© May 2024 | IJIRT | Volume 10 Issue 12 | ISSN: 2349-6002

Design And Analysis of Supra-Sae Chassis Student Version (Design Methodology)

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Abstract— Chassis is a major part of any automotive design. It is responsible for supporting all functional systems of a vehicle and accommodates the driver in the cockpit. Designing a chassis for driver's safety is always been a concern, especially for a race car. In this report, few techniques are mentioned on how to analyse a formula student race car chassis to ensure its structural stability for the driver's safety.

I. INTRODUCTION

Our project is about the design & analysis of supra-sae student version. In this we are going to design the body and all the parts in the supra vehicle to analyse the proper functiong and strength of the vehicle. The design of the supra SAE student version represents an exciting blend of innovation and engineering prowess. This high-performance vehicle is the result of the collective creativity and expertise of budding automotive engineers, showcasing cutting-edge technology and a passion for pushing the boundaries of automotive design. In this introduction, we will delve into the key features and design philosophy that make the supra SAE student version a remarkable and competitive entry in the world of student-built race cars. Although, this document discusses the design of the Supra SAE student version, with a specific emphasis on the chassis. The chassis is highlighted as a critical component of any vehicle, serving as the support system for various vehicle elements. The report addresses the challenges associated with chassis design, particularly in the context of a race car, focusing on structural stability for driver safety. It explores various materials for chassis construction, comparing factors such as density, tensile strength, and modulus of elasticity.

The problem identification and formulation section outlines key challenges, including safety, weight, cost, manufacturability, durability, and performance. The research methodology involves setting objectives, reviewing the literature, budgeting, acknowledging limitations, designing the research, and creating a prototype. The working section delves into the engine, steering, suspension, and braking system of the Formula Supra SAE, emphasizing performance enhancement. The document concludes with a list of references from various sources in the field of automotive engineering and chassis design.

II. SELECTION OF MATERIAL

There are many material available in the market for the material selection of chassis. After a certain research it was that the below listed material was ideal for chassis material, after comparing the material on different parameters it was found that AISI 4130 was found to be ideal for chassis material w.r.t comparison factor and costing.

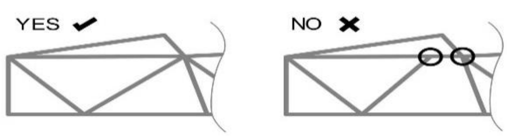
COMARISION FACTOR	AISI 4130	AISI 4140	GREY CAST IRON G1800	SAE 1018	ASMT A710
DENSITY (X1000)	7.85 Kg/M^3	7.85 Kg/M^3	7.15 Kg/M^3	7.87 Kg/M^3	7.85 Kg/M^3
TENSILE STRENGTH (U)	670 MPa	655 MPa	440 MPa	440 MPa	585 MPa
TENSILE STRENGTH (Y)	460 MPa	415 MPa	400 MPa	370 MPa	515 MPa

MODULUS OF ELASTICITY (GPa)	190-210	190-210	95-110	205	205
BULK MODULUS	140 GPa	140 GPa	90 GPa	135 GPa	160 GPa
SHEAR MODULUS	80 GPA	80 GPA	75 GPa	80 GPa	80 GPa
POISSONS RATIO	0.27-0.30	0.27-0.30	026	0.29	0.29

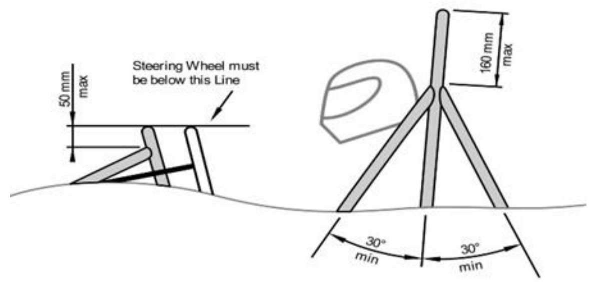
III. DESIGN METHODOLOGY

The design of the chassis is made with respect to the rules in the Supra SAE rulebook All the aspects of the piping and cockpit have been considered before designing the chassis Triangulations of the weldments have been made with proper aspects. The key aspect is the construction of a chassis design is it's the material, the better the material the best will its strength analysis and the defamation will be less.

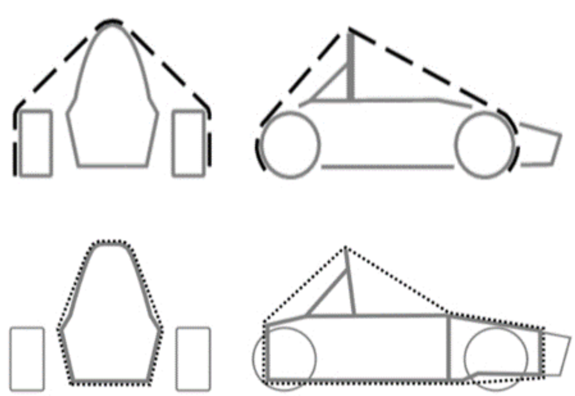
- TRIANGULATION:- An arrangement of chassis members projected onto a plane, where a co-planar load applied in any direction, at any node, results in only tensile or compressive forces in the chassis members.



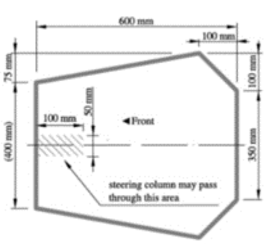
- FRONT HOOP BRACING: - The front hoop bracing attaches on each side of the front hoop as well as the structure forward of the driver's feet. A minimum of two tubes without any bends must be straight on a line in the side view of the frame and must have a minimum distance of 100 mm between each other at the front hoop. The front hoop bracing structure must be attached no lower than 50 mm below the top-most surface of the front hoop. If the front hoop is inclined more than 10° to the rear, additional braces extending rear wards are required. Composite front hoop bracing structures and their attachments cannot be counted towards the front bulkhead support structures and vice-versa for the structural equivalency documentation.

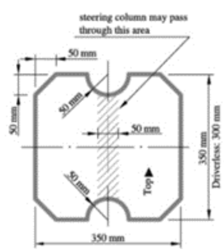


- ROLLOVER ASSURANCE ENVELOPE: - Envelope of the essential structure and any extra structures settled to the essential structure which meets the least determination characterized in.
- SIDE AFFECT STRUCTURE: - The range of the side of the chassis between the front circle and the fundamental circle and from the chassis floor to the stature as required in T3.15 over the least interior chassis point between front band and fundamental hoop.
- SURFACE ENVELOPE –The surface envelope is the surface of the union of the rollover security envelope, see T1.1.15, and the volume characterized by best of the roll bar and the exterior edges of the four tire.



- COCKPIT OPENING: - The estimate of the cockpit opening needs to be adequate for the format appeared on the cleared out in to pass vertically from the opening underneath the beat of the side effect structure when held evenly. The format may be moved fore and aft. If the side effect structure is not made of tubes, the format must pass until it is 320 mm over the most reduced interior chassis point between the front and fundamental hoop. The directing wheel, situate and all cushioning may be evacuated for the format to fit. Any other parts may as it was be expelled if they are coordinates with the directing wheel.
- COCKPIT INSIDE CROSS AREA.: - The cockpit must give a free inner cross area adequate for the format appeared on the right in, to pass from the cockpit opening to a point 100 mm rearwards of the confront of the rearmost pedal in an out of commission position. The layout may be moved up and down. Flexible pedals must be in their most forward position. The controlling wheel and any cushioning that can be evacuated without the utilize of apparatuses whereas the driver is situated may be expelled for the layout to fit. The drivers' feet and legs must be totally contained inside the essential structure when the driver is situated ordinarily and the drivers' feet are touching the pedals. In the side and front sees, any portion of the driver's feet or legs must not expand over or exterior of this structure.





IV. DESIGN OF CHASSIS

1. STEEL TUBING AND MATERIAL: - Minimum Requirements for Steel Tubing

A tube must meet all four minimum requirements for each Size specified:

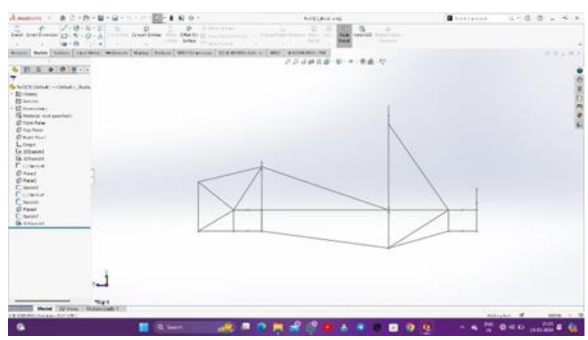
A tube must meet all four minimum requirements for each Size specified:

	Tube	Minimum Area Moment of Inertia	Minimum Cross Sectional Area	Minimum Outside Diameter or Square Width	Minimum Wall Thickness	*Example Sizes of Round Tube*
a.	Size A	11320 mm^4	173 mm^2	25.0 mm	2.0 mm	*1.0" x 0.095"* *25 x 2.5 mm*
b.	Size B	8509 mm^4	114 mm^2	25.0 mm	1.2 mm	*1.0" x 0.065"* *25.4 x 1.6 mm*
c.	Size C	6695 mm^4	91 mm^2	25.0 mm	1.2 mm	*1.0" x 0.049"* *25.4 x 1.2 mm*
d.	Size D	18015 mm^4	126 mm^2	35.0 mm	1.2 mm	*1.375" x 0.049"* *35 x 1.2 mm*

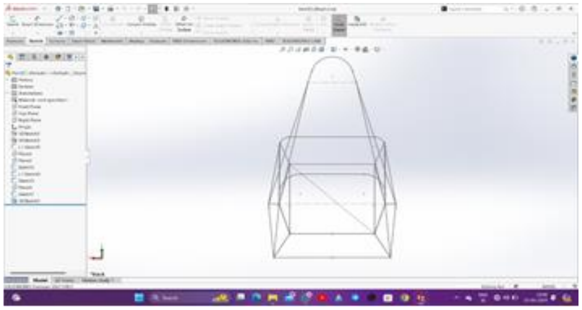
2. TUBING REQUIREMENT :- Requirement by application

	Application	Steel Tube Must Meet Size per **F.3.4**:	Alternative Tubing Material Permitted per **F.3.5** ?
a.	Front Bulkhead	Size B	Yes
b.	Front Bulkhead Support	Size C	Yes
c.	Front Hoop	Size A	Yes
d.	Front Hoop Bracing	Size B	Yes
e.	Side Impact Structure	Size B	Yes
f.	Bent Upper Side Impact Member	Size D	Yes
g.	Main Hoop	Size A	NO
h.	Main Hoop Bracing	Size B	NO
i.	Main Hoop Bracing Supports	Size C	Yes
j.	Driver Restraint Harness Attachment	Size B	Yes
k.	Shoulder Harness Mounting Bar	Size A	NO
l.	Shoulder Harness Mounting Bar Bracing	Size C	Yes
m.	Accumulator Protection Structure	Size B	Yes
n.	Component Protection	Size C	Yes
o.	Other Structural Tubing	Size C	Yes

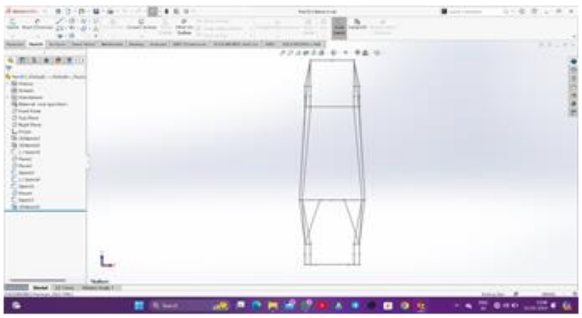
3. LINE DIAGRAM OF CHASSIS: - Below are the line diagram cad model of chassis of supra sae.



Side view of line diagram

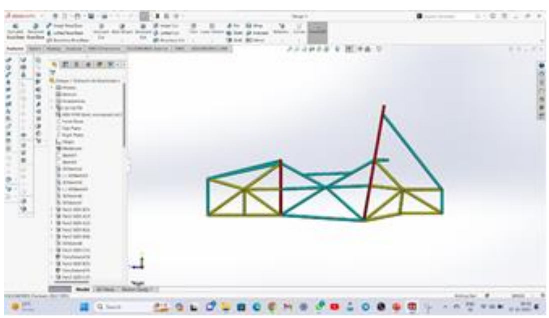


Front view of line diagram

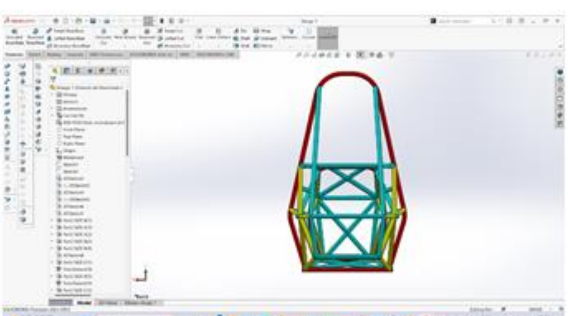


Top view of line diagram

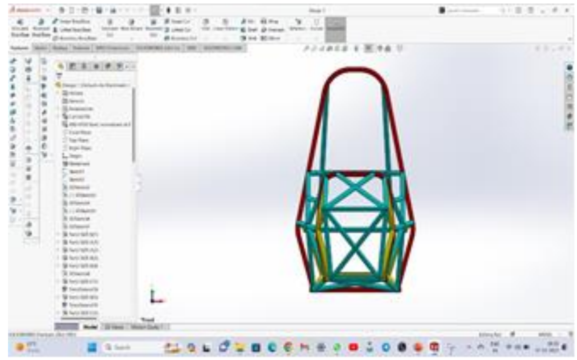
4. CAD MODEL OF CHASSIS: - The cad model of chassis is made on solidworks using the design consideration as mentioned above, different piping sizes are shown with different colours according to the tubing requirement



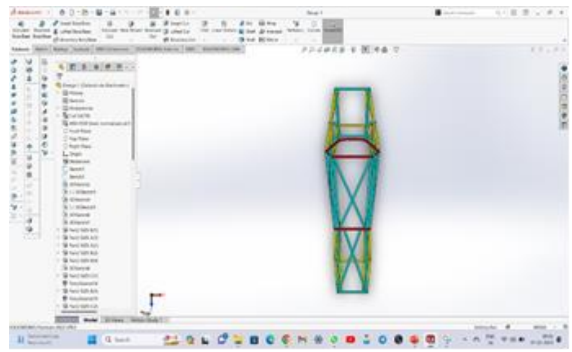
SIDE VIEW



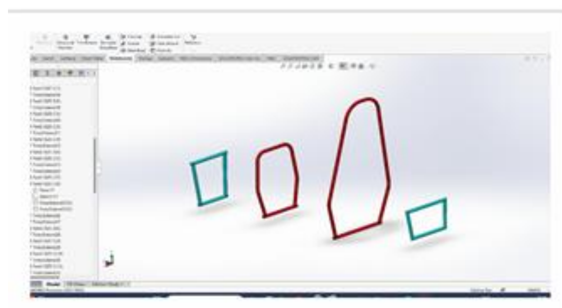
REAR VIEW



FRONT VIEW



TOP VIEW

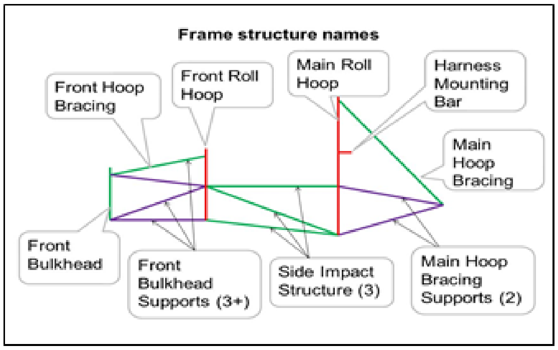


MAIN HOOPS ON WHICH BRACES AND SUPPORT MEMBERS ARE PROVIDED

V. NOMENCLATURE OF CHASSIS

Primary Structure:

- Front Bulkhead
- Front Bulkhead Support
- Main Roll Hoop
- Front Roll Hoop
- Side Impact Structure
- Roll Hoop Bracings.



VI. RESEARCH METHODOLOGY

To conduct A research methodology for formula SAE, India, we followed the below step.

i) *Research objective*: To build a whole new chassis that is air resistant, driver comfortable and performance based.

ii) *Literature review*: Many literature reviews were studies for proper design and analysis.

iii)*Budget*: Proper budget was made so that the vehicle was not so expensive.

iv) *Limitations*: The chassis need to be made within limited resources and time constraint.

v) *Research design*: Many designs and rule book of formula supra sae was studies carefully for proper output of the design and proper quality chassis was designed.

vi) *Prototype*: Prototype of the model was made so that it could be made into existence.

VII. ANALYSIS OF CHASSIS

FRONTAL IMPACT: - In Front Impact the vehicle's front portion may collide with any object. Assuming the impact velocity as 70KMPH and time taken during impact is 0.2sec. The maximum force acting on the chassis during frontal impact is calculated below. (ASSUMPTION MASS OF VEHICLE AS 230 KG)

calculation:

velocity = distance/ time

therefore, distance = velocity X time

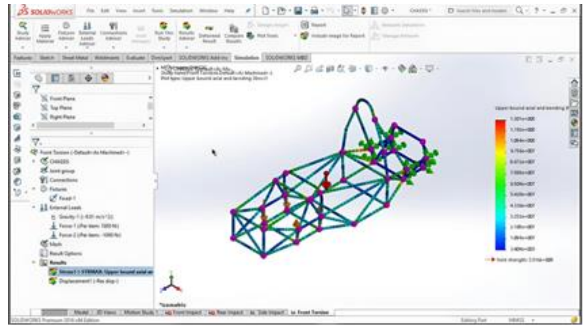
distance = 19.4 X 0.2

D = 3.88m

Force = (0.5 x m x v2)/D

= (0.5 X 230 x 19.42)/3.88

F = 11155 N



FRONT IMPACT ANALYSIS

Side Impact: Side Impact is possible in many ways. One of the assumption is:- Assuming the velocity of vehical at impact as 40KMph and impact time as 0.3 sec.

calculations :

velocity = distance/ time

therefore, distance = velocity X time

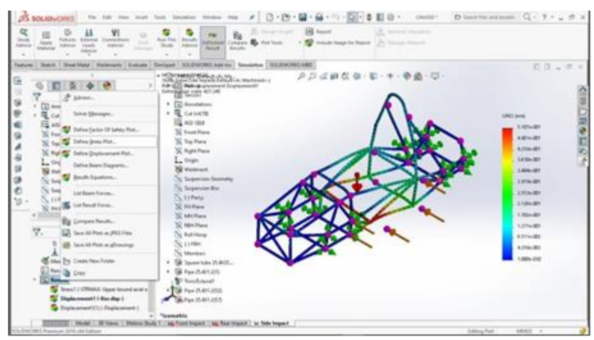
distance = 11.11 X 0.3

D = 3.33m

Force = (0.5 x m x v2)/D

= (0.5 X 230 x 11.112)/3.33

F = 4262.67 N



SIDE IMPACT ANALYSIS

Rear Impact: In case of Rear Impact it involves a theory of relative velocity in which a vehicle from behind can get in accident with the frontal vehicle. Assuming the velocity of our vehicle 40KMph and following vehicle as 70KMPH impact time as 0.1 sec.

calculations:

relative velocity = 70 - 40 KMPH = 30 KMPH

velocity = distance/ time

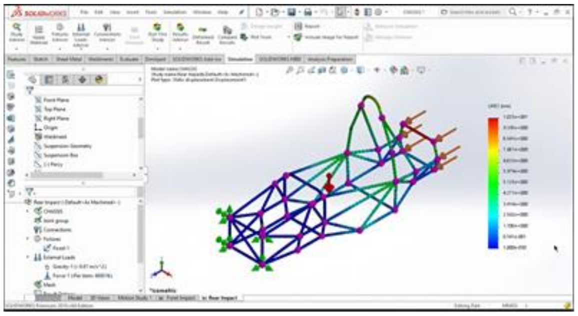
therefore, distance = velocity X time

distance = 8.33 X 0.1

D = 0.833m

Force = (0.5 x m x v2)/D

= (0.5 X 230 x 8.332)/0.833
F = 9579.5 N



REAR IMPACT ANALYSIS

VIII. WORKING

1. ENGINE The equation supra sae works on the 4-Stroke engine. The motor mounted will be 390cc KTM DUKE motor which is most capable in this extend. Assist tunning will be done in the motor and sensors, which will encourage upgrade control yield. A information comparison sheet will be made comparing the information some time recently and after tunning the engine.
2. STEERING Ackerman controlling framework will be utilized in the equation car will direct the way of the vehicle agreeing to the driver require or race track. The issue of wheels requiring to follow out circles with diverse radii on the interior and exterior of a turn driven to the advancement of the Ackermann controlling geometry, a geometric plan of associations in the directing of an vehicle or other vehicle. The Ackermann controlling geometry that all automobiles utilize anticipates the legitimate turning point of the directing wheel from being delivered when exploring a twist or a bend.
3. SUSPENSION: - All of the components in a street car's suspension are too show in a Equation One vehicle. These parts incorporate arms, anti-sway bars, dampers, springs, and dampers. Tall loads must be backed by the suspension. The suspension of an F1 car must be tough and unbending to oversee the weights set on it whereas it voyages through a bend at tall speeds without being harmed. Suspension's essential work is to connect a car to its wheel. Since moving a overwhelming requires a modern framework with numerous parts, this is not necessary
4. BRAKING SYSTEM: - Disk Brake: One of a Equation One car's most grounded focuses is its braking framework. Equation 1 cars utilize composite brake circles that incorporate carbon fiber support. When the brakes are warmed up, the coefficient of contact between the cushions and the circles might reach 0.6. At these tall temperatures, steel brake plates would have a higher rate of wear.

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