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Design Analysis and Fabrication of Roll Cage of M-BAJA ATV

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Abstract - *This paper give an introduction to the material selection procedure, pipe size selection and various tests that need to be done before finalizing the design using ANSYS WORKBENCH 14.0.we used to two different material to construct a roll cage primary material and secondary material. In this project work ,various factors such as Factor of safety ,deformation ,von-misses stress , mesh size dependence of generated stress and impact forced are studied and also to understand working process of CNC machine.*

Key Words: Roll cage, ATV, Modelling, analysis, FEA.

1. INTRODUCTION

Roll cage is the skeleton of an ATV. The roll cage not only forms the structural base but also 3D surrounding the occupant which protect the occupant in case of impact and roll over of vehicle. The roll cage also adds the aesthetics of the vehicle. Roll-Cage is a frame of pipes providing a rigid structure and robust design to the vehicle. They can be used either as the only-frame (like in ATVs) or as the inner supporting structure in the conventional vehicles to provide strength against impacts. Here at the institute we designed and manufactured our roll cage and impact analysis is done using ANSYS.

1.1 DESIGN CONSIDERATION

Selection of proper material for building of roll cage is very important. There are various material available. For this consideration various parameter like cost, weight, availability, mechanical properties and manufacturing conditions comparison various material is show in table.

TABLE NO.1

	AISI 1018	AISI 1040	AISI 4130	AISI 5130	AISI 1020
Density kg/m2	7700	7845	7700	7700	7700
Ultimate strength N/mm2	634	518.08	560	580	394.7
Yield Strength N/mm2	388	353.4	480.8	430	294.8
Young's Modulus Gap	200	200	200	200	200
Hardness BHN	197	149	156	379	111

This time we use two type of material in roll cage to reduce the weight of vehicle

TABLE NO.2

	Material	Outer Diameter	Inner Diameter	Wall Thinkness
Primary member	AISI 1018	25.4 mm	19.304 mm	3.05 mm
Secondary member	AISI 4130	25.4 mm	22.1 mm	1.65 mm

1.2 BENDING STRENGTH AND STIFFNESS CALCULATION

Following calculations are done in order to meet the material requirement based on SAE BAJA Rulebook for bending strength consideration.

Reference Material 1018 (say X)

Yield Tensile Strength (Sx)=365 N/mm2

Thickness = 3mm

Outer Diameter (Do) = 25.4 mm

Inner Diameter (Di) =19.4 mm

Centre Diameter (C) = 12.7 mm

Modulus of Elasticity (Ex) = 205*10^3 N/mm2

Moment of Inertia = pi/64(Do^4 – Di^4) = 13478.6389 mm ^4

Bending Strength = Sx*I*C = 387.4 N m

Bending Stiffness = Ex*Ix = 2763.12 N m ^2

Required Material 1018 (Say Y)

Yield Tensile Strength (Sx)=370 N/mm2

Thickness = 3mm

Outer Diameter (Do) = 25.4 mm

Inner Diameter (Di) =19.4 mm

Centre Diameter (C) = 12.7 mm

Modulus of Elasticity (Ex) = 205*10^3 N/mm2

Moment of Inertia = pi/64(Do^4 – Di^4) = 13478.6389 mm ^4

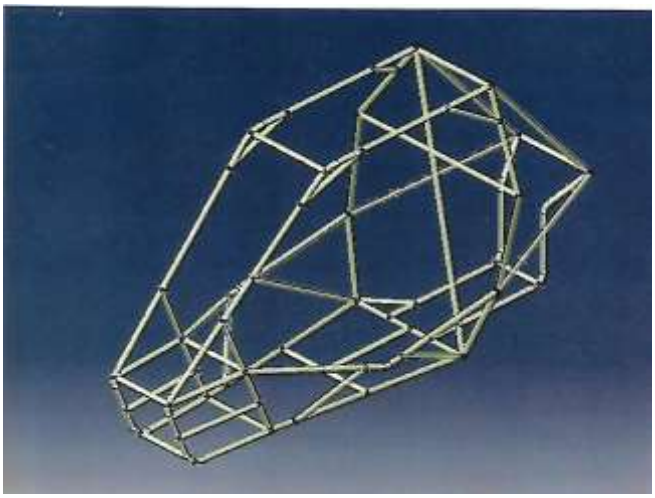
Bending Strength = Sx*I*C = 392.68 N m

Bending Stiffness = Ex*Ix = 2763.12 N m ^2

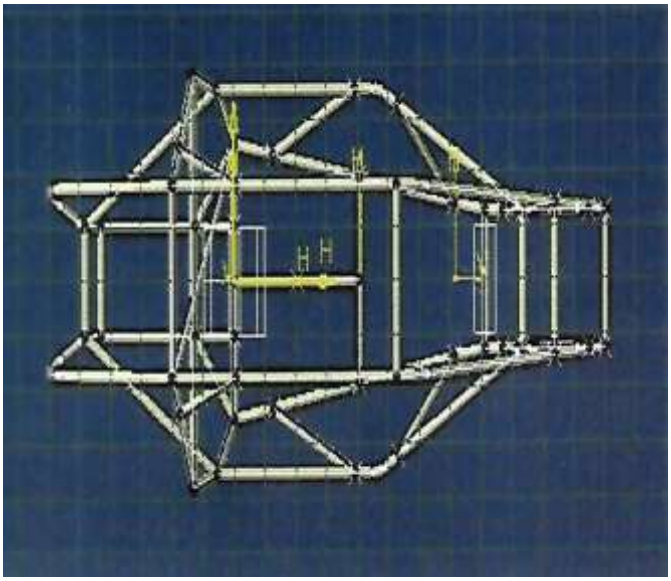
2. MODELING

Preparation of CAD model

For setting dimensions reference of SAE INIDA BAJA 2016 Rule book was Taken .Consider all the other points dimensions all member were set and model of roll cage was prepared using Catia V5 Software.



Isometric view



Top view

3. METHODOLOGY

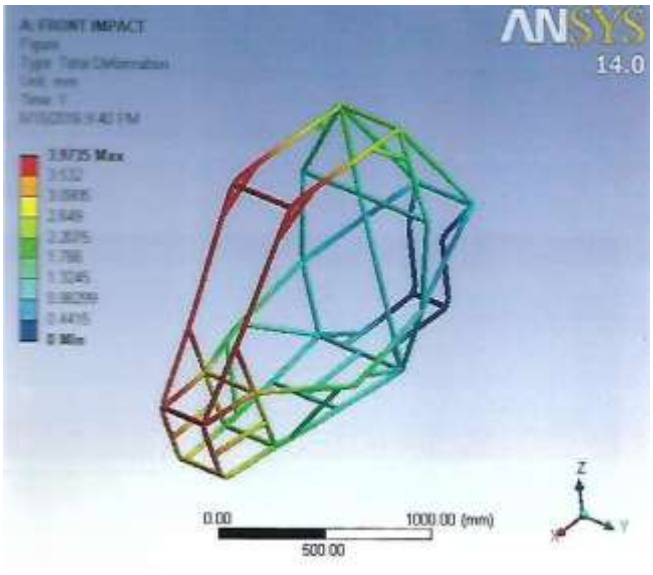
1. Creation of a cad model of the structure.
2. Generation of mesh.
3. Application of the loads & constraints in depending.
4. Solution of the respective test Determination of the stress values and deformation forces.
5. Modification of Cad- design.

Repetition of the process till safe design is obtained.

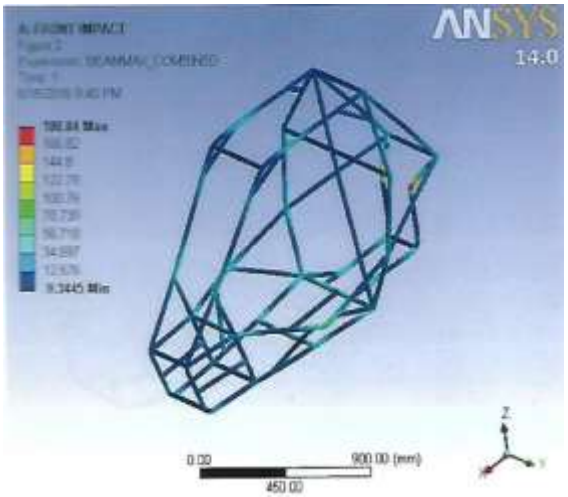
We have selected 1D meshing for analysis of Roll Cage by taking consideration of factor which are given below

1. Most accurate –preferable
2. Level of assumption is very less
3. Capture the geometry
4. Give results on joints
5. Triad or Quad or mixed element meshing.
6. Output received von-misses stress & displacement on 1D element.
7. Only cross section of pipe is required.
8. Average element size - 4 or 5 mm to capture the geometry properly.

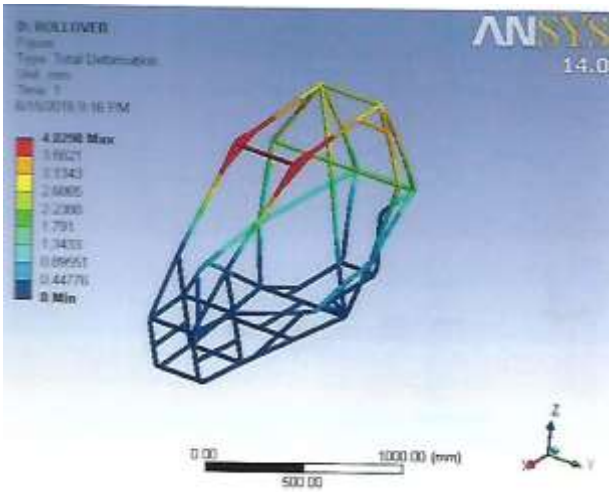
4. IMPACT ANALYSIS



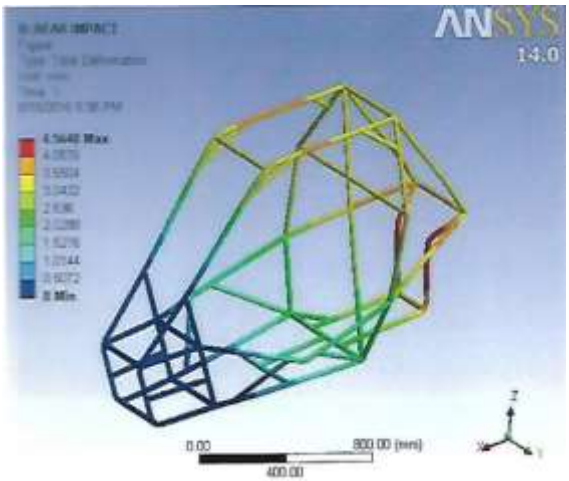
Front Impact Deformation Analysis



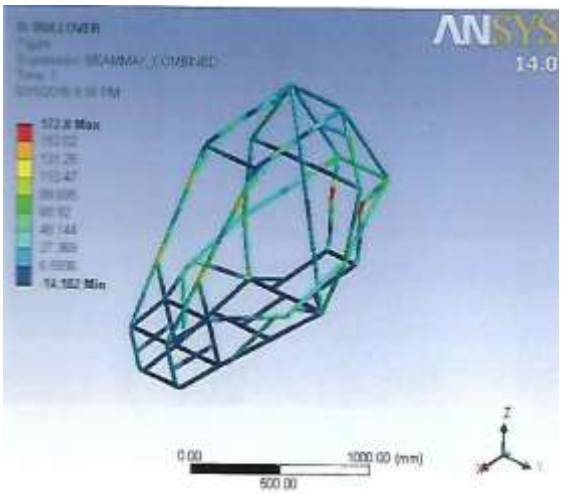
Front Impact Stress Analysis



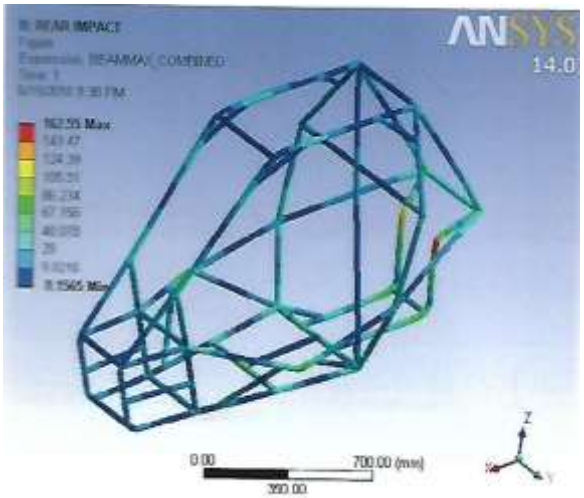
Roll Over Deformation Analysis



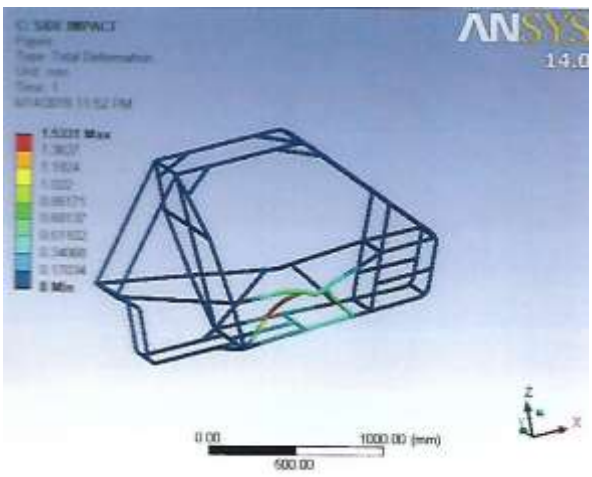
Rear Impact Stress Analysis



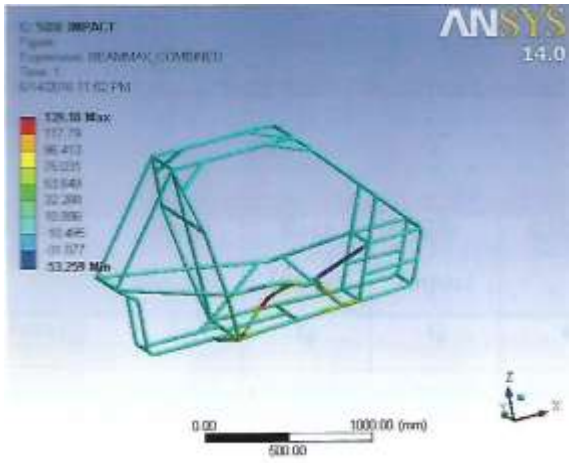
Roll Over Stress Analysis



Rear Impact Stress Analysis



Side Impact



Side Impact Stress Analysis

PVC Pipe Model of Roll Cage

Table3:-Cost report

Sr. no.	Description	Qty	Cost
1	Material 4130 AISI (primary)	50ft	7040
2	Material 4130 (primary)	55ft	6400
3	Material 1018 AISI (secondary)	75ft	6300
4	Material exporting and handling	-	2350
5	Fabrication ,Pipe bending, Pipe welding	-	14000
6	Raw material	-	2000
	Total cost		38090

5. FEA ANALYSIS RESULT

Table 4

Parameters	Front Impact	Rear Impact	Side Impact	Rollover
Max. force(g)	8g	8g	4g	4g
Fixed Supports	Rear points	Front points	Opposite points	Base plane member
Impact time	2sec	2sec	2sec	2sec
Max. Equivalent stress (Mpa)	188.84	162.55	139.18	134.73
Max. Deformation(mm)	3.97	4.58	1.53	4.02
FOS	1.5	1.78	2.87	2.96

CONCLUSION

The use of finite element analysis was valuable to the design and analysis of the frame for SAE BAJA off road vehicle. We had successfully analyzed the roll cage structure for its strength against the collision from front, rear as well as side.

This paper thoroughly deals with various load analysis on roll cage and optimization has been achieved by reducing the weight of the roll cage. Roll cage designed is perfect for use in BAJA SAE event with all the systems perfectly mounted on it.

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