MODLING AND FINITE ELEMENT ANALYSIS OF ATV ROLLCAGE

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Abstract - *An ATV rollcage is a specially designed protective frame around the driver that protects the driver in each & every condition. During the designing of rollcage take few objectives like diver safety, easy of manufacturing, light weight, ergonomics. This paper outline static analysis of rollcage of ATV by doing per & post processing in ANSYS 16.0 & CAD modeling done in CREO 4.0. to obtain optimum FOS (factor of safety) in worst condition under a set of particular rules given by Society of Automotive Engineers (SAE) Which ensure that the rollcage of ATV will be safe in all conditions.*

Key Words: **FEA, Rollcage, ATV, FOS, Meshing**

1. INTRODUCTION

The rollcage is the skeleton of an all train vehicle that protect the driver & support all the control system & sub assembly. The design objective of the rollcage are driver safety, easy of manufacturing, light weight, ergonomics, durable etc. The start designing of the rollcage with taking few assumptions wheelbase & track width & the design of the driver cockpit according to average of human dimension & comfort then design the bulk-head & engine compartment with the help of suspension pickup points & engine integrals. By taking this making several prototypes & ensure with best one with the help of FEA & Baja SAE rulebook 2018 [1]. It is very important to ensure all failure modes of rollcage .This research discus about the static analysis of the rollcage of ATV in all possible impact condition during in real world. Aru et al., 2014 [2], Noorbhasha, N., 2010 [3] and Raina et al., 2015 [4] have done static analysis for predicting failure modes of roll cage. In this research static analysis is done with the help of Newton's 2nd law for calculating the actual force & also optimum the meshing like Aspect ratio, seizing, Jacobean ratio for all analysis. The sizing of mesh was selected according to grid independence test for better & accurate result.

1.1 Specification of the Rollcage

The rollcage must ensure the minimum clearance of 3 inch. In between the member of rollcage & driver's free movement taking all clearance according to Baja SAE 2018 rulebook. Two type of cross-section tube used in rollcage Primary which have 1.25 inches of OD & 1.6mm of thickness & secondary tube which have 1 inches of OD and 1.2mm of thickness.

Table -1: Parameters

Wheel Track	Wheel Base	Overall length	Overall Height	Overall Width	Tyre Size	Ground clearance
Front- 52 Inch Rear- 50 Inch	54 inch	76 inch	64 inch	59 inch	22*7*10F 22*7*10R	14 Inch

1.2 Material Selection

The frame material "CHRO-MOLY" (AISI 4130) is selected based on availability, strength, machinability, light Weight, economical, high weight to strength ratio.

Table -2: Material Properties

S. No.	Mechanical Properties	Material 2 (AISI4130)
1.	Yield strength	460MPa
2.	Ultimate strength	560MPa
3.	Elongation	11-13%
4.	Carbon %	0.28
5.	Density	7.85gm/cc
6.	Machinability	Average
7.	Welding	TIG

2. METHODOLOGY

CAD modeling design of any component comprises of three major principles, Optimization, Safety and Comfort.

The main features of chassis are

Nodal geometry utilization
Less weight
Driver comfort
Appropriate Triangulation

The major factors considered in designing an ergonomically suited roll cage were, Seat location, Seat inclination, Steering, wheel location, Steering Column location, Design of the foot box area.

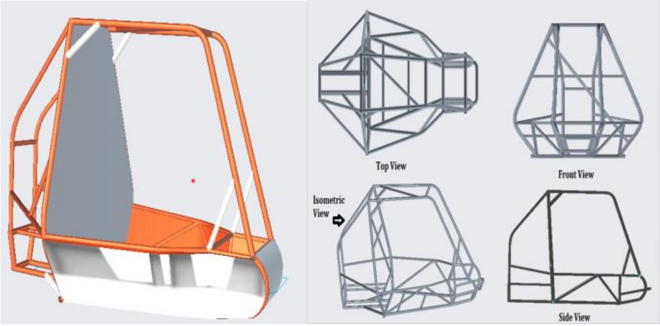

Fig -1: CAD modal of Rollcage

Mesh size is calculated by checking the mesh independency. Mesh size of 3 mm is selected, as the deformation becomes constant (3.5 mm). It means that there will be negligible changes in accuracy of results on further reduction in mesh size.

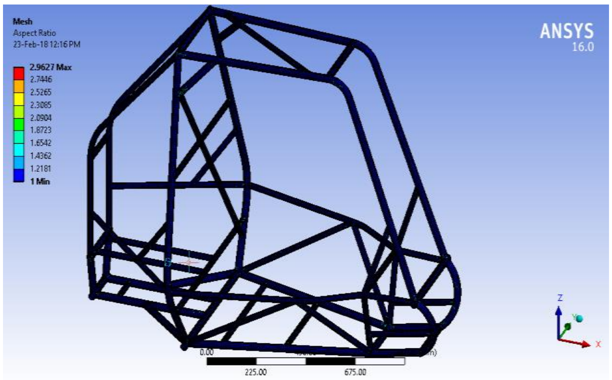

Fig -2: Meshing

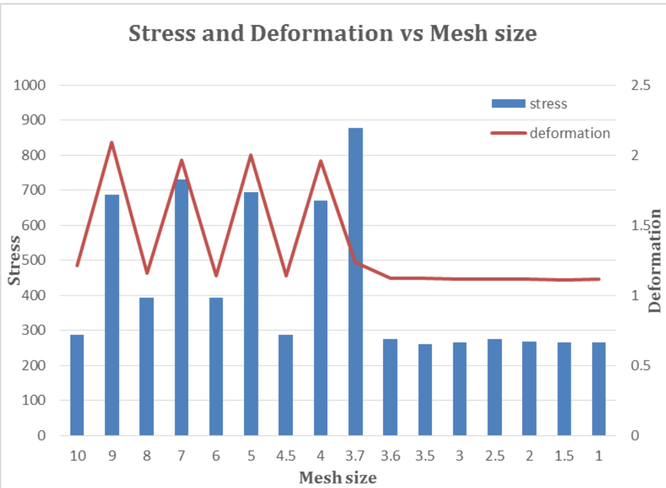

Chart -1: Gird independence test

3. CAE ANALYSIS OF ROLLCAGE

The Finite Element Analysis (FEA) of the vehicle was done using ANSYS 16.0. The stress analysis was done under worst case scenarios and maximum forces were applied in the analysis. Adequate factor of safety was ensured for all the components under these worst case conditions. The analysis for rollcage includes front impact, side impact, rear, rollover front & rear, etc.

Assumption & Considerations for all static structural analysis

For the analysis of AISI 4130 the weight of the vehicle is kept 250 Kg with driver. Other than this some assumptions which are kept in considerations are as follows

1. Roll cage has uniform cross section.
2. Roll cage is stationary, i.e. considering the impact on vehicle from front.
3. Time of impact is assumed to be 0.2 seconds.
4. Force impact location considered first at roll cage member in contact during front impact
5. Material Condition: Homogeneous
6. Structure Simplification: front impact members are supported by overhead member.
7. Boundary Condition: Suspension Pickup Points are Constraints.
8. Time of Impact: 0.2 sec
9. Meshing Conditions:
   A. Mesh Size –3 mm
   B. Element Type –Quadrilateral and Triangles
   C. Method –2-D Shell Method

3.1 Impact force calculation & analysis images in case of Static analysis

3.1.1 Front impact

During front impact analysis front impact forces are considered with the help of Newton's 2^{nd} law. We applied the calculated force of 20825 N to the front impact protection member of the chassis (Front part of bulk head) while applying the boundary conditions And considered the translation and rotation of all suspension mounts is locked when impact And remaining Assumption & Considerations are same as above.

Mass = 250 kg

Max. Velocity = 60Km/hr.
=16.67m/sec
Time of Impact (T) = 0.2 sec

Force (F) = mass* (initial velocity-final velocity)/T

= 250 * (16.66-0)/0.2

= 20825 N

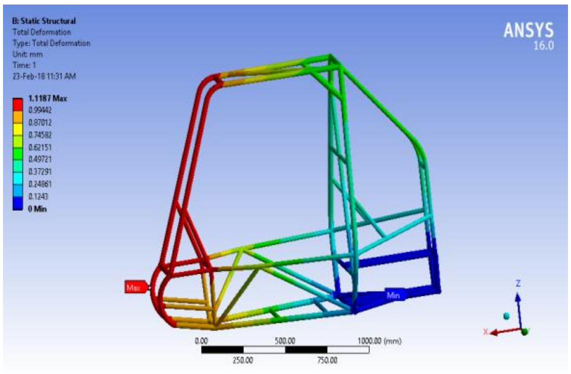

Fig -3: Total Deformation of Front impact

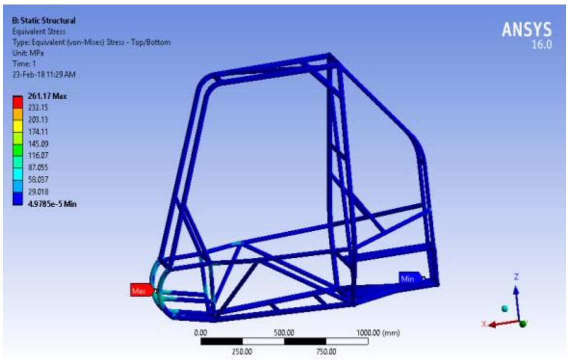

Fig -4: Equivalent Stress of Front impact

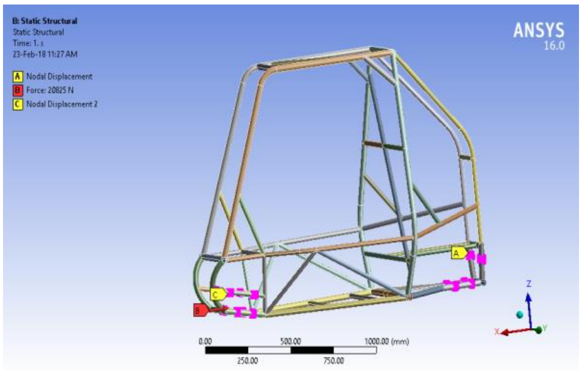

Fig -5: Analysis Condition for Front impact

3.1.2 Rear impact

During Rear impact analysis Rear impact forces are considered with the help of Newton's 2nd law. We applied the calculated force of 20825 N to the rear impact protection member of the chassis part. While applying the boundary conditions And considered the translation and rotation of all suspension mounts is locked when impact And remaining Assumption & Considerations are same as above.

Mass = 250 kg

Max. Velocity = 60Km/hr.
=16.67m/sec

Time of Impact (T) = 0.2 sec

Force (F) = mass* (initial velocity-final velocity)/T

= 250 * (16.66-0)/0.2

= 20825 N

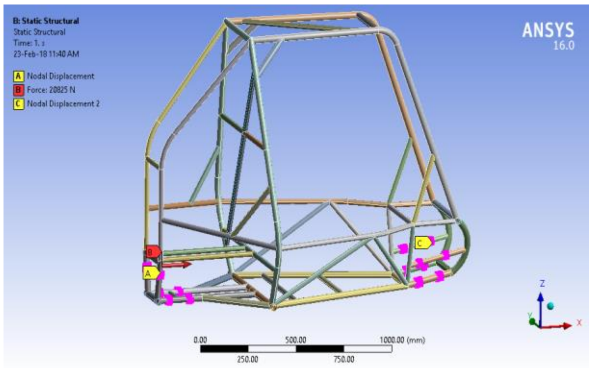

Fig -6: Analysis Condition for Rear impact

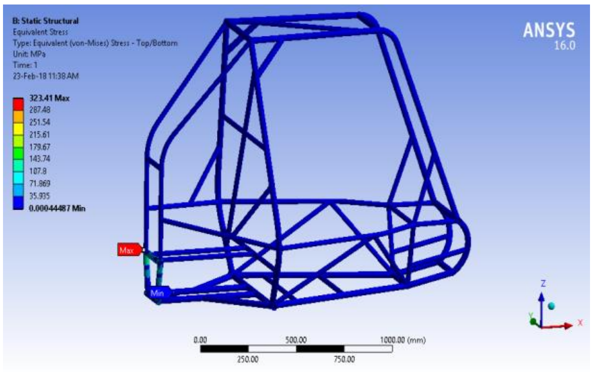

Fig -7: Equivalent Stress of Rear impact

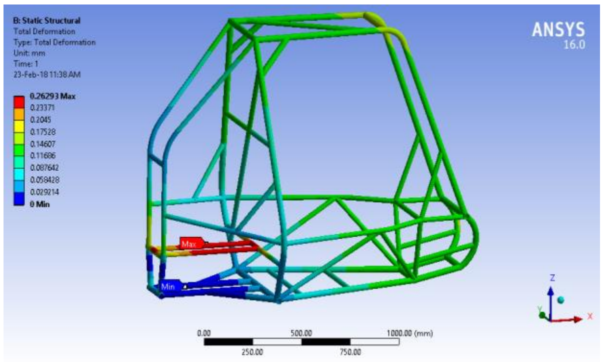

Fig -8: Total Deformation of Rear impact

3.1.3 Side impact

During side impact analysis Side impact forces are considered in terms of g-force. We applied the calculated 3G force of 7500 N to the side impact protection member of the chassis while applying the boundary conditions. And considered the translation and rotation of left side all suspension mounts is locked when impact on right side & vice versa. And remaining Assumption & Considerations are same.

Calculation of Impact Forces

Mass = 250Kg, gravitational force = 10 m/s^2

Side Impact Force = 3 x gravitational force x mass

= 3 x 10 x 250

= 7500 N

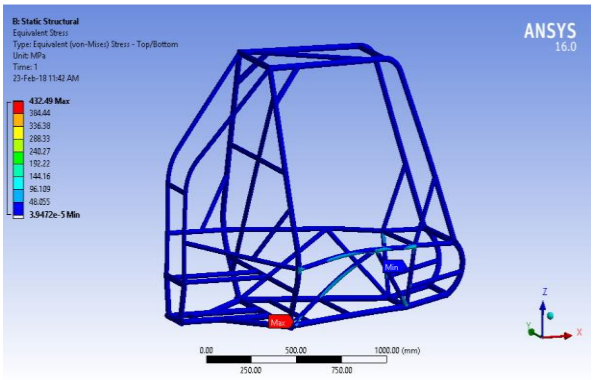

Fig -9: Equivalent Stress of Side impact

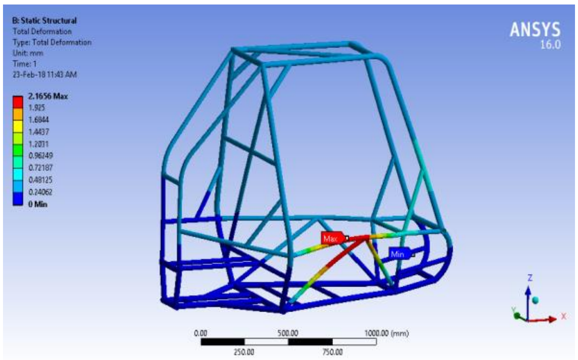

Fig -10: Total Deformation of Side impact

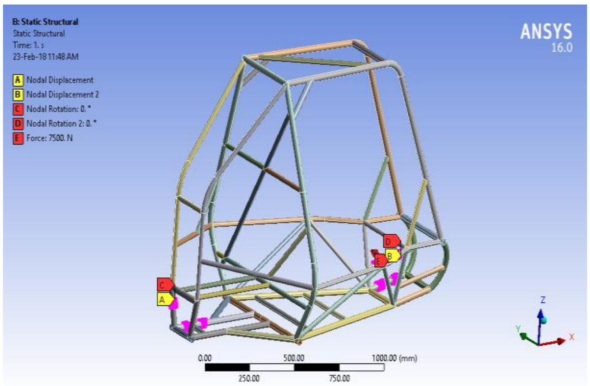

Fig -11: Analysis Condition for Side impact

3.1.4 Front Rollover Analysis

For Rollover Analysis Force impact location considered first at roll cage member in contact during rollover. Rollover forces are considered in terms of g-force. We applied the calculated 3g force of 7500 N to the members of chassis which would be first in contact with the surface of road in case of rollover. The force was applied perpendicular to the curved members of the chassis. And the translation and rotation of all the suspension mounts is locked when impact and remaining Assumption & Considerations are same as above.

Calculation of Impact Forces:

Mass = 250Kg
gravitational force
= 10 m/s^2
Front Rollover Force = 3 x gravitational force x mass

= 3 x 10 x 250

= 7500N

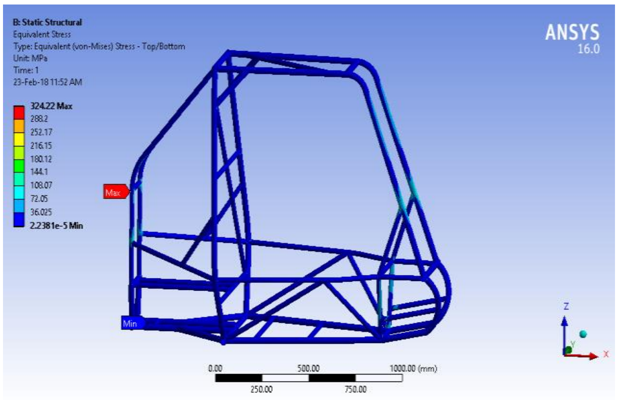

Fig -12: Equivalent Stress of Front Rollover Analysis

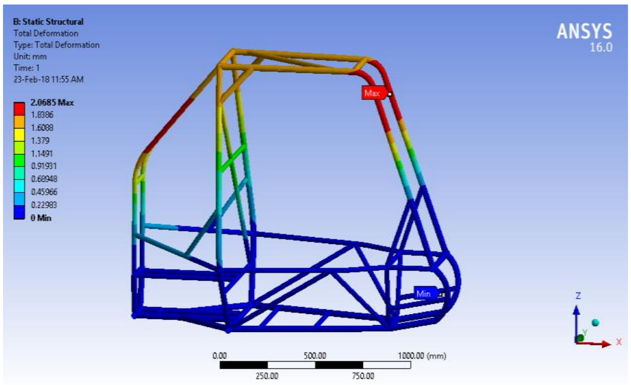

Fig -13: Total Deformation of Front Rollover Analysis

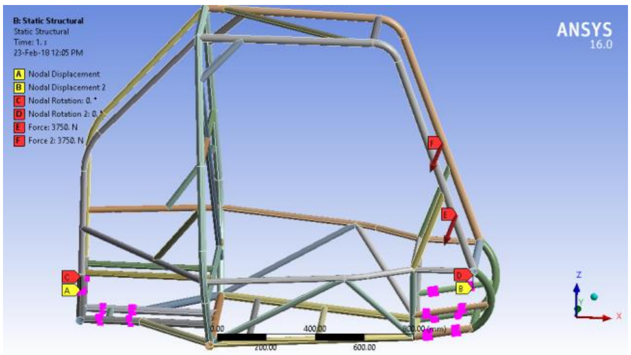

Fig -14: Analysis Condition for Front Rollover Analysis

3.1.5 Rear Rollover Analysis

For Rear Rollover Analysis Rear impact location considered first at roll cage member in contact during rear rollover. Rollover forces are considered in terms of g-force. We applied the calculated 3g force of 7500 N to the members of chassis which would be first in contact with the surface of road in case of rear rollover. The force was applied perpendicular to the curved members of the chassis. And the translation and rotation of all the suspension mounts is locked when impact and remaining Assumption & Considerations are same as above.

Calculation of Impact Forces:

Mass = 250Kg
gravitational force
= 10 m/s^2

Rear Rollover Force = 3 x gravitational force x mass

= 3 x 10 x 250

= 7500N

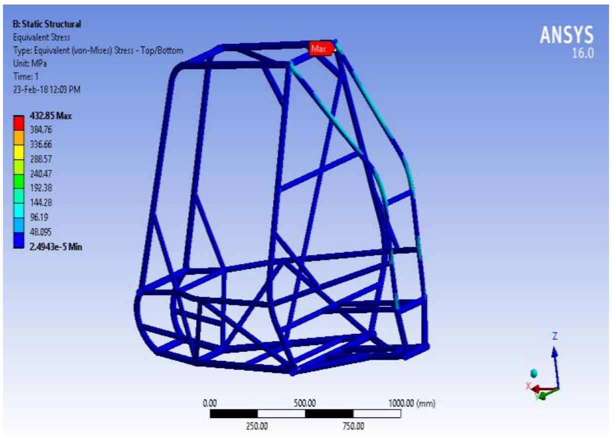

Fig -15: Equivalent stress of Rear Rollover Analysis

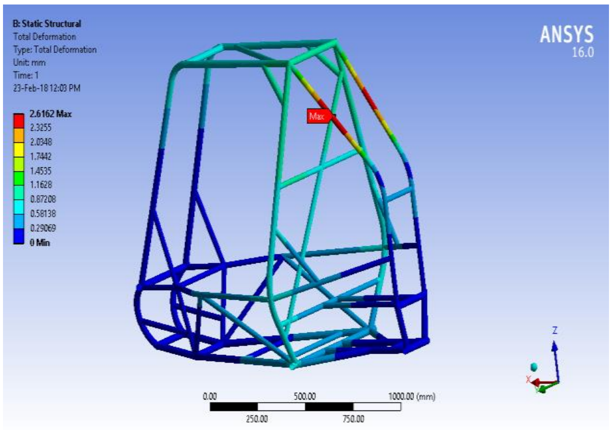

Fig -16: Total Deformation of Rear Rollover Analysis

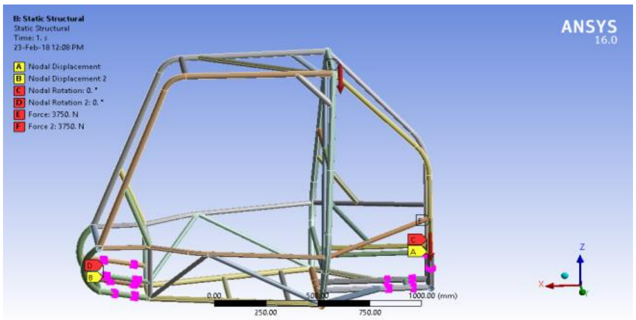

Fig -17: Analysis condition for Rear Rollover Analysis

4. CONCLUSIONS

We successfully analyzed the roll cage structure for its strength against the collision from front, rear, side. Factor of safety is under the safe limit as well as explained concepts of static analysis and selection of mesh size in finite element analysis. It is observed that the stresses obtained are within the safe range for the material AISI 4130 (Chromoly). The stresses and deformation obtained by the simulation for material 4130 (Chromoly) gives optimum result at mesh size 3 mm. The design, development and fabrication of the FRAME is carried out successfully.

Table -3: Results

S.NO.	TYPE	STRESS (MPa)	DEFORMATION (mm)	FORCE (N)
1	FRONT	261.7	1.1	20825
2	SIDE	432.49	2.16	7500
3	REAR	323	0.2	20825
4	REAR ROLLOVER	432	2.6	7500
5	FRONT ROLLVER	324	2	7500

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