

NASA Human Exploration Rover Design and Analysis

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ABSTRACT

In this paper, we are going to present design and analysis of NASA human exploration rover so as to maintain the strength, stiffness and stability at the specified track. This is annual competitions challenge for college students to design, build, and race human powered, collapsible vehicles over simulated lunar terrain. The main emphasis should be on the manufacturability, cost and weight reduction. Validate the optimum design selected by conventional Hand Calculation.

Keywords

Chassis, suspension, ansys, catia, stress, displacement, frequency etc.

1. INTRODUCTION

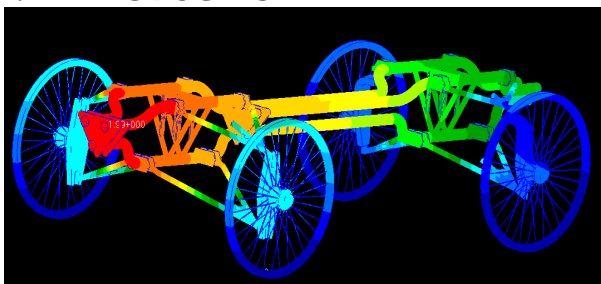


Fig.1 Frame design and wheel assembly.

It is triangular supported 3 parallel beam chassis with independent suspension and having four wheel configuration which is human powered.

2. DESIGN CONSTRAINTS

Design of the Rover should be collapsible so that it should fit into 4*4ft cube. It can be assembled and disassembled easily during competition. As it is driven by male and female drivers therefore anthropometry and ergonomics play very important criteria while designing.

2.1 Material properties (Al-7075)

- Young's Modulus $E = 72398.8 \text{ N/mm}^2$
- Poisson's Ratio = 0.33.
- Density of material = 2810 kg/m^3 .
- Allowable Yield Stress = 448.18 N/mm^2
- Ultimate tensile stress, $F_{tu} = 537.82 \text{ N/mm}^2$

- Shear yield stress, $F_{sy} = 303.4 \text{ N/mm}^2$
- Factor of safety = 2.5
- Allowable working stress = 179.27 N/mm^2
- Stress- Strain curve for Al-7075

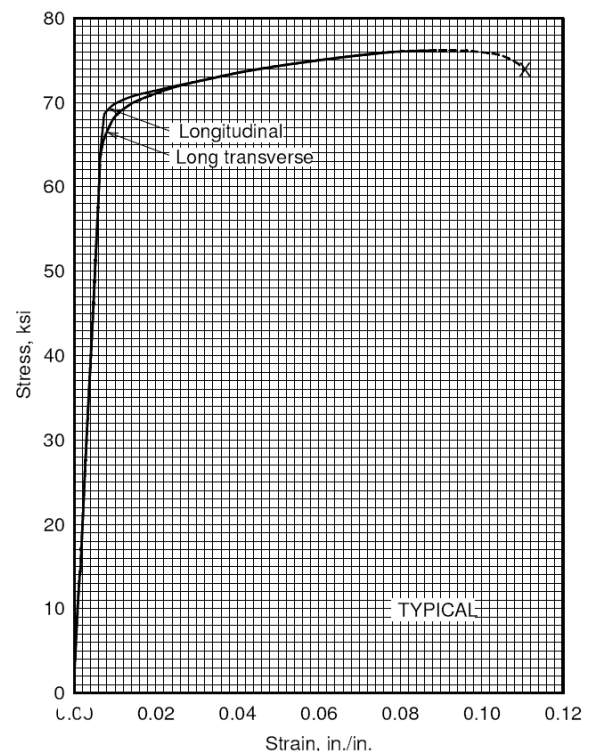


Fig.2 Typical tensile stress strain curve (full range) for clad 7075-T6 aluminum alloy sheet at room temperature

3. FE ANALYSIS OF ROVER ASSEMBLY

In order to make sure that design carried out is safe, it is necessary to carry out FE analysis and compare it with design calculations. The main scope of this FE analysis was to carry out strength analysis of rover with available commercial FE analysis tool (NASTRAN & PATRAN), compare the predicted maximum stresses under the given loading condition.

Design and assembly in catia V5.

FEM is generated in PATRAN

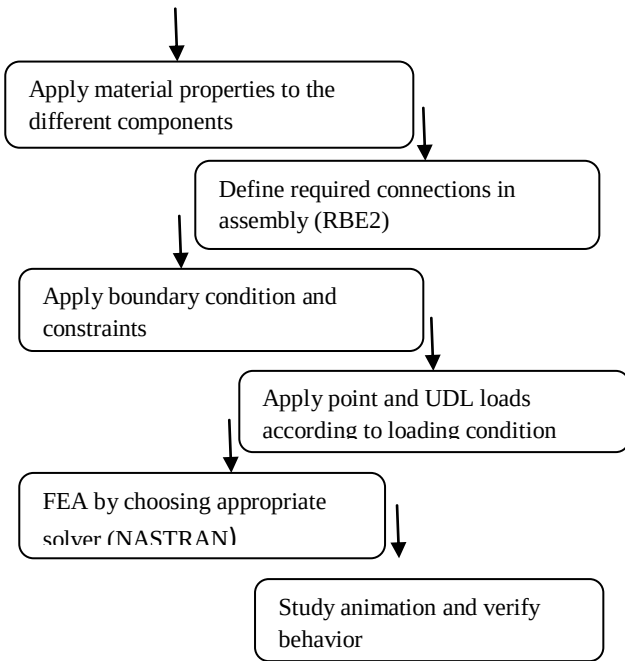


Fig.3 Systematic tasks performed while analysis

4. MESHED MODEL

Quality of meshing plays important role in FEA. Finer the meshing better will be the results but on the other hand solution time also increases. In this project, 3d meshing with tet 10 element is used for meshing of structure which is equivalent to hex 8 elements.

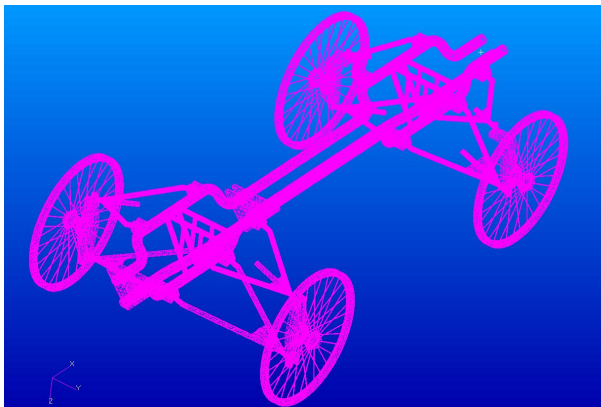


Fig.4 meshed model

5. BOUNDARY CONDITION AND LOAD APPLICATION

All the boundary condition and load application on rover has been done in Patran. All the connections between various

components has been simulated with RBE2 and shock absorber has been simulated with the help of spring constant.

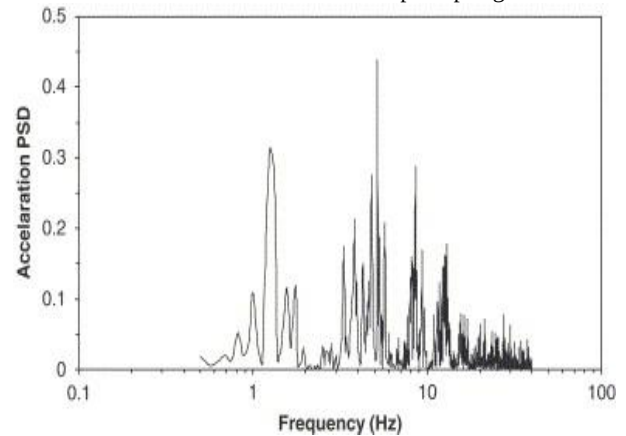


Fig. 5 Acceleration Vs frequency curve for rough terrain.

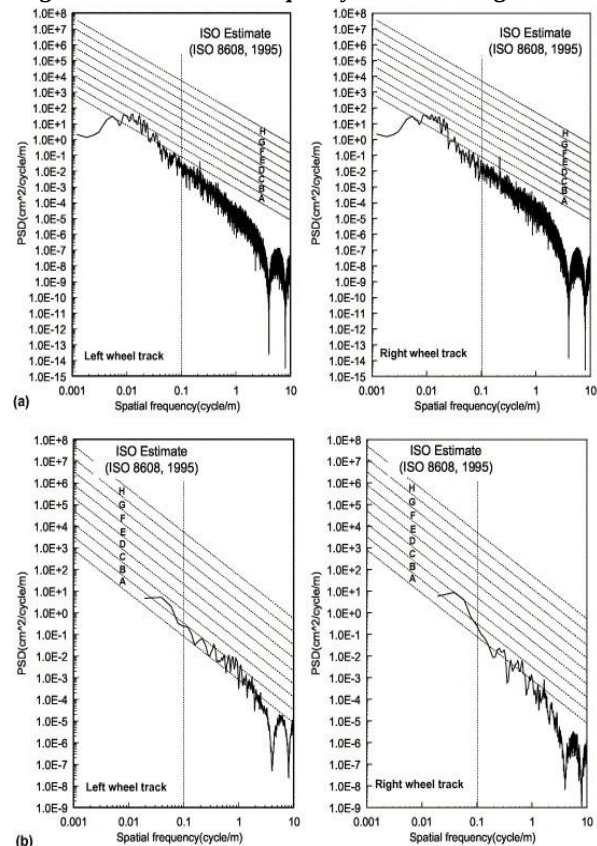


Fig.6 PSD Vs Spatial frequency curve for left and right wheel track.

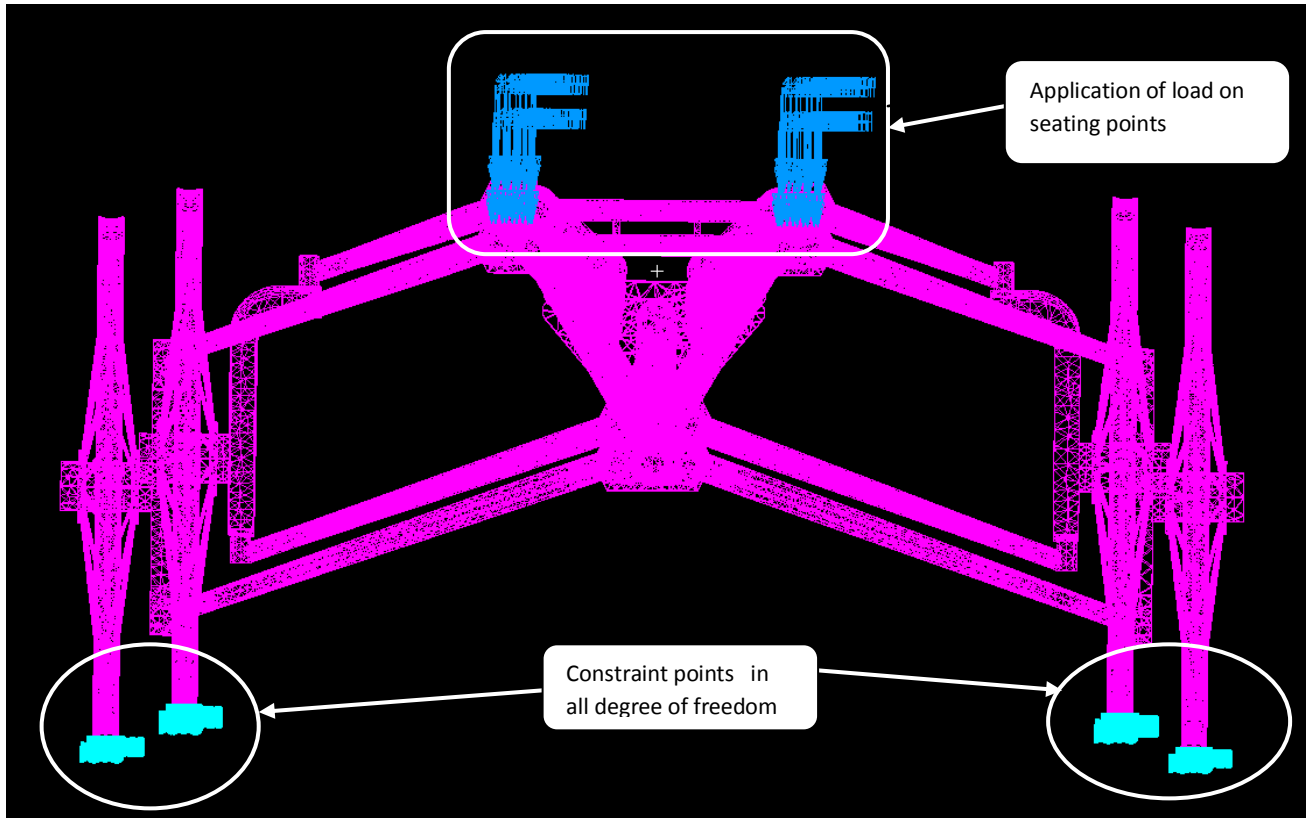


Fig.7 Loading and constraint points

6. FEM ANALYSIS WITHOUT SHOCK ABSORBER

Stress and displacement analysis (without shock absorber)

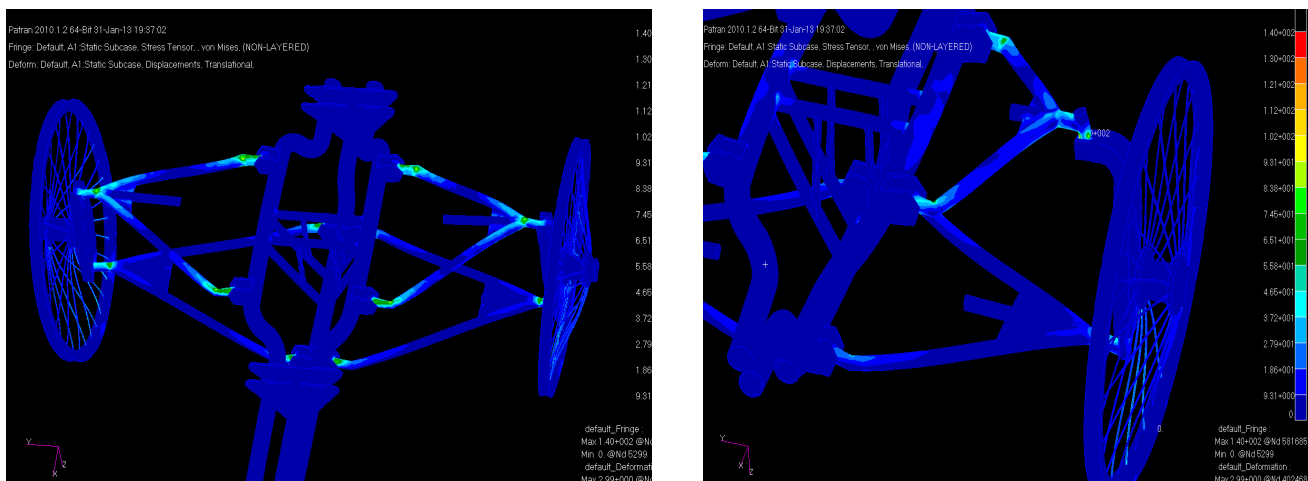


Fig.8 Stress concentration in chassis and wishbones (without shock absorber).

Displacement plots

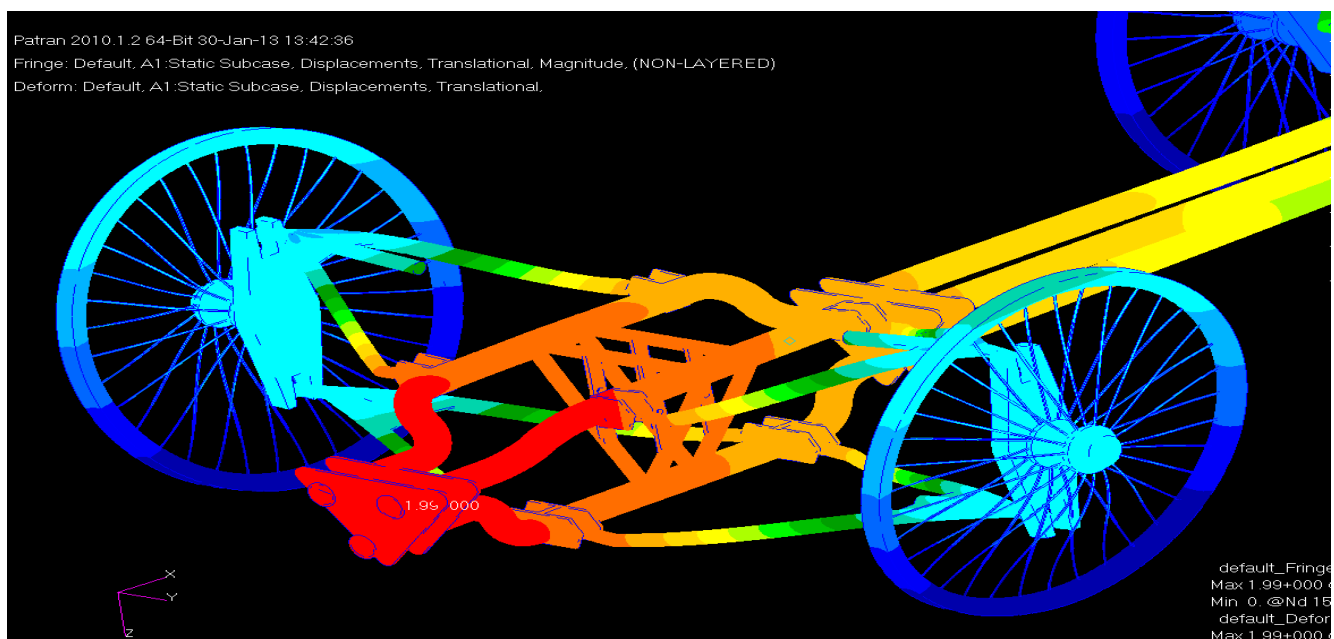


Fig.6 Displacement analysis

Results

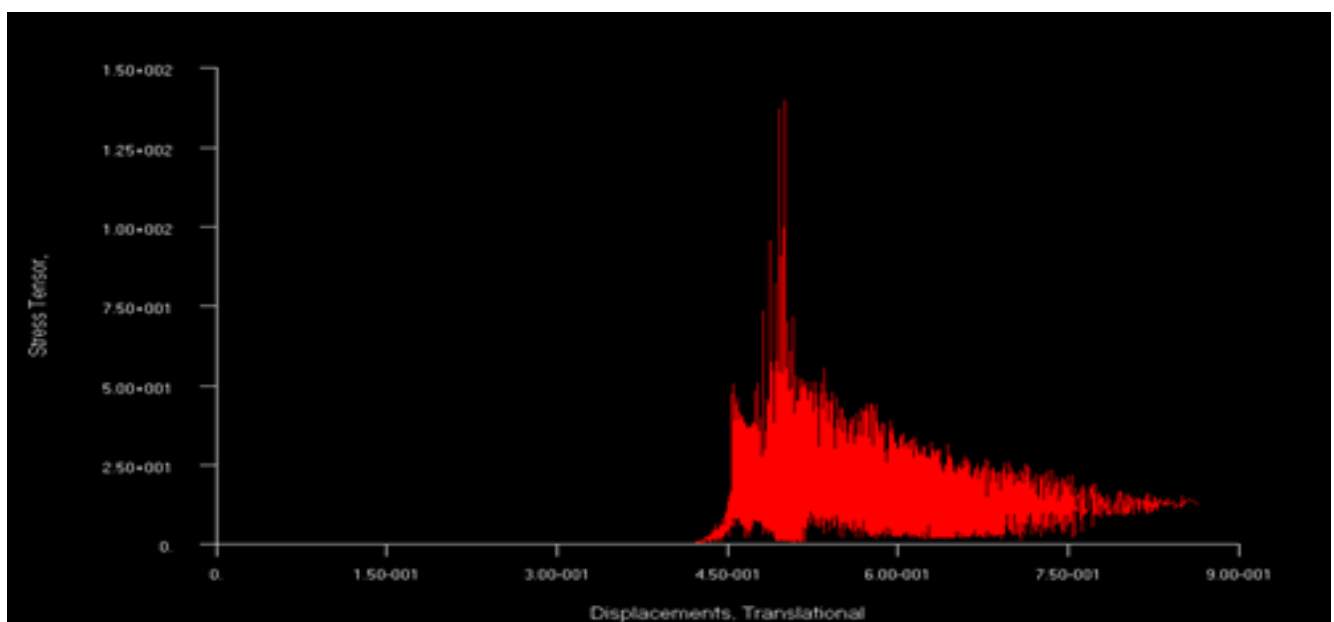


Fig.7 Stress Vs Displacement graph

Stress Calculated	Displacement
140 N/mm ²	2.99 mm

Remarks: The Stress so produced was lower than the required value i.e. 179.27 N/mm² but the displacement of wheels is more, which can hamper the functionality of rover so, design modification is recommended.

7. FE ANALYSIS WITH SHOCK ABSORBER

Stress analysis

Shock absorbers can be used to reduce the displacement as shock absorbers will absorb a great amount of energy transferred to the wheel.

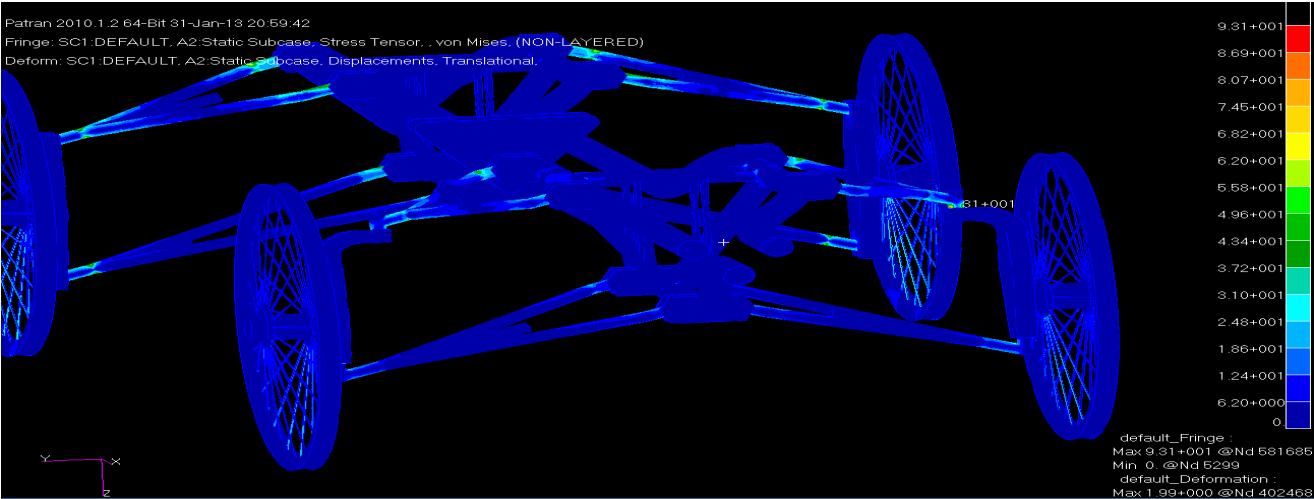


Fig.7 Stress analysis (with shock absorber)

Displacement analysis

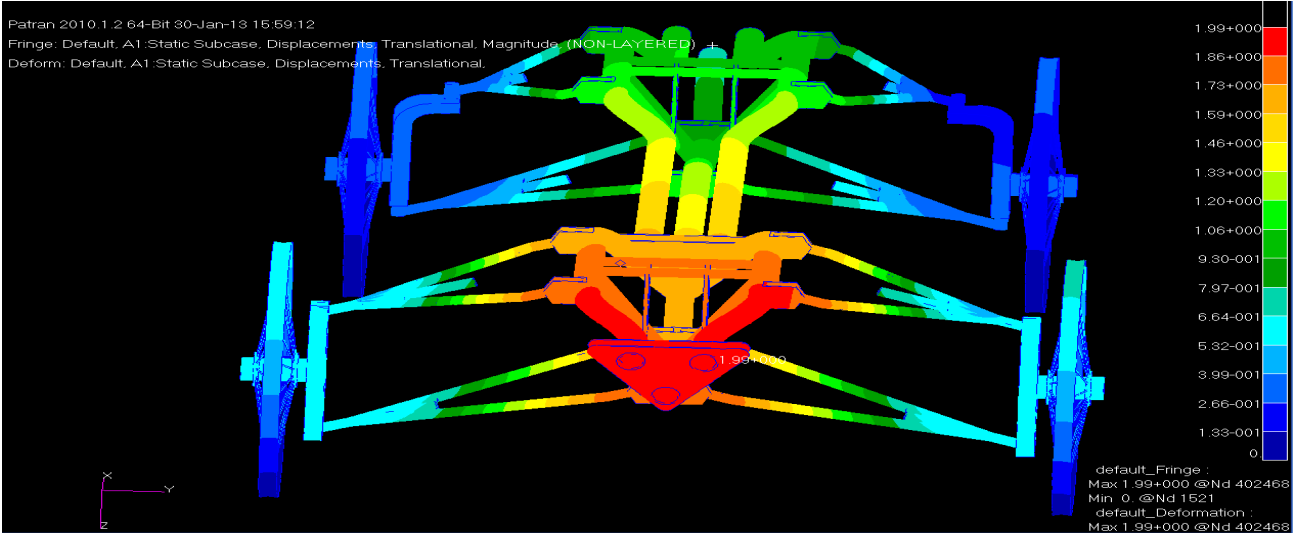


Fig.8 Displacement analysis (with shock absorber).

Graphical plot

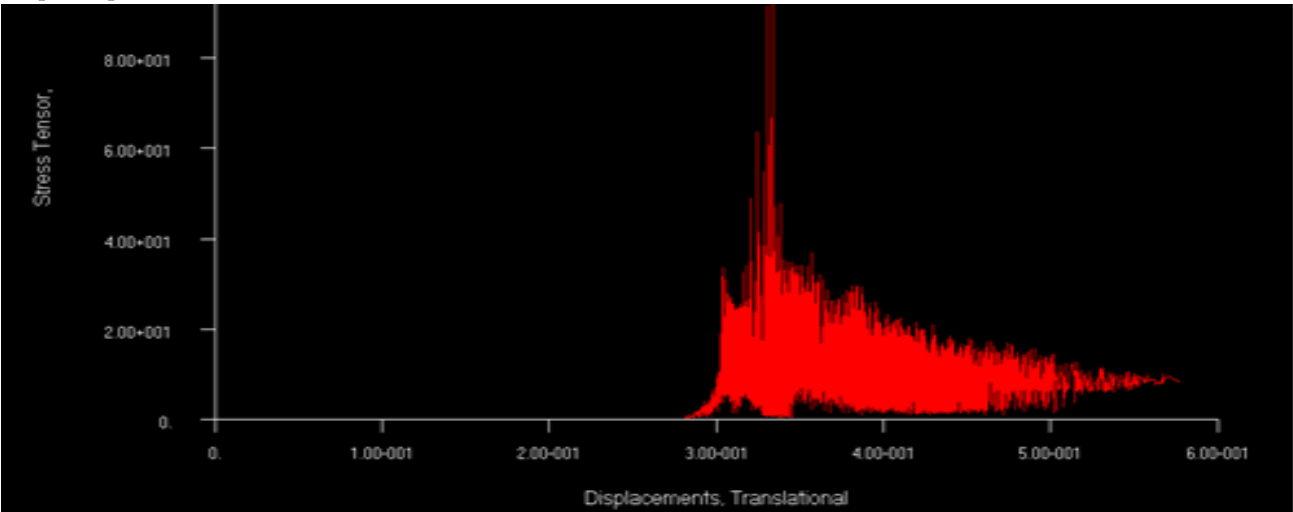


Fig.9 Stress Vs Displacement graph.

Results

Stress Calculated	Displacement
93.1 N/ mm ²	1.99 mm

Remarks: The Stress so produced is far below the required value i.e. 179.27 N/ mm² and moreover the displacement of the wheels is under control with the use of shock absorbers.

8. CONCLUSION

The current structure is on the conservative side. The reported stresses are well below the allowable stresses. The use of shock absorbers will absorb the undue energy transferred to the lower frame, hence will help in decreasing the unwanted displacement of wheels.

9. ACKNOWLEDGMENTS

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10. REFERENCES

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