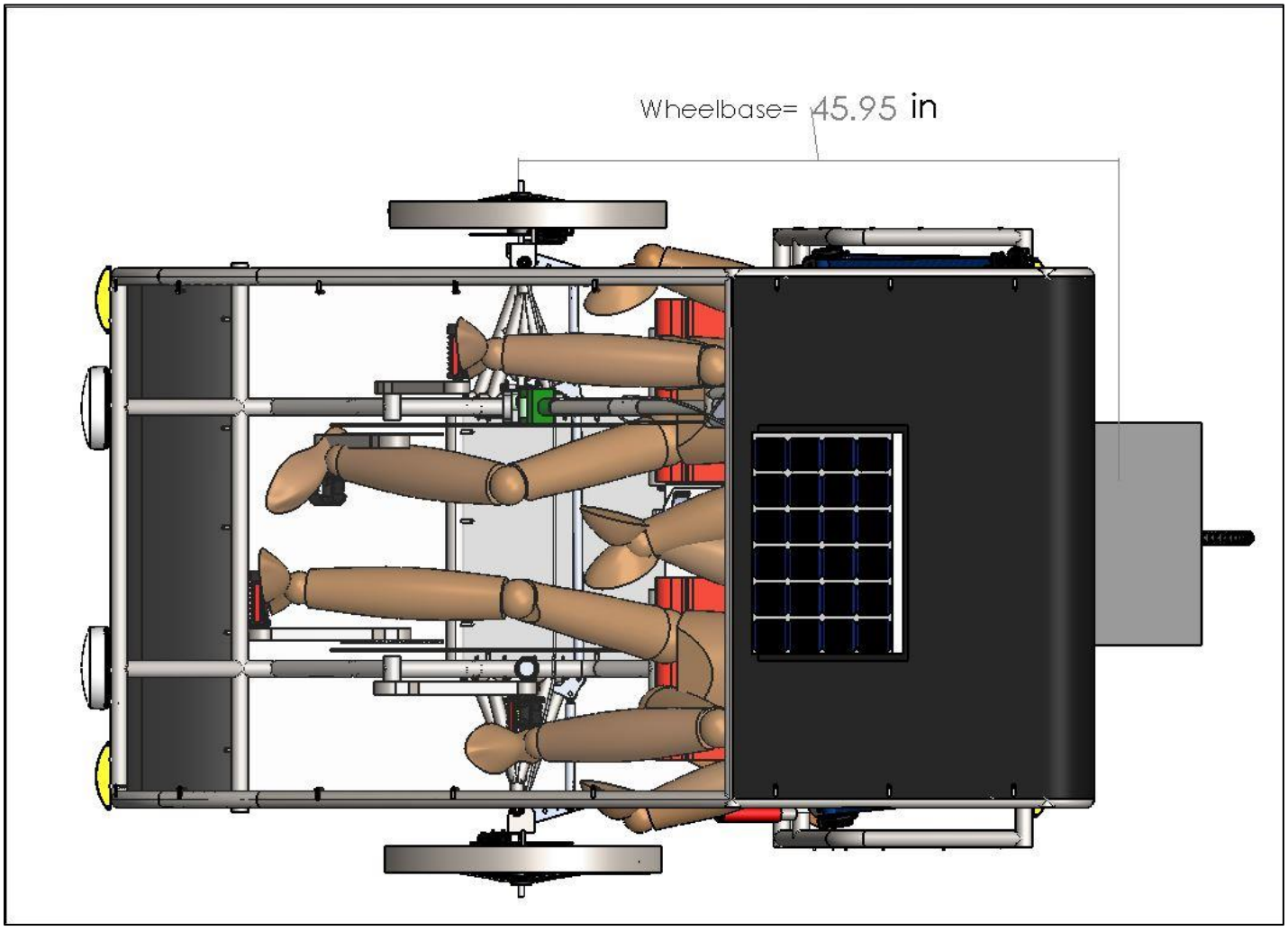


Figure-4 (Top View of Vehicle)

APPENDIX-2: CAE INPUT PARAMETERS

1. MATERIAL PROPERTIES

Mention the material properties as per software data.

	Unit	Material-1	Material-2	Material-3	Material-4
Density	g/cm^3	7.87	7.87	7.85	7.85
Young's Modulus	GPa	205	205	205	205
Yield Strength	MPa	365	365	460	460
Ultimate Strength	MPa	440	440	560	560
Poison's Ratio	-	0.29	0.29	0.29	0.29

2. MESH DETAILS

	Frontal Impact	Side Impact	Rollover	Bending Analysis	Torsional Analysis	Hard Point Analysis
No of Elements	45439	45439	45439	45439	45439	28415
Type of Elements	SHELL181 SOLID186	SHELL181 SOLID186	SHELL181 SOLID186	SHELL181 SOLID186	SHELL181 SOLID186	Bonded
No of Nodes	33033	33033	33033	33033	33033	33010
Minimum Element Length	3.98870mm	3.98870mm	3.98870mm	3.98870mm	3.98870mm	3.98730mm
Maximum Element Length	19.9440mm	19.9440mm	19.9440mm	19.9440mm	19.9440mm	19.9360mm

GUIDELINES

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