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Design and Analysis of the Roll Cage of an ATV

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Abstract—*Roll cage is most important part of ATV .it is a 3D cage which support a system like powertrain, suspension , steering , braking and most imp it protects the driver from .roll cage determine the shape of overall vehicle. The roll cage is design according to the SAE BAJA rule book 2018.rollcage is designed in solid works and analysis is done in Ansys 15.SAE BAJA is a competition bought by Mahindra in India. Here in the competition engineers who are under graduate try to build an ATV.*

***Keyword*:-Roll cage static structural analysis, material selection, material calculation impact force calculation.**

1. Introduction

1. Design

Various software are available for designing purpose in engineering to design roll cage of an ATV we use the software solid works, creo. Solid works is developed by basic works .we use these software because we are comfortable with this software but before implementing the line sketch on software we have sketch on the rough paper. We have gone through the SAE BAJA rulebook for designing the roll cage according to limitations .We also gone through the books which would help us to build an ATV . The ideas of our team, the design combinations we finally brought on the rough paper . We took the measurements by keeping the driver on the floor and we did the marking of the members at approximate measurements. Some design rule we keep in mind such as

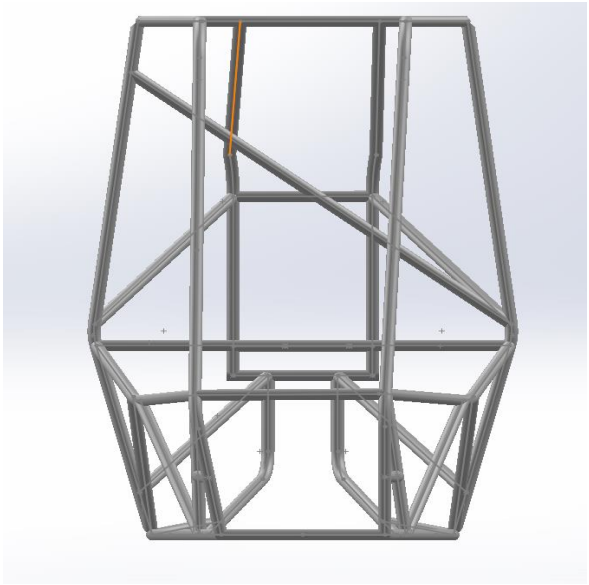
1) Design the roll cage of an ATV by considering the ergonomic of the driver .

2)Avoid the sharp edges because it has High stress concentration on its surface and it also harmful for other for getting hurt.

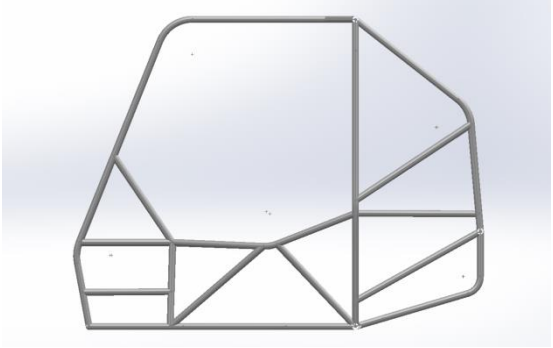
3)The roll cage design would be according to the rule book

Ones the sketching is done on the rough paper now its time to bring the design into the software. The overall weight of vehicle should be low. Try to make the roll cage light weight but don't forget that it should bear the impacts and should have high strength. first create the line sketch on the software then give the weldment according cross section of the selected material after giving weldments the software gives the correct view of the roll cage we design. During reducing the weight don't compromise with the strength. Design the roll cage in such a way that attachment should be proper shown in assembly and considering all the attachment of the assembly. Use the triangular shape in the side member because it helps to take more load then the straight or any other shaped member. After so many iterations we came up with this final design.

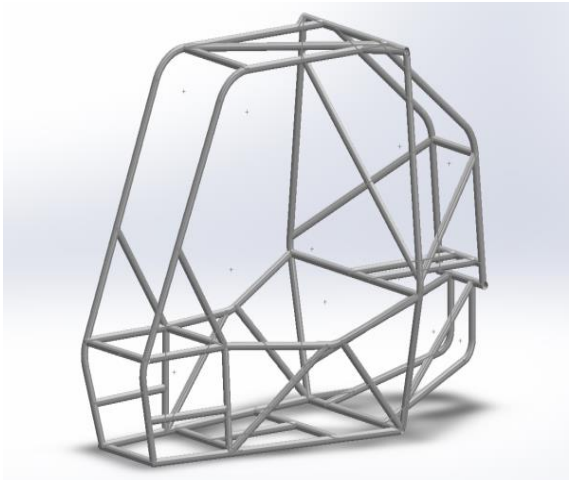
Front View



Side view



Isometric view



Basic dimensions and elements of the frame:

Attributes	Values
Length	2250mm
Width	935mm
Wheelbase	2190mm
Weight(with driver)	249.5kg
Weight(Roll cage)	40kg
Height of CG	560mm
Height	1300mm

1. Material property

Many materials are used for the roll cage and some of the materials are proposed by SAE BAJA which are stated in Baja Rule book which are AISI 1018,AISI 1040,AISI4130.

The properties of material are given below. The structural analysis is done of the roll cage. For analysis there are many software like Ansys , Nastran, etc. According to our convenience we have used Ansys . The static conditions are used. The test are conducted as follows

Property	AISI 1018	AISI 1026	AISI 1040	AISI 4130
Yield Tensile Strength	370 Mpa	415 Mpa	415 Mpa	440 Mpa
Ultimate Tensile Strength	440 Mpa	490 Mpa	620 Mpa	560 Mpa
Modulus of Elasticity	205 Gpa	210 Gpa	210 Gpa	190 Gpa
Poissions Ratio	0.290	0.300	0.300	0.2

Depending upon the Yield Strength of the material we select the material. After selecting the material the analysis process begins.

Optimization Process

Selecting best material from AISI 1018, AISI 1040, AISI 4130 we gone through this process. In this process we considered the Cylinder Tube.

2. Analysis

The structural analysis is done of the roll cage. For analysis there are many software like Ansys , Nastran, etc. According to our convenience we have used Ansys . The static conditions are used. The test are conducted as follows.

- Front impact test

Few approximations were taken as follows

Weight =300kg

v(initial)=16.67m/s

v(final)=0

Impact time=0.13sec

Work done=|-0.5Mv|

=|-0.5x250x(16.67)^2|

=34736.11Nm

Workdone=Fxd d=t*v(initial)

=0.13x16.67

=2.1671m

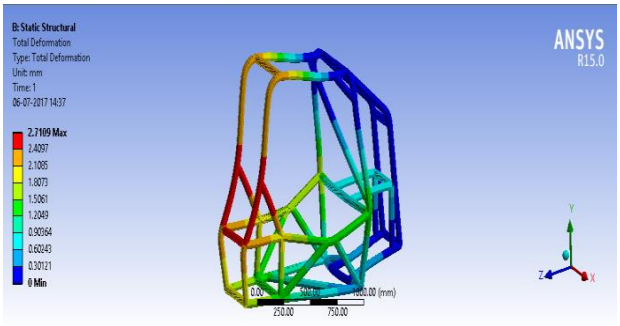
F=34736.11/2.16

=16081.53N

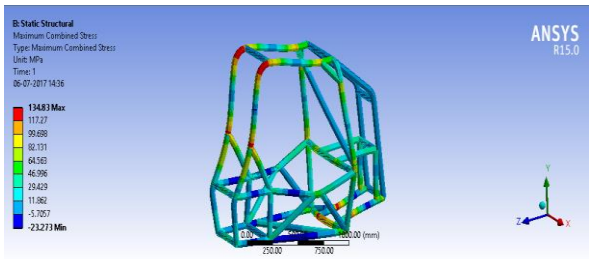
From the above results the final changes are made and the design is finalized.

This is the force applicable for front impact and analysis result obtain from Ansys is below:

A) Maximum Stress Concentration



B. Total Deformation



Front impact	17000N
FOS	3.2
Total deformation	2.6mm
Maximum stress	135.690Mpa

FOS means Factor of Safety and the range of FOS should be 1.5 or above.

FOS= Yield strength of material / max stress
=435/135.69
=3.2

- **Rollover Test**

Calculations for the stress developed on a roll cage at the time of inverted fall. During the fall Potential energy is converted into Kinetic energy;

M*g*h=0.5*M*(v^2)

$v=\sqrt{(g)\times h\times 2}$

10ft=3.048m v=7.733m/s

Just substitute this v in the work done equation and find outwork done.

Work done=6945.83J

impact time(t)=0.13sec d=t*v

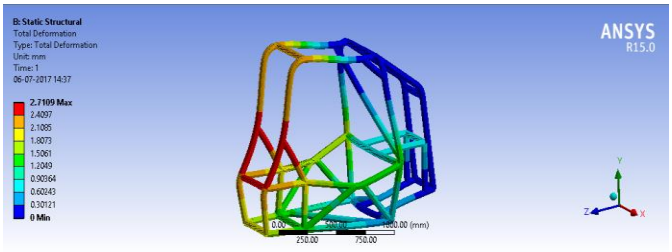
d=1.005m

Same procedure as front impact for calculating F=force.

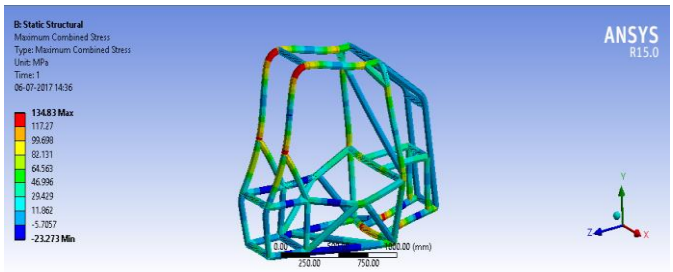
F=6945.83N

F≅7000N

A Maximum stress concentration



B. Total Deformation



Impact	7000N
FOS	3.2
Maximum stress	135Mpa
Total deformation	2.6 mm

The FOS of this case is also calculated by following the same steps as in case of front impact test.

- **Side impact test**

Here we will test how much stress the roll cage can take from sideways.

Impact time (t) =0.30sec

Velocity(v)=16.67m/s

Again by same method we have calculated the work done.

Work done=34763.11N

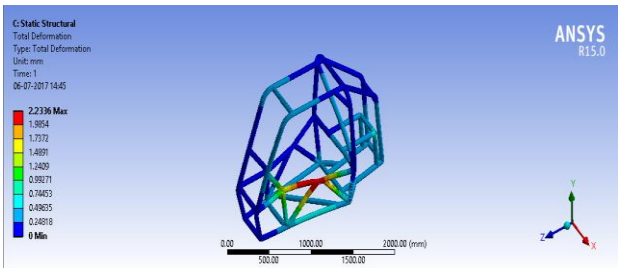
d=v*t d=5.001m

F=work done/d

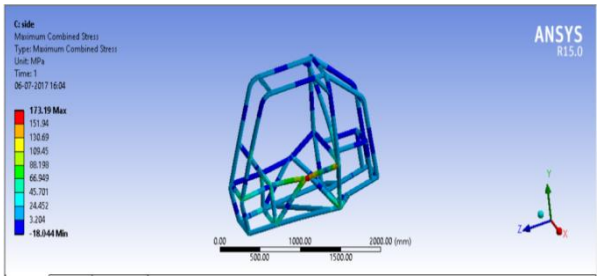
F=6945.83N

F≅7000N

A. Maximum Stress Concentration



B. Total Deformation



Side impact	7000N
FOS	2.5
Maximum stress	173Mpa
Total deformation	2.23mm

Steps for calculating FOS is same in every condition.

- ***Rear impact test***

Considering the impact coming to the roll cage from the rear part.

Impact time(t)=0.30sec

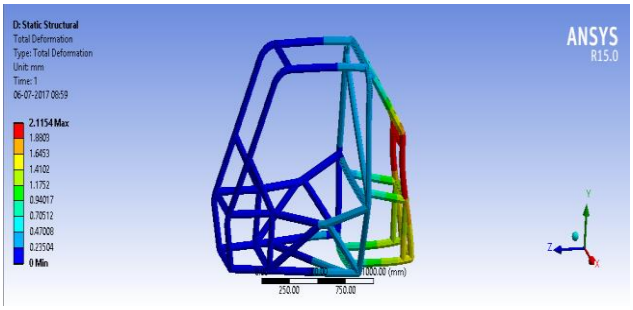
v=16.67m/s

work done is again calculated by same method and is

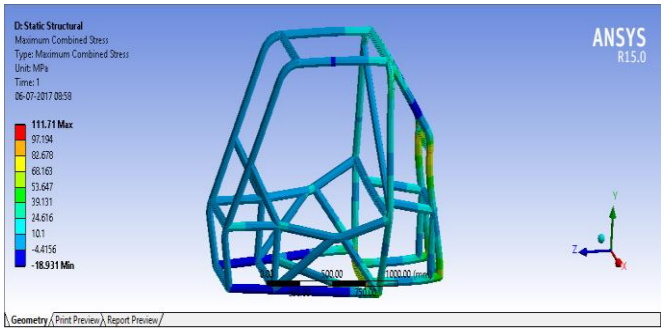
34736.11N d=t*v d=5.001m F=workdone/d F=6945.83N

F≅7000N

A. Maximum stress concentration



B. Total Deformation



Rear impact	7000N
FOS	3.4
Maximum stress	112Mpa
Total deformation	2.11mm

Steps for calculating FOS is same in every condition.

3. CONCLUSION

This paper explores the ways of designing the roll cage of an all terrain vehicle and also sheds on possible key points kept in mind for designing. You can also find analysis results in this paper along with their respective results and formulae used .During the static analysis of the roll cage the design of the roll cage was changed several times in order to obtain a higher FOS. A higher value of factor of safety insures the durability of the roll cage in the most extreme conditions and hence makes the roll cage safe interms of production.

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