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Simulation of ATV Roll Cage Testing

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Abstract : *In the present investigation, the performance of ATV roll cage is studied against crashes that can be encounter in the real life scenario and its consequences on the individual components. The roll cage structure which must be designed to ensure the safety of the driver while not compromising the ergonomics .Generally the testing on roll cage is done by considering it as a single unit but in this paper I have tried to make model of ATV roll cage and test it while considering the mass of individual elements like engine, transaxle, driver and steering assembly also considering the effect of suspension revolute joint and spring–damper in chassis. An approximate model is developed in ANSYS APDL using different elements and tested against the standard load to checkout for failure.*
Keywords: *Analysis, Ansys APDL, ATV, Mass, Roll Cage,*

I. Introduction

In this Era the automobile industry has changes drastically so the importance of safer vehicle increased day by day. The main objective of this paper was to test the ATV Roll Cage against the collision. [1]Chassis usually refers to the lower body of the vehicle including the tires, engine, frame, driveline and suspension. Out of these, the frame provides necessary support to the vehicle components placed on it. Also the frame should be strong enough to withstand shocks, twists, vibrations and other stresses. The roll cage design is tested against all modes of failure by conducting various simulation and stress analysis with aid of Ansys Software while doing so, the main focus remained on considering mass of every component including driver, effect due to gravity and attaching a suitable suspension system to the chassis.

II. Structural Analysis

1. Introduction:

For the present study, I have taken a roll cage of ATV design by the standards of SAE Baja rulebook 2014 .The material used in roll cage is AISI 1020 DOM Steel Pipe with following specification:

a. OD – 25.4mm
b. Wall thickness- 3.0mm
c. Tensile strength- 379 Mpa
d. Yield strength – 448 Mpa

2. **Ansys Model:** The analyzing of roll cage is done on Ansys APDL 14.5.It uses finite element analysis which allow us to virtually test all possible loading scenarios on roll cage without the prohibitive costs of real world testing .Now a days the extensive research is carried out by industries to develop the suitable methods to test the roll cage and this paper is small step towards it .The different ansys element used in modeling are following**:**

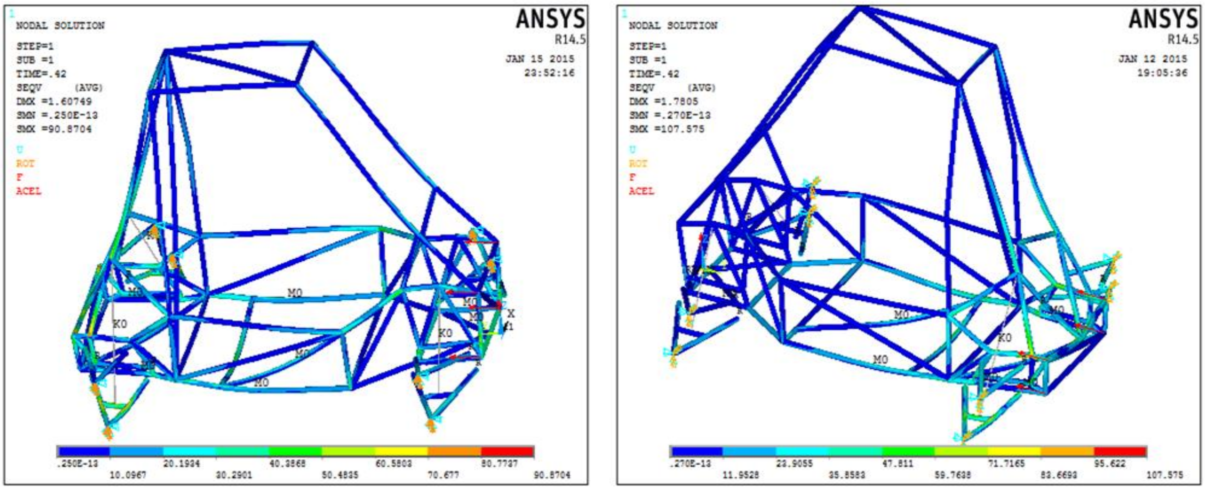
Table 1: Ansys element

Sr.No	Component	Element
1	Roll cage	PIPE289
2	Spring and damper	COMBIN14
3	Suspension joints	MPC184
4	Mass of driver and engine assembly	Mass21
5	Suspension Arms	Pipe289
6	Self-Weight of chassis	-

3.Test's on Roll Cage: For testing the roll cage, A-arm is joint with the chassis by revolute joint using ansys element MPC184, mass of driver +engine assembly is added to respective point in roll cage by ansys element Mass21 and to add Spring-Damper COMBINE14 element is used.

3.1 Front impact: For front impact we have applied the force on front portion of the vehicle and the front and rear suspension point is in all direction is constrained. It has been assumed that the vehicle has front collision with other stationary vehicle, considering our vehicle is moving at its maximum speed 60 kph stated by Baja rulebook

Impact time Calculation
Standard load -4G
Weight of vehicle -300kg
Impact time -Velocity/load
Impact time – 16.66/4×9.81=**0.42 sec**



(a) (b)

Figure1: Structural Analysis (a) Front Impact (b) Rear Impacts

3.2 Rear impact- In Rear impact the force is applied in rear part of the vehicle and all 4 suspension point is constrained in all direction, vehicle is assumed stationary. Considering the other vehicle with same specification is moving at its maximum speed 60 Kph as stated by Baja rulebook and hit the first vehicle from rear.

Impact time calculation
Standard load -4G
Weight of vehicle -300kg
Impact time -Velocity/load
Impact time – 16.66/4×9.81=**0.42 sec**

3.3 Side impact- it is performed by applying the force on side impact member and constraining the suspension points in all direction

Impact time
Standard load -2G
Weight of vehicle -300kg
Impact time – 16.66/2×9.81=**0.84 sec**

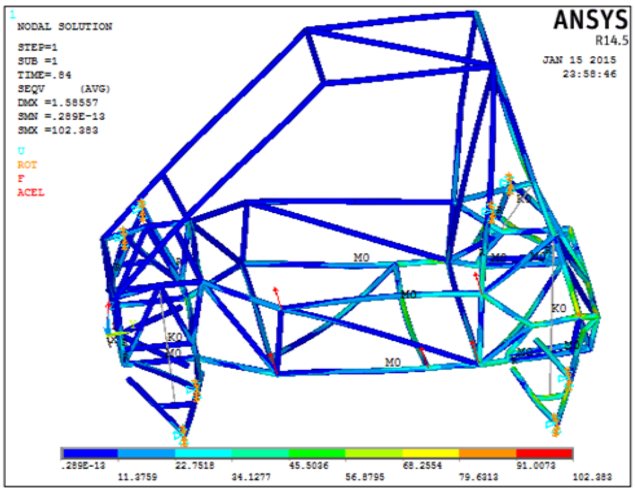


Figure2: Side Impact Structural Analysis

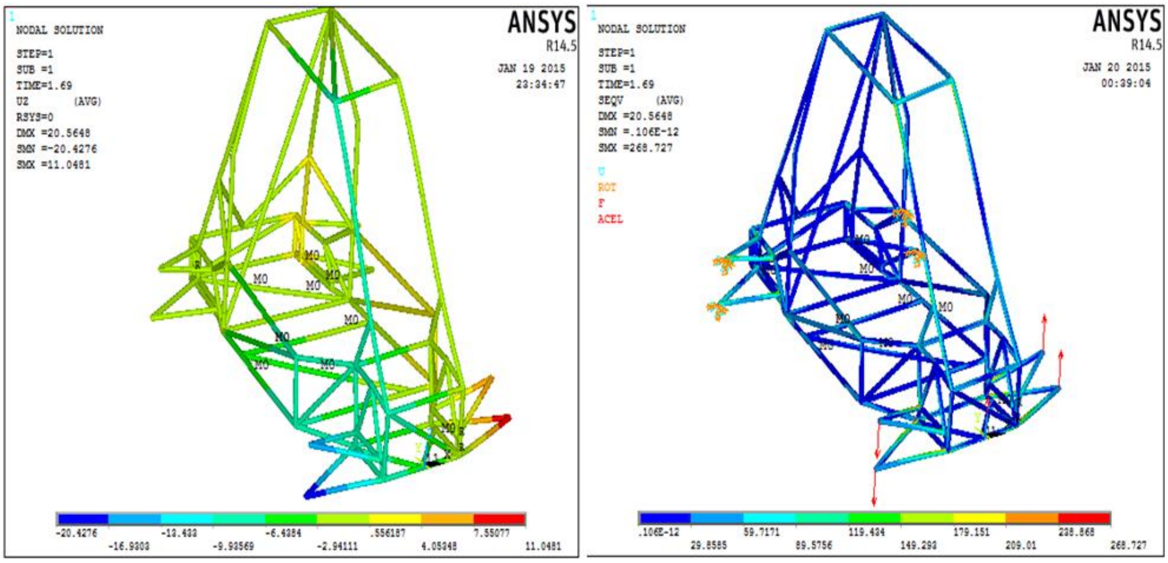
3.4 Torsional Stiffness - It is one of the most important property of vehicle chassis .Lack of chassis torsional stiffness effects the load transfer distribution. It is performed by considering A-arm and roll cage as a single unit while removing revolute joint and constraining the rear A–arm vertex points in all direction and applying the equal and opposite force on the front A–arm vertex points.
Torsional rigidity is calculated by the formula given below:

Track width = 1135 mm
Standard Load -1G
Weight of vehicle-300kg
Impact time-16.66/1×9.81= **1.69 sec**

Torsional Stiffness = Input Torque/Angular Deflection
Angular Deflection = arc tan(Vertical Deflection/ Moment Arm)

The input moment arm is half of the track width and the input torque is the torque caused by the input suspension loads on the front a –arms.

Angular Deflection = **1.115 mm**
<u>Torsional Stiffness</u> = **1497.5 Nm/deg**



(a) (b)

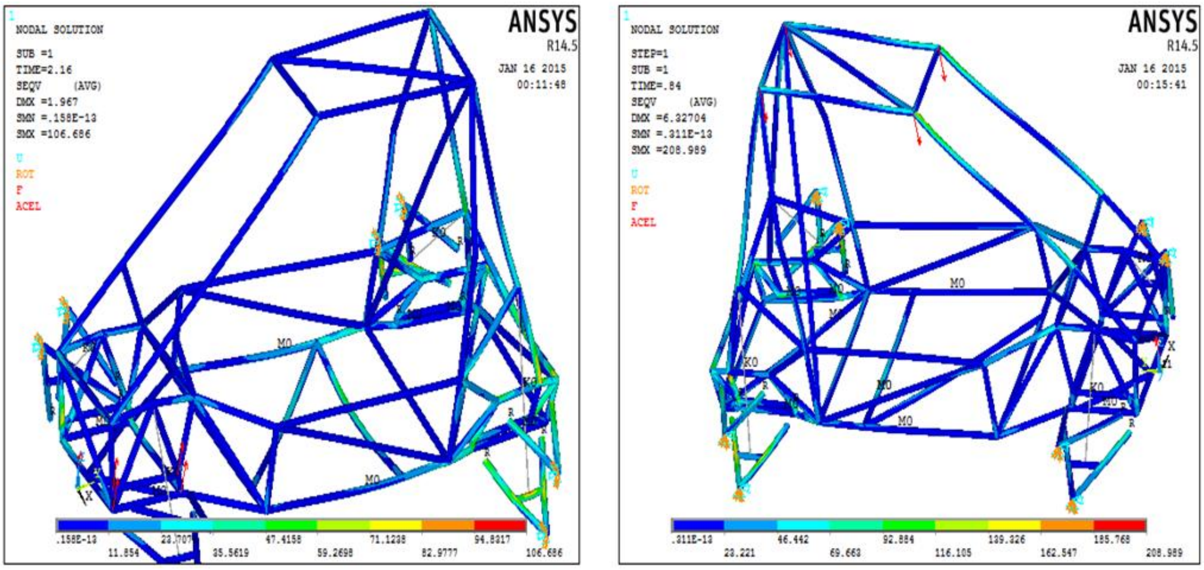
Figure 2: Torsional Stiffness (a) Vertical deflection (b) Von misses stress

3.5 Front wheel Bump- It is used to determine that, how chassis will distribute the load if there is failure of suspension in bump. If so happens the total load will be transferred from tire to chassis .It is performed by constraining the suspension points of three wheels and applying the force on suspension point of right front wheel.

Standard load -0.8G
Weight of vehicle -300kg
Impact time – 16.66/0.8×9.81=**2.12 sec**

3.6 Roll over Analysis- In roll over analysis we consider the worst case situation in which all the load is transferred to roll hoop overhead member and constraining the suspension points in all direction

Impact time
Standard load -2G
Weight of vehicle -300kg
Impact time – 16.66/2×9.81=**0.84 sec**



(a) (b)

Figure 3: Structural Analysis (a) Front Bump Impact (b) Roll over Impact

III. Results

Sr No	TEST	Standard Load	Constraint	Von-Misses Stress(Mpa)	Deflection (mm)	FOS
1	Front Impact	4G	All SP	91.0	1.6	4.2
2	Rear Impact	4G	All SP	107.6	1.8	3.5
3	Side Impact	2G	All SP	98.5	1.7	3.8
4	Roll over	2G	All SP	209	6.3	1.8
5	Front Wheel Bump	0.8G	Three SP	107.0	2	3.5
6	Torsional Stiffness	1G	Rear AVP	209	11	1.8

Table 2: Ansys Result

SP= Suspension Points, FOS= Factor of Safety, AV= A-arm vertex Points

IV. Conclusion

After analyzing the roll cage against all six test we can conclude that the ATV roll cage stress and deflection is under the safe limit and we can further optimize our chassis while not lowering the FOS value by less than limiting value. The lighter chassis will give us better fuel economy as well as higher acceleration.

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