

FEM Analysis of BAJA Chassis

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ABSTRACT

The BAJA SAE Series® is an event for the undergraduate engineering students, organized globally by the Society of Automotive Engineers, USA. The event originated in the name of Mini - BAJA, in the year 1976 at University of Carolina. Since then, the event has spanned across six countries – USA, Mexico, South Africa, Korea, Brazil and India. The BAJA SAE tasks the students to design, fabricate and validate a single seater four - wheeled off road vehicle to take part in series of events spread over a course of 3 days that test the vehicle for the sound engineering practices that have gone into it, the agility of the vehicle in terms of gradability, speed, acceleration and manoeuvrability characteristics and finally its ability to endure that back breaking durability test.

The vehicle needs to traverse all types of off-road conditions including rocks, logs, mud holes, steep inclines, jumps and sharp corners. During the competition events there is significant risk of rollovers, falling from hill track, collisions with stationary objects, or impacts from other vehicles. The frame design has been analyzed in a variety of different situations to predict whether it will survive the impact of fail in that situation. The results from these simulations indicate that the frame is indeed safe enough in the variety of worst-case scenarios tested.

Off-road race vehicles are required to navigate rough terrain while maintaining high speeds. For this competition the vehicle will compete in a 4 hour endurance event in which it must navigate terrain with jumps, logs, rocks, mud, and hills all while maintaining a speed of 20-35 mph. The frame needs to be designed to handle impacts due to front collision roll over, jump landings. It also must be able to ensure driver safety during extreme impacts and collisions.

General Terms

CATIA V5, hypermesh, hyperview

Keywords

ATV, FEA, Modeling, Roll Cage, Strength, Hyperview, Hypermesh, hyperworks.

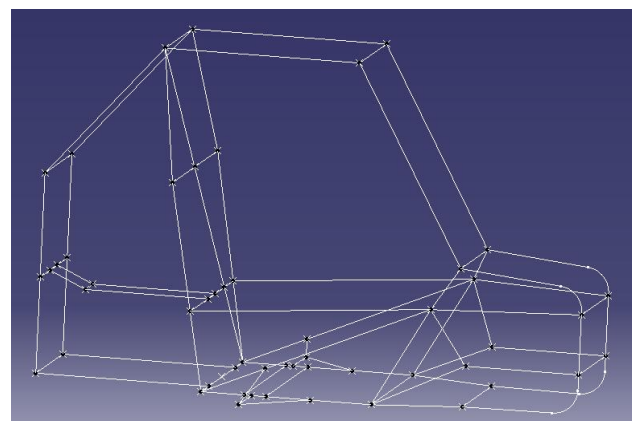
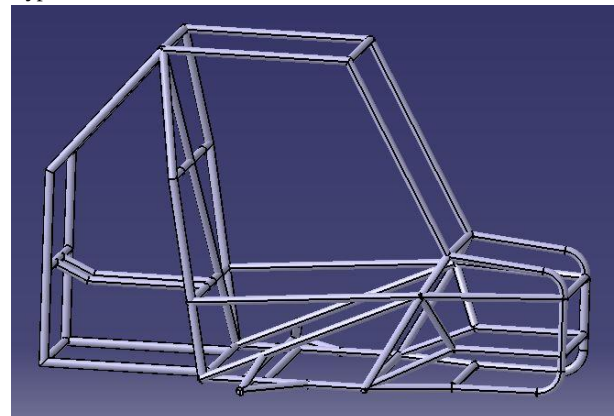
1. INTRODUCTION

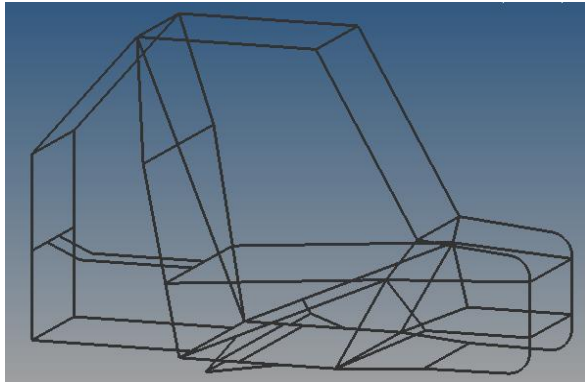
Roll Cage is the basic frame of a vehicle. Its purpose includes seating the driver, providing safety and incorporating other sub-systems of the vehicle frame. We have designed the roll cage keeping in view the safety and aesthetics. This paper focus on various loading tests like Front Impact, Rear Impact,

Side Impact, Gront jump landing, rear jump landing, Roll over to check whether our chassis can bear all types of impacts

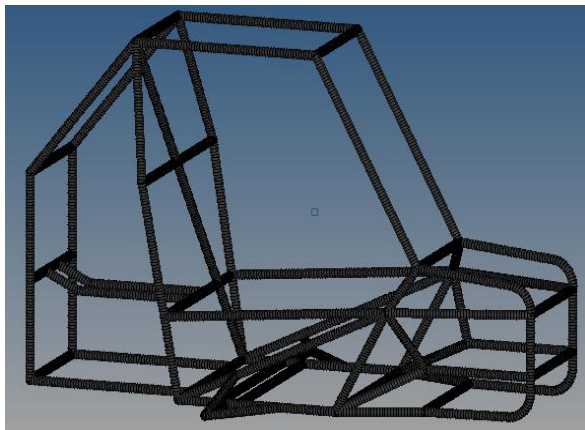
2. ANALYSIS METHODOLOGY

Once modeling of the roll cage structure is done by using catia, this design is checked by Finite Element Analysis. We have used **Hyperworks** software. We have first imported the catia file in hypermesh via import geometry, then specified material, defined the cross-section, its property, created component, done 1D meshing, applied load collectors, load steps and then done OptiStrut. The final analysis is shown in Hyperview.





Importing igs file in hypermesh



Applying 1-D meshing

3. MATERIAL USED

Table 1. Mechanical Properties of AISI 1018 Steel

Density(x1000 kg/m3)	7.7-8.03
Poisson's Ratio	0.27-0.30
Elastic Modulus (GPaTensile)	190-210
Tensile Strength (MPa)	634
Yield Strength (MPa)	386
Hardness(HB)	197

Table 2. Dimensions of pipe section

Pipe diameter (mm)	15.875
Wall thickness (mm)	14.275

4. FEM ANALYSIS

After finalizing the frame along with its material and cross section, it is very essential to test the rigidity and strength of the frame under severe conditions. The frame should be able to withstand the impact, torsion, roll over conditions and provide utmost safety to the driver without undergoing much deformation. Following tests were performed on the roll cage.

(1)Front Impact, (2)Rear Impact, (3)Roll Over, (4)Side Impact, (5)Front jump landing, (6)Rear jump landing

NOTE- all displacement in mm and all stresses in MPa

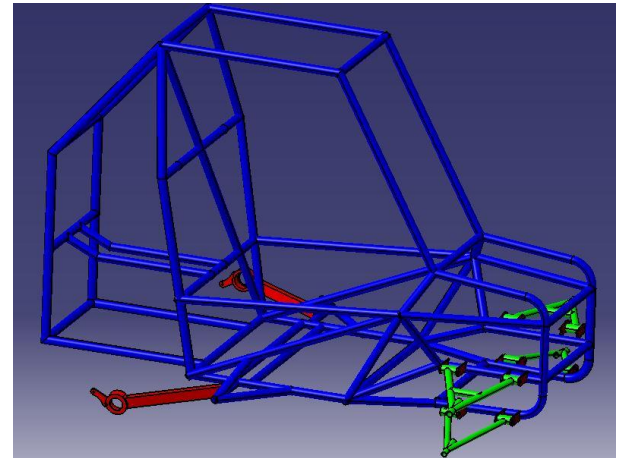


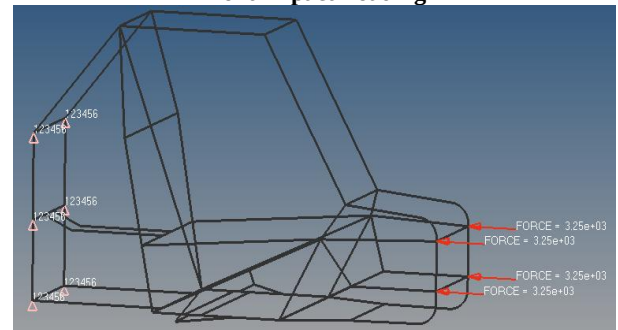
Figure depicting double wishbone and trailing at front and rear respectively. Knuckle will be placed at the end of upper and lower wishbones.

4.1 Front Impact

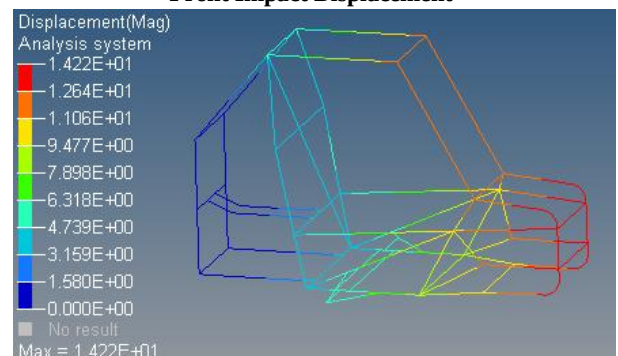
4.1.1 Front Impact load calculation:

Using the projected vehicle + driver mass of 330 kg, the impact force was calculated base on a G-load of 4. $F = ma$
 $330 \times 4 \times 9.81 = 13000 \text{ N (approx)}$. We apply 13000 N from the front for the test of front impact of the roll cage structure of the vehicle for determining strength at the time of front collision.

Front Impact Loading

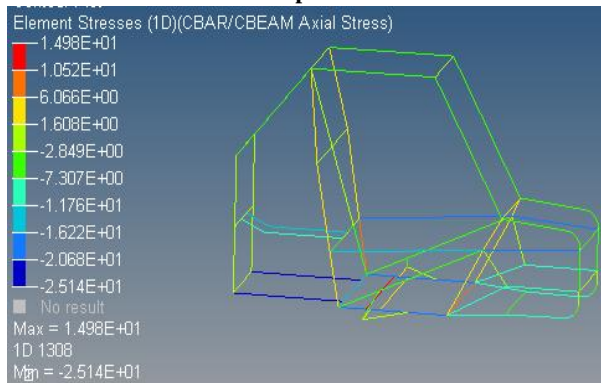


Front Impact Displacement



Maximum deformation: 14.22 mm. Maximum deformation is within the permissible limit.

Front Impact Stress



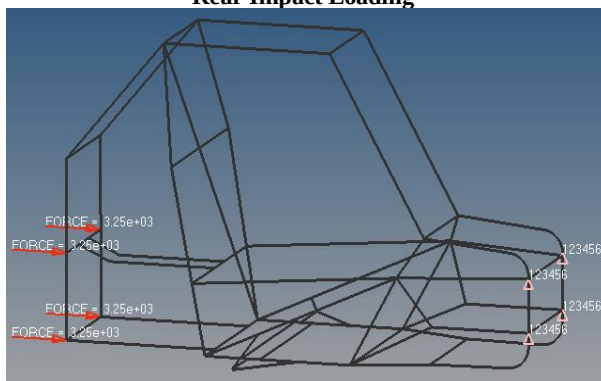
Maximum Von Mises Stress= 14.98 MPa . Maximum stress is within permissible limits.

4.2 Rear Impact

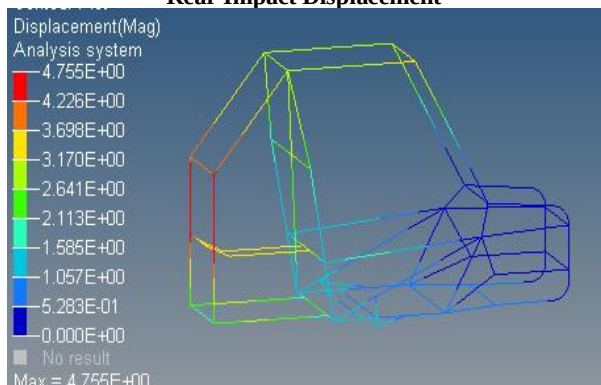
4.2.1 Rear Impact load calculations

Using the projected vehicle+driver mass of 330 kg, the impact force was calculated base on a G-load of 4. $F = ma$
 $330 \times 4 \times 9.81 = 13000$ N(approx). We apply 13000 N from behind for rear impact of the roll cage structure of the vehicle.

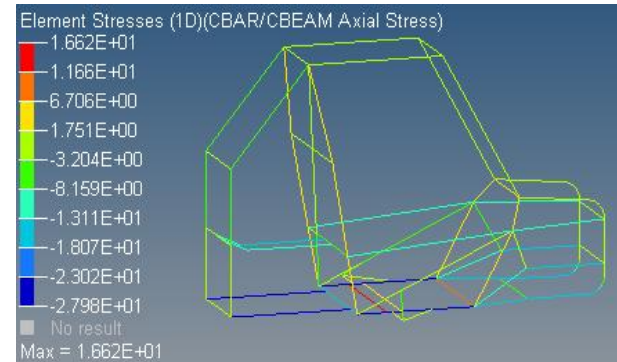
Rear Impact Loading



Rear Impact Displacement



Maximum deformation: 4.755 mm. Maximum deformation is within the permissible limit.



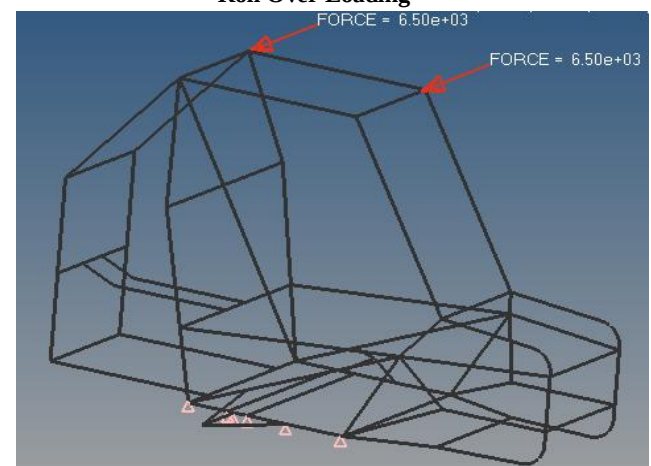
Rear impact stressesMaximum Von Mises Stress= 16.62. Maximum stress is within permissible limits.

4.3 Roll over

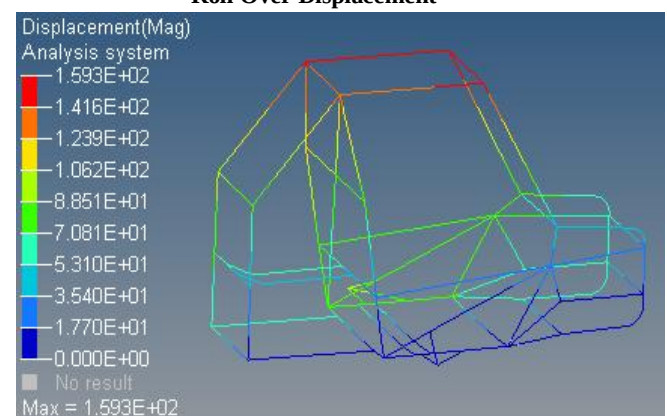
4.3.1 Roll over Impact load calculations

Using the projected vehicle+driver mass of 330 kg, the impact force was calculated base on a G-load of 4. $F = ma$
 $330 \times 4 \times 9.81 = 13000$ N(approx). We apply 13000 N from the side for the test of front impact of the roll cage structure of the vehicle for determining strength at the time of roll over.

Roll Over Loading

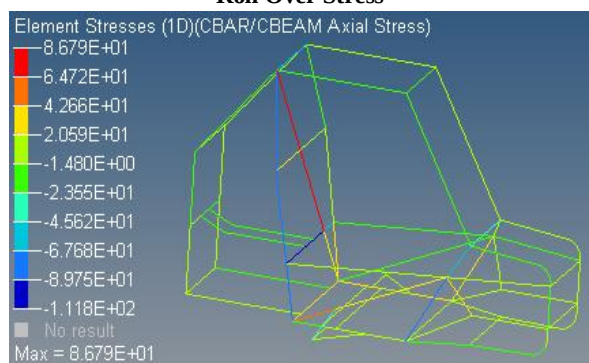


Roll Over Displacement



Maximum deformation: 159 mm. Maximum deformation is within the permissible limit.

Roll Over Stress



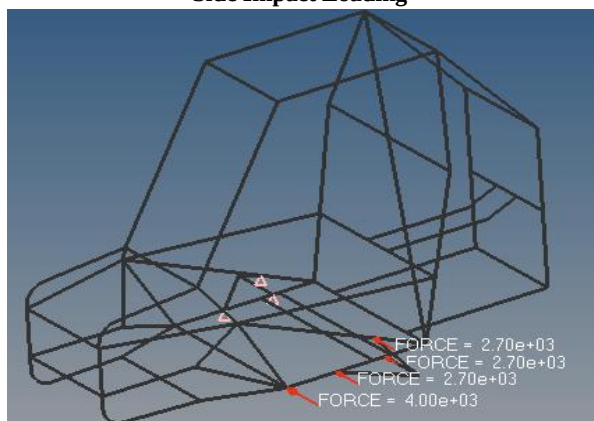
Maximum Von Mises Stress= 86.79 MPa. Maximum stress is within permissible limits.

4.4 Side Impact

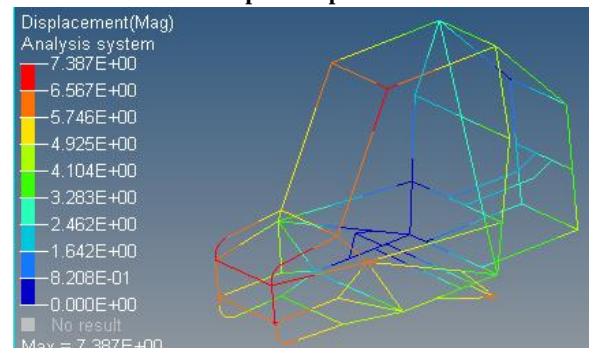
4.4.1 Side Impact load calculations

Using the projected vehicle+driver mass of 330 kg, the impact force was calculated base on a G-load of 2.5. $F = ma$, $330 \times 2.5 \times 9.81 = 8100$ N(approx). We apply 8100 N from the side for the test of front impact of the roll cage structure of the vehicle for determining strength at the time of side impact.

Side Impact Loading

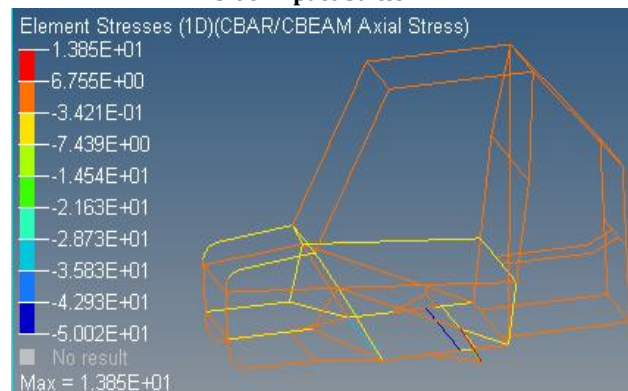


Side Impact Displacement



Maximum deformation: 7.387 mm. Maximum deformation is within the permissible limit.

Side Impact Stress



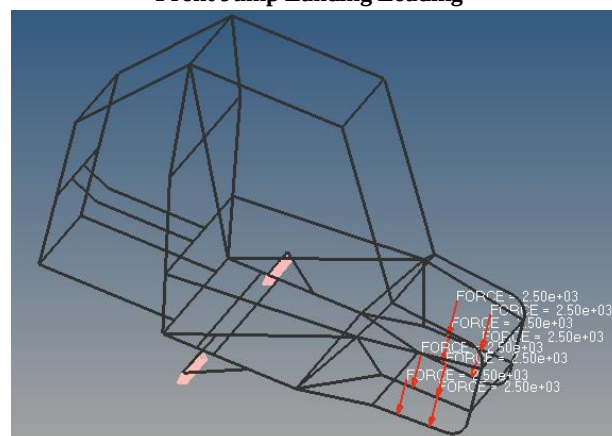
Maximum Von Mises Stress= 13.85 MPa. Maximum stress is within permissible limits

4.5 Front jump landing

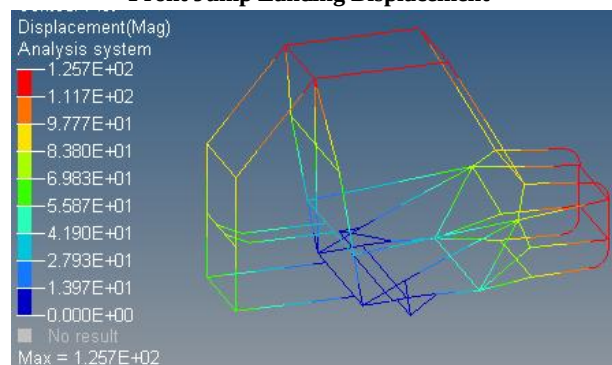
4.5.1 Front jump landing load calculations

Using the projected vehicle+driver mass of 330 kg, the impact force was calculated base on a G-load of 6. $F = ma$, $330 \times 6 \times 9.81 = 20000$ N(round about). We apply 20000 N on the front suspension points

Front Jump Landing Loading

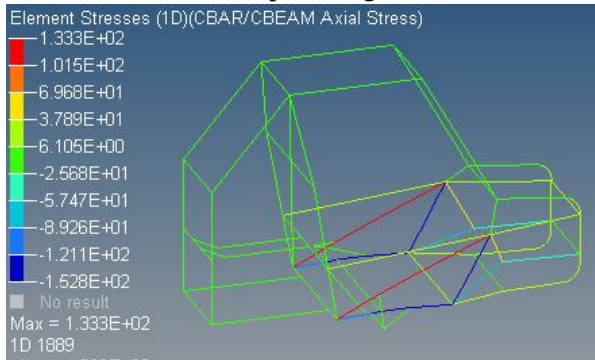


Front Jump Landing Displacement



Maximum deformation: 125.7 mm. Maximum deformation is within the permissible limit.

Front Jump Landing Stress



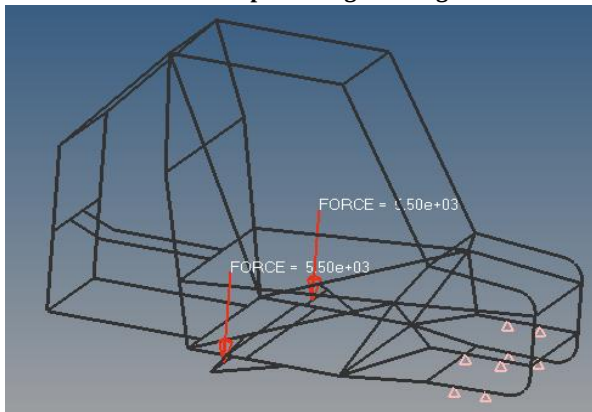
Maximum Von Mises Stress= 133.3 MPa. Maximum stress is within permissible limits.

4.6 Rear jump landing

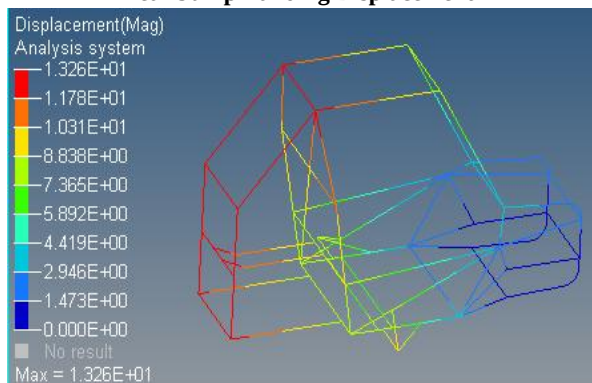
4.6.1 Rear jump landing load calculations

Using the projected vehicle+driver mass of 330 kg, the impact force was calculated base on a G-load of 3.5. $F = ma$
 $330 \times 3.47 \times 9.81 = 11000$ N(round up). We apply 11000 N on the rear suspension points

Rear Jump Landing Loading

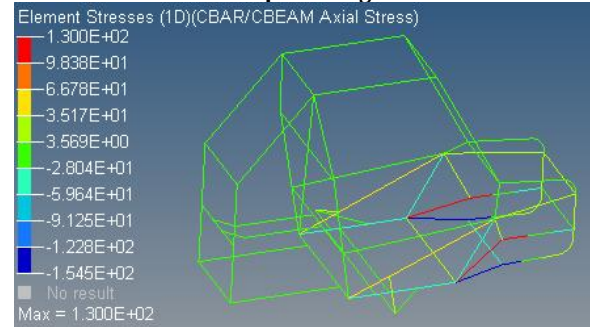


Rear Jump Landing Displacement



Maximum deformation: 12.26 mm. Maximum deformation is within the permissible limit.

Rear Jump Landing Stress



5. CONCLUSION

CASE	STRESS (MPa)	DEFORMATION (mm)
FRONT IMPACT	14.98	14.22
REAR IMPACT	16.62	4.755
ROLL OVER	86.79	159
SIDE IMPACT	13.85	7.387
FRONT IMPACT	133.3	125.7
REAR IMPACT	130.3	13.26

Since our stresses developed in each case is less less than yield stress hence our design is safe.

6. ACKNOWLEDGMENTS

I want to thank Mr Sandeep Sharma- our mentor under whose guidance I was able to complete this.

7. REFERENCES

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- [3] Finite Element Analysis of Impact on Chassis & Frame of a Mini Baja Vehicle 1Hemant Kumar Nayak, 2Nagendra Prasad, 3 Deepty Verma,4Tulsi Bisht Hindustan College of Science and Technology Farah, Mathura, UP, India, International Journal of Emerging trends in Engineering and Development ISSN 2249-6149 Issue1, Vol. 3(November-2011)
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