ANALYSIS OF FSAE CHASSIS

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Abstract— This paper is related to the analysis, simulation and designing of the Single Seater Race Car Chassis which is made according to the rules and restriction provided in the FSAE Rulebook 2018. Chassis for any vehicle is most important part as it becomes a structural backbone for support of different systems attached to it and carry out the load of all the different component as well as passenger and goods. The designing task is so complicated for the design of a good chassis and we have to consider the various parameters and factors while designing of this chassis and also loads experienced by the chassis due to various system is also an important aspect. Making a lightweight chassis without any compromise for safety of the driver, and considering various rules and regulation given in the SAE rulebook while designing of the chassis, and also understanding various specific cross section for the chassis fabrication is very important. In this various software like ANSYS and SOLIDWORKS have been used for the process of doing modeling and Analysis of the car frame.

Keywords – Ansys, Solidworks, FSAE, Finite Element Analysis, Space Frame Chassis, Chassis, Beam Element 189

1 INTRODUCTION

SAE SUPRA is the national level event which is held under the banner of SAE International All the under graduate students from all around the nation takes participation in making the aesthetic, ergonomic and safe chassis, for the purpose of the competition. For this competition, the teams thrive to make the most well-designed car frame with all parameters considered. Designing of the chassis is the most important part for any team, due to the fact that it supports all the various department of the whole vehicle. Cockpit design is important, as it has to accommodate 95th percentile male, and also the design should be made in such a way that it should not compromise the driver safety at any condition. The design should not fail at any cost, and it should have the minimum required stiffness, strength and torsional rigidity, and it should be highly reliable and safe. At the end after the analysis and fabrication of the chassis, during its presentation the judging is done by the officials by considering results from technical inspection, static event and dynamic event, and by summing up all the given points in this all events the final decision is taken.

2 Methodology

The following model of the single seater FSAE race car chassis is made on ANSYS Design Modeler by using ANSYS Beam 189. The BEAM189 element is suitable for analyzing slender to moderately stubby/thick beam structures.

The element is based on Timoshenko beam theory which includes shear-deformation effects. The element provides options for unrestrained warping and restrained warping of cross-sections. The element is a quadratic three-node beam element in 3-D. With default settings, six degrees of freedom occur at each node; these include translations in the x, y, and z directions and rotations about the x, y, and z directions. An optional seventh degree of freedom (warping magnitude) is available. The element is well-suited for linear, large rotation, and/or large-strain nonlinear application.

First the required coordinates were found and inputted in the design modeler, and then the corresponding points were generated by mirroring it along the axis. After that the remaining thing was to joint the point with lines, along with various cross members joint from node to node. According to the FSAE Rulebook there are different cross sections given for different parts of the chassis members and cross members.

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ITEM or APPLICATION	OUTSIDE DIMENSION X WALL THICKNESS
Main & Front Hoops, Shoulder Harness Mounting Bar	Round 1.0 inch (25.4 mm) x 0.095 inch (2.4 mm) or Round 25.0 mm x 2.50 mm metric
Side Impact Structure, Front Bulkhead, Roll Hoop Bracing, Driver's Restraint Harness Attachment (except as noted above) EV: Accumulator Protection Structure	Round 1.0 inch (25.4 mm) x 0.065 inch (1.65 mm) or Round 25.0 mm x 1.75 mm metric or Round 25.4 mm x 1.60 mm metric or Square 1.00 inch x 1.00 inch x 0.047 inch or Square 25.0 mm x 25.0 mm x 1.20 mm metric
Front Bulkhead Support, Main Hoop Bracing Supports EV: Tractive System Components Protection	Round 1.0 inch (25.4 mm) x 0.047 inch (1.20 mm) or Round 25.0 mm x 1.5 mm metric or Round 26.0 mm x 1.2 mm metric
Bent Upper Side-Impact Member (T3.24.3a)	Round 1.375 inch (35.0mm) x 0.047 inch (1.20mm)

Fig.1 Cross section

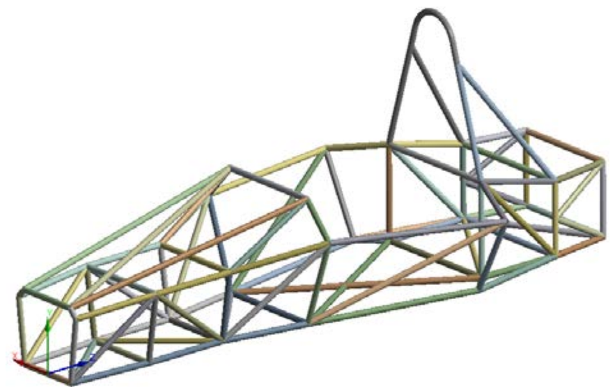

Fig 2. Geometry of the chassis

3 MATERIAL SELECTION

There are various loads and forces which act during the motion of the chassis, therefore proper selection of the material is an important aspect. Stiff and lightweight chassis is very important, and this is directly affected by the stiffness of the chassis. The chassis material must take various loads and forces, and must perform under extreme environmental conditions. After reviewing mechanical properties, availability, cost and other significant factors, following material was selected for the fabrication of the chassis and the material is AISI 4130. Every material having different parameters and properties as follows, from them AISI 4130 is selected due to its advantages over other materials in ultimate strength and the low in weight mentioned in following table.

Material → / Properties ↓	AISI 1018	AISI 1020	AISI 4130
Carbon %	0.15-0.20	0.18-0.23	0.28-0.33
Density (Kg/m3)	7.87×103	7.7×103	7.85×103
Tensile Yield Strenght (MPa)	370	350	435
Tensile Ultimate Strenght (MPa)	440	400	560
Modulus of Elasticity (GPa)	205	200	210
Poisson's Ratio	0.29	0.29	0.29

Fig 3. Material properties

4 Mesh

The mesh consists of 9082 quadratic beam elements with six degrees of freedom (UX, UY, UZ, ROTX, ROTY, ROTZ) at each node, these elements are based on Timoshenko beam theory and it's computationally efficient and has good convergence properties with respect to mesh refinement.

5 Analysis

Linear Static structural analysis is performed on four different cases which are resulting into four different results.

Case1 Side Impact
Case2 Front Impact
Case3 Rear Impact
Case4 Acceleration

In this the Side Impact, the Front Impact and the Rear Impact are further divided into 2 more cases on which the analysis is done. The reason for doing these cases is to make sure that the chassis is safe in both condition during the impact and the deformation is minimal as possible.

Case 1 – Side Impact Test

Side impact are caused when the vehicle crashes the side of one or more vehicles when impacted. The common cause for side impact is during an unaatended crossing at an intersection. Side impact test are done to know how much the driver or any other passenger are safe during an accident. In FSAE also the side impact structures are important to make sure safety of driver.

Deformation: -

Case 1.1 - Side Impact test at a cockpit node

As discussed above about the side impac, in this case the side impact is considered at a node of the cockpit as shown in the fog below. The load experienced at that point is far more and crucial.

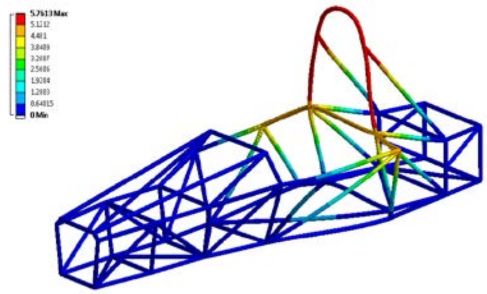

Fig 4. (a) Isometric view

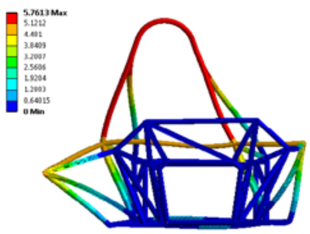

Fig 4. (b) Front view

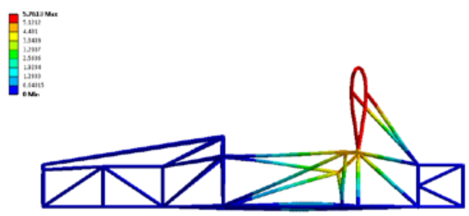

Fig 4. (c) Side View

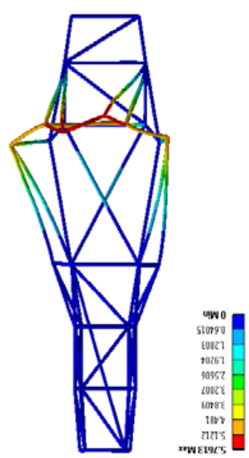

Fig 4. (d) Top View

Case 1.2: - When Side impact is at whole plane of structure

In this case it is assumed that the whole side impact structure takes the load during an accident. So, the whole force of the impact is taken by the whole area and it is divided to the others adjoining members.

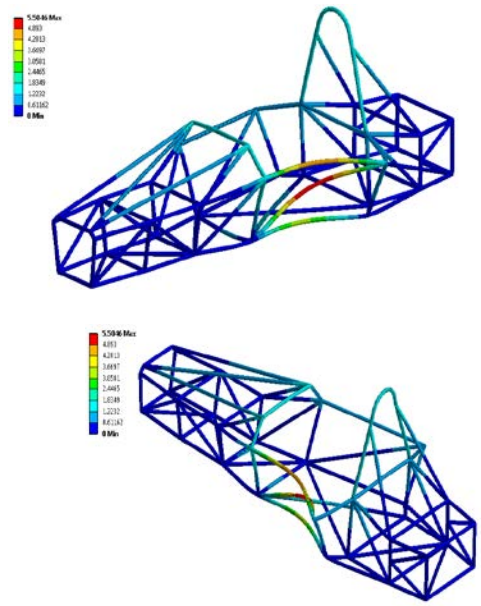

Fig 5. (a) isometric views

The results presented above are for a scenario where the side impact occurs at the common nodejoint, and that results in stresses over 360 MPa. If the side impact forces are distributed over the side member, means the whole side impact structure take the whole impact then the peak stresses are around 312 MPa, this scenario was analysed and the direct and bending stress results are presented below.

Case 2: - Front Impact

Front Impact is the necessary test to be done due to utmost importance, as 46% of the total accidents are front impact and has most influence on the vehicle so test are done to check the safety of the chassis. For this purpose a full area frontal impact test is conducted assuming a suitable ground clearance.

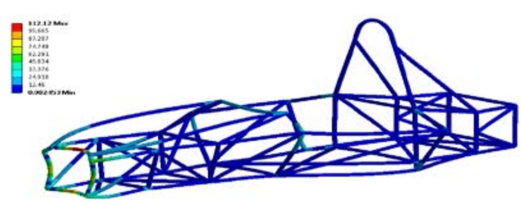

Fig 7. (a) Bending Stress

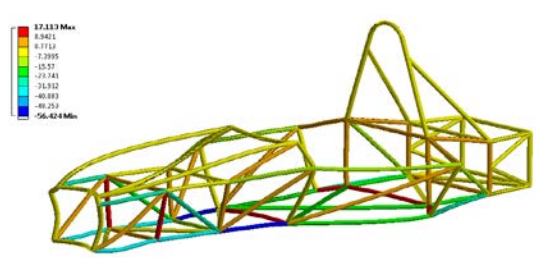

Fig 7. (b) Direct Stress

The results presented above for front impact are for a scenario where the front wheels are not in contact with the ground and the vehicle front structure is allowed to deflect upwards due to the impact, as shown in the deformation plots. In such scenario which is the general case, the stresses are around 435 MPa which is not safe. However, if an assumption is made where during the front impact, if the front tires are on the ground and the upward deflection of the front portion of the vehicle is prevented by some control techniques, then the peak stresses are around 112 Mpa, this scenario was analyses and the direct

Case 3: - Rear Impact

Rear impact is accident caused at when there is traffic, wherein a vehicle crashes into the vehicle in front of it. This is impact happens on rare occasions but when it does happen it may cause a lot of harm.

Case 3.1: - Nose dip

When there is hard breaking the Nose of the chassis is dip and there is a small lift at the rear.

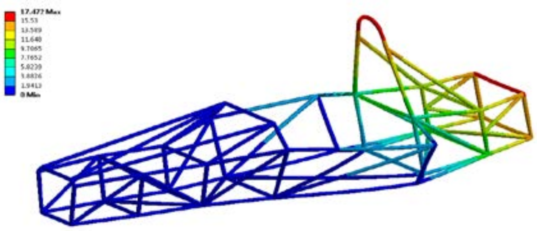

Fig 8. (a) Isometric Rear Impact

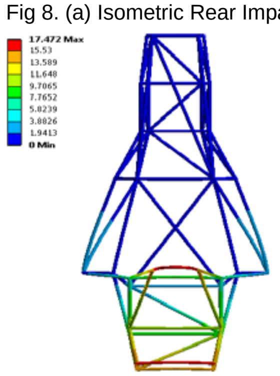

Fig 8. (b) Top View

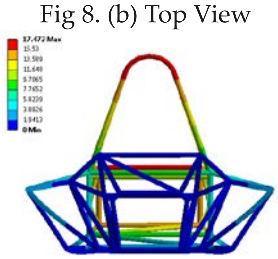

Fig 8. (c) Front View

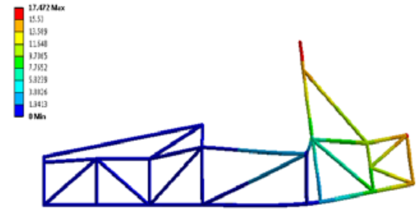

Fig 8. (d) Side View

The results presented above for rear impact are for a scenario where the rear wheels are not in contact with the ground and the vehicle rear structure is allowed to deflect upwards due to the impact, as shown in the deformation plots. In such scenario which is the general case, the stresses are around 421 MPa which is not safe. However, if an assumption is made where during the rear impact, if the rear tires are on the ground and the upward deflection of the rear portion of the vehicle is prevented by some control techniques, then the peak stresses are around 152 MPa, this scenario was analysed and the direct and bending stress results are presented below.

Case 3.2: - No Nose Dip

In this condition there is some things provided which avoid the chances of nose dip during the sudden braking.

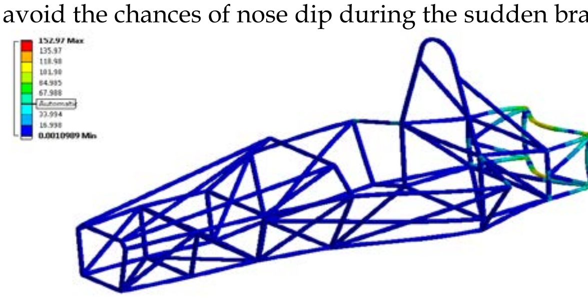

Fig 9. (a) Bending Stress

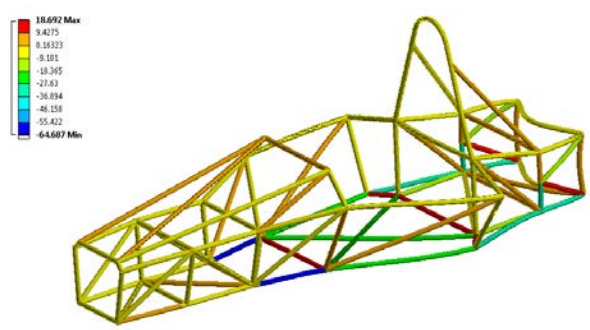

Fig 9. (b) Direct Stress

Case 4. Acceleration

This test is done at the force of 4G and the results are shown below.

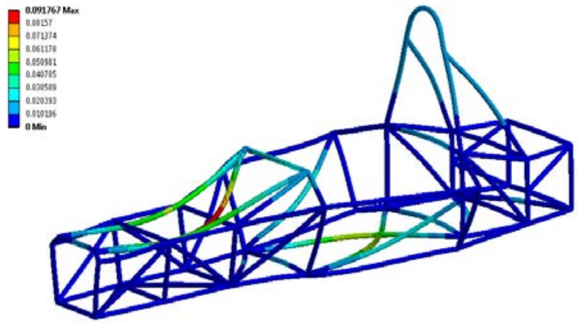

Fig 10. (a) Isometric view

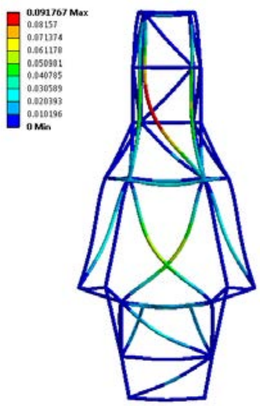

Fig10. (a) Top View

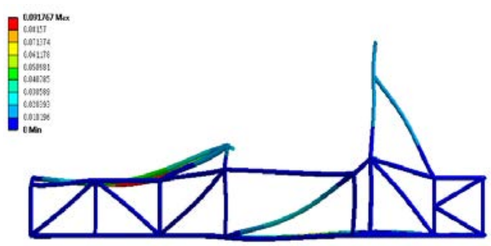

Fig 10. (c) Side View

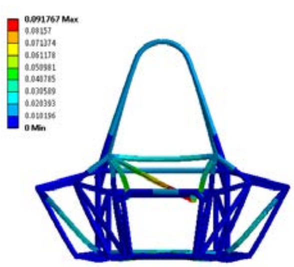

Fig 10. (d) Front View

6 CONCLUSION

A chassis consists of an internal vehicle frame that supports an artificial object in its construction and use, can also provide protection for some internal parts. In this work Structural frame of chassis is first designed on solid works software and also structural Analysis are used. After designing this structural chassis, it is tested and analyzed for different fatigue, static and dynamic loads which is done on ANSYS Software to obtain proper chassis design with minimum deflection for failure. For fabrication of chassis selection of material is also an important criterion due to fact of sustaining loads and forces, and resist any deformation. Any deflection or deformation may be averted by the use of structural support which may provide rigidity and stiffness to the chassis and also may help in terms of reliability and endurance strength. The overall need is to create a light, stiff, rigid and safe chassis to fulfill its given purpose.

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