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Design and Structural Analysis of a Go-Kart Vehicle Chassis

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Abstract:

A go-kart as known is a single seated simple car like vehicle. Its size is a big factor, but one major aspect of a kart is its complete lack of a traditional suspension. Here the axle is firmly affixed to the frame, there is no differential (both rear tires turn at the same speed), and while things like camber and caster may be adjustable, there are no dampers or springs. Both camber and caster angles are included in the chassis design. To validate our design we have performed various crash tests to find when our model fails for a given chassis material and pipe thickness. A study has been made to optimize weight to strength ratio of the chassis. A slight variation may lead to problems and failure of the design. Our main aim is to maintain good ergonomics and safety.

Key words: ***Go-Kart, chassis, Structural Analysis, Loading, Deformation.***

Table.1: Proposed vehicle dimensional specifications:

DIMENSIONS	FRONT	REAR
Overall length	1802mm	NA
Overall width	1371mm	NA
Overall height	637mm	NA
Wheel base	1359.35mm	NA
Track width	1052.52mm	1060.34mm

Overall weight of the vehicle (including driver weight of kg)	190 kg

Table.2: Technical Specifications of Chassis:

Material of main frame	Mild Steel(Automobile grade)
Thickness	2mm
Poisons ratio	0.3
Young's modulus	2.1e^5 N/mm2

Other frame materials	Material
L bars	Mild Steel
Simple rectangular c/s bars	Mild Steel
Material of bumpers	Stainless Steel

Table.3: Progress of the chassis design from beginning to end:

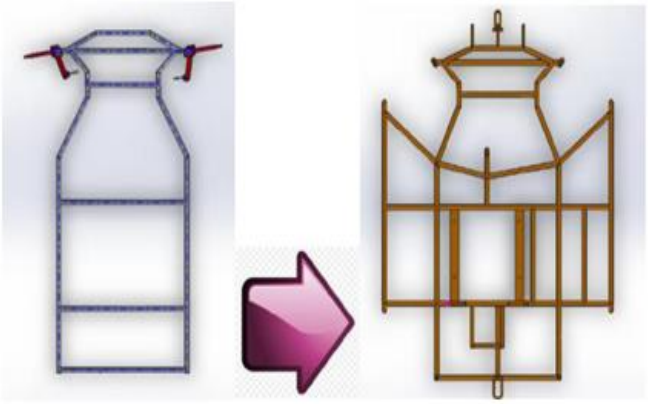

Fig.1: Progress achieved from beginning to end

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Design of Chassis:

The entire design and analysis was done using Solid Works 2012 developed by Dassault Systems[9-10] which is Engineering Design software. The design of the complete vehicle chassis is shown below.

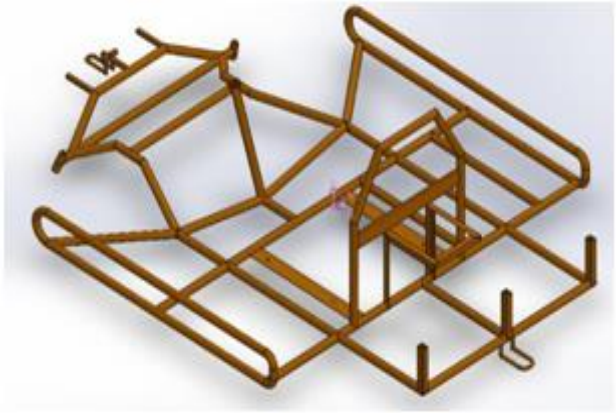

Fig.2: Complete Chassis model

Table.4: Various parameters of our chassis are as shown:

Mass of the chassis	24.5 kg
Position of center of gravity of chassis alone(shown in above fig)	X = 558.31mm Y = 73.15mm Z = 3.19 mm

Structural Analysis of Chassis:

Chassis will be affected by many forces while in rest and motion[3]. Various analyses were carried out on the chassis using SOLID WORKS SIMULATION EXPRESS such as static, impact, torsional and heave analysis.

Impact analysis includes:

1) Front Impact Loading
2) Back Impact Loading
3) Side Impact Loading

Torsional analysis include

1) Front torsional
2) Back torsional

Table.5: Analysis Test Results

TEST	Maximum Deflection (mm)	Maximum Stress (MPa)	FOS	Constraints	Loads
Static	2.743	140	1.57	Wheel mount points	Self-Weight+ 1250N
Front Impact	2.412	124.9	1.77	Wheel mount points	(Driver + Engine) weight +600N force on front members
Back Impact	2.207	123.7	1.78	Wheel mount points	(Driver +Engine) weight + 400N on back members
Side Impact	2.418	137.6	1.6	Wheel mount points	(Driver +Engine) Weight + 400N on side bumper members
Front torsional	2.447	124.4	1.77	Wheel mount points	(Driver +Engine) Weight + 200N on front side members
Back torsional	2.89	115.7	1.91	Wheel mount points	(Driver +Engine) weight+ 400N on Back side members
Heave Analysis	10.053	109	2.02	Jack points	Self-weight +Engine weight (450N)

*Note: In all the above types of tests meshing size is taken as very fine while conducting analysis.

In all the following figures:

 Indicates point of COG.

 Indicates Forces acting on respective members.

 Indicates Fixture points.

1. Static Loading:

Static loading is the sum of all forces acting on the vehicle when it is not moving[5]. By making the wheels as fixed points, major loads(such as engine and driver weight) are applied on chassis.

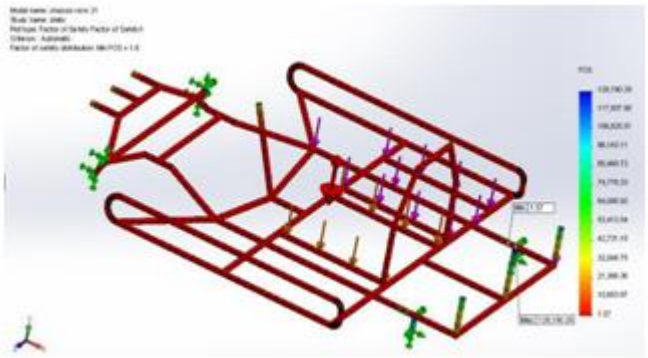

Fig.3: Static Loading (FOS)

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•Force applied on Chassis = 1250 N (80kg on driver's place + 45kg engine) +weight of chassis.
•Factor of safety was evolved as 1.57 which is well within the limits.

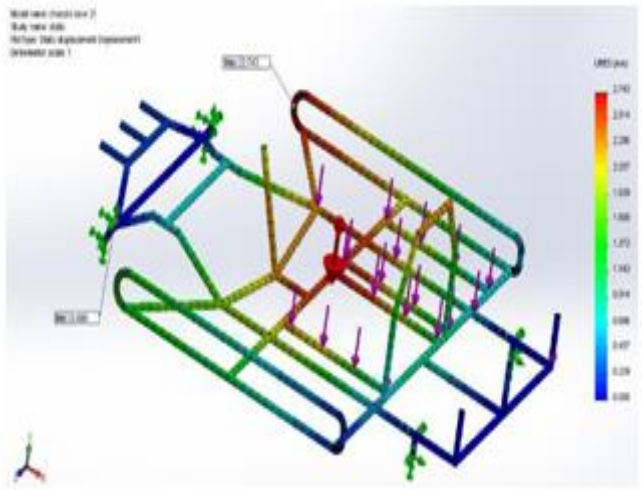

Fig.4: Static Loading (Deformation)

•Maximum deformation of 2.743 mm is occurring on side bumpers.

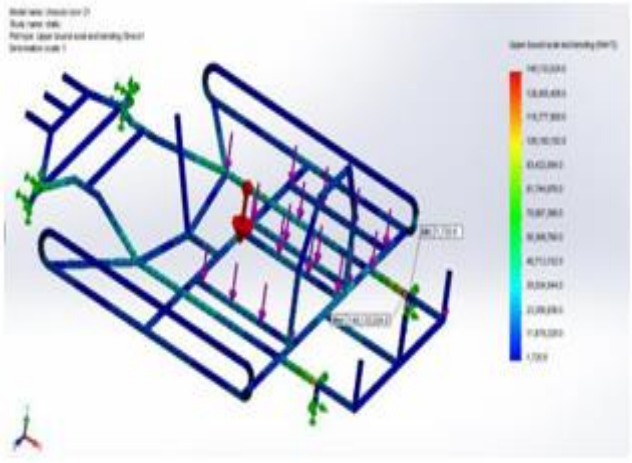

Fig.5: Static Loading(Stress Concentration)

•Maximum stress concentration of 140Mpa is taking place at right rear wheel.

2.1 Front Impact Loading:

Vehicle may hit accidentally which will impound severe impact load from front. So by neglecting chassis weight, by fixing back of the chassis, force is acted on the front end of vehicle (on front bumpers)

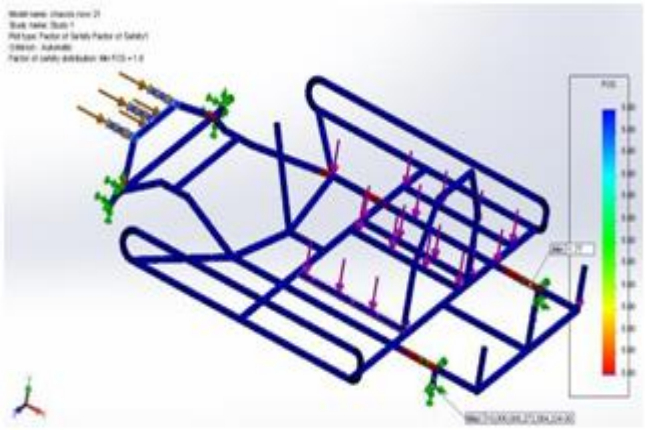

Fig.6: Front Impact Loading (FOS)

•Force applied on front end of chassis = 600 N.
•Factor of safety was evolved as 1.77

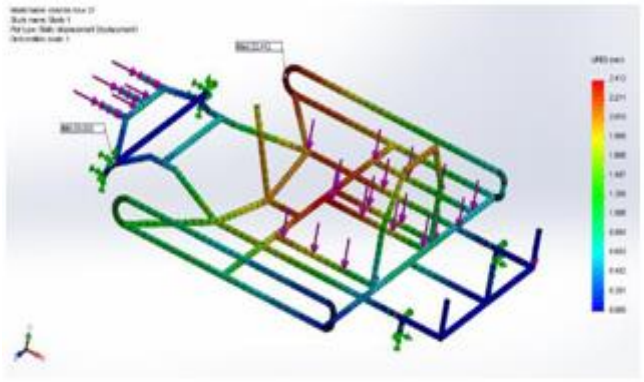

Fig.7: Front Impact Loading (Displacement)

•Maximum displacement of 2.412mm is occurring on bumpers.

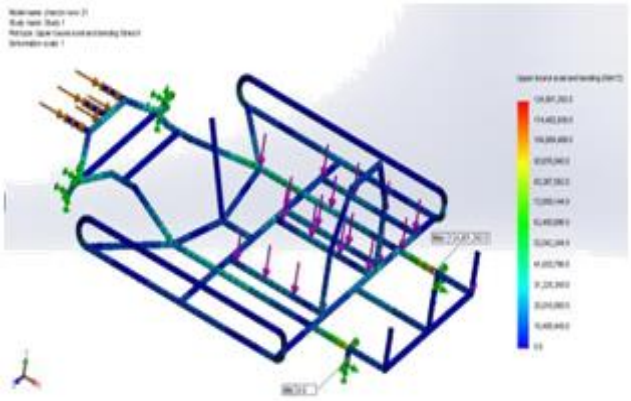

Fig.8: Front Impact Loading (Stress Concentration)

•Maximum stress concentration is 124Mpa.

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2.2 Back Impact Loading:

Here vehicle's front portion is constrained and a constant load is applied at back end of vehicle (on back bumpers).

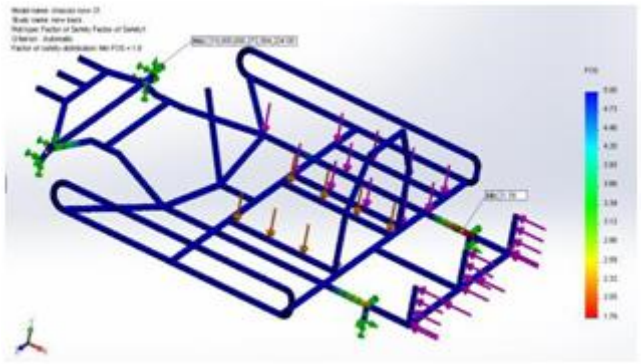

Fig.9: Back Impact Loading (FOS)

•Force applied on rear end of chassis = 400 N
•Factor of safety was evolved as 1.78

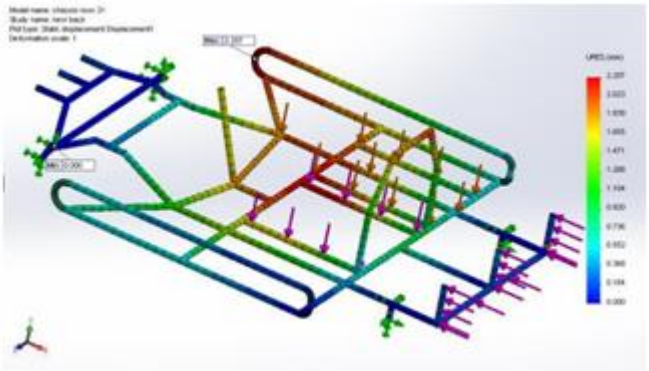

Fig.10: Back Impact Loading (Dsplacement)

•Maximum displacement value is 2.207mm.

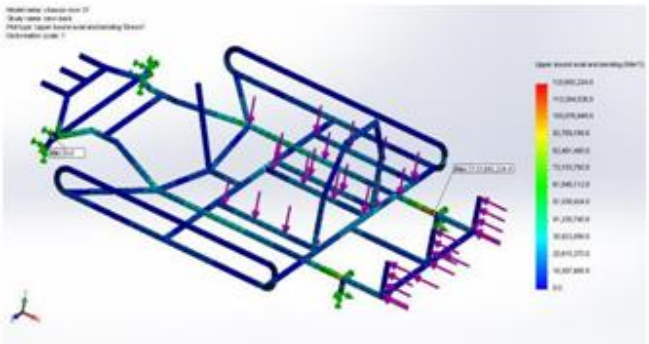

Fig.11:Back Impact Loading (Stress Concentration)

•Maximum stress concentration is 123.7Mpa.

2.3 Side Impact Loading:

Here one side of chassis end is fixed and a constant force is applied at other end.

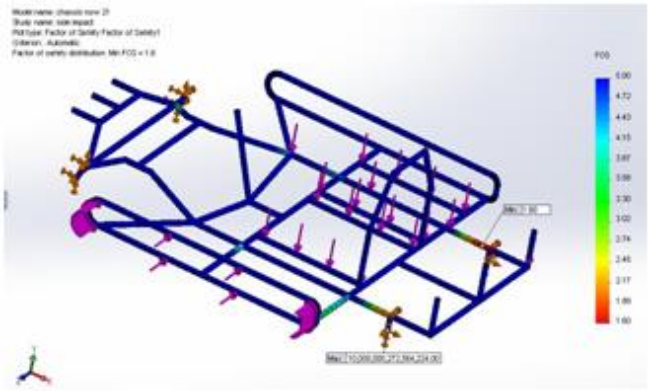

Fig.12: Side Impact Loading (FOS)

•Force applied from left side of chassis = 400 N
•Factor of safety evolved as 1.6

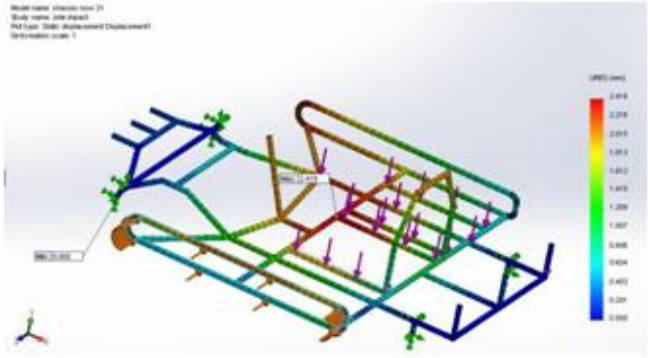

Fig.13: Side Impact Loading (Displacement)

•Maximum displacement is 2.42mm.

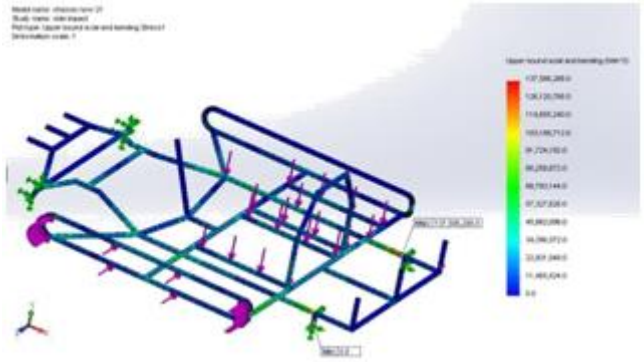

Fig.14: Side Impact Loading (Stress Concentration)

•Maximum stress concentration is 137.6Mpa.

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3.1 Front Torsional:

As no suspension system is provided to our vehicle, it is necessary to analyze torsional stresses acting on our vehicle since there may be small up and downs in vehicle travelling path.

Rear and front portion of our vehicle at wheel erecting points are fixed and torsional load is applied at portion of front wheels.

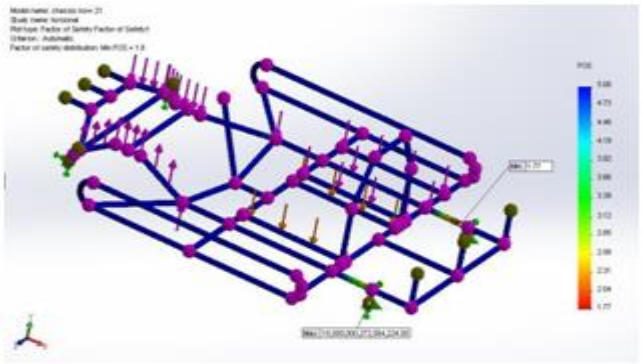

Fig.15: Front Torsional (FOS)

•Torsional force applied = 200N(up+down)

•Factor of safety evolved as 1.77

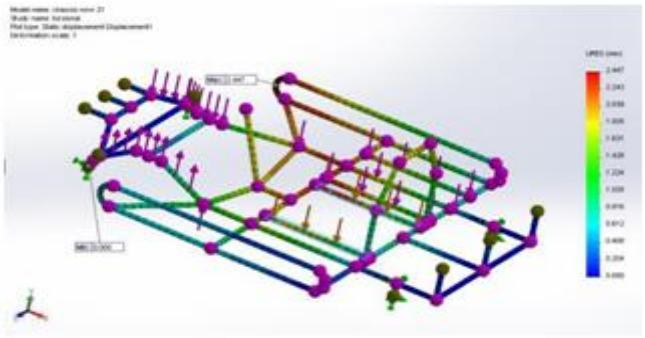

Fig.16: Front Torsional (Displacement)

•Maximum displacement is 2.45mm.

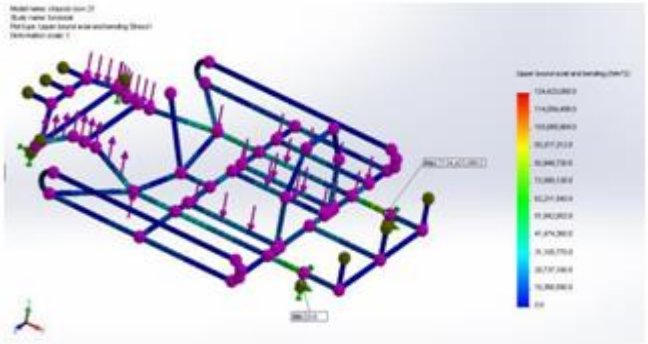

Fig.17: Front Torsional (Stress Concentration)

•Maximum stress concentration is 124.4Mpa.

3.2 Back Torsional:

Here front and rear portion of chassis was fixed and a constant torsional load is applied at rear end position of chassis near back axle.

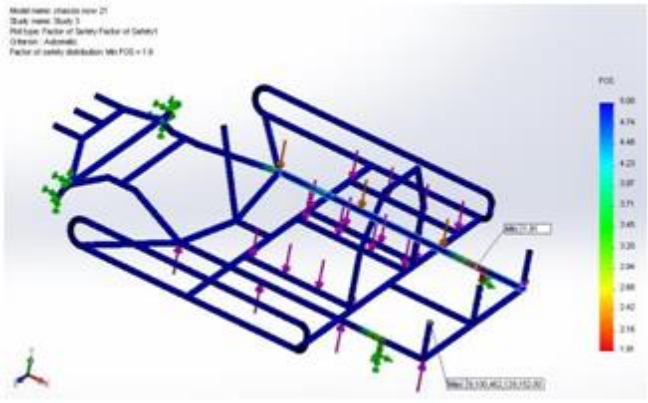

Fig.18: Back Torsional (FOS)

•Torsional force applied at back portion of chassis = 400 N.

•Factor of safety evolved as 1.91

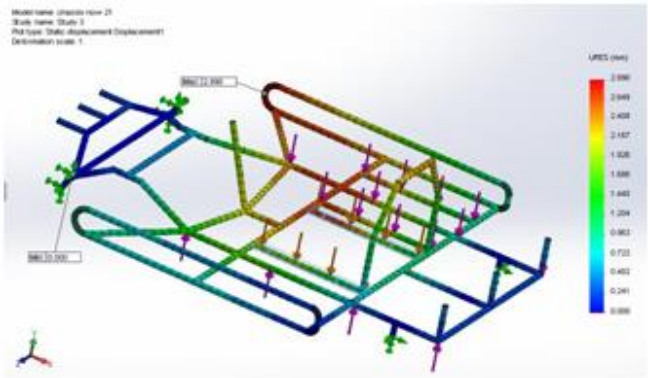

Fig.19: Back Torsional (Displacement)

•Maximum displacement is 2.89mm.

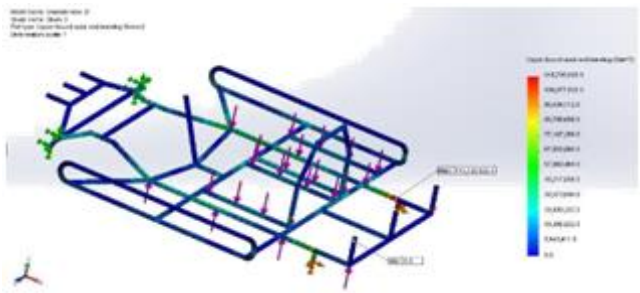

Fig.20: Back Torsional (Stress Concentration)

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•Maximum stress concentration factor is 115.7Mpa.

4 Heave Analyses:

Heave analysis was done to validate the rigidity of the frame when lifted by a jack. Jack points were constrained and static load is applied.

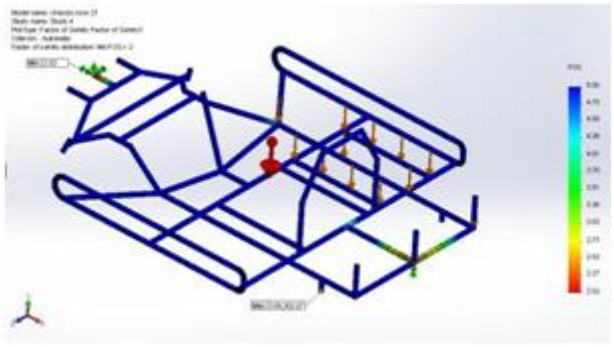

Fig.21: Heave Analysis (FOS)

•Chassis and engine weight are applied. Static engine force = 450N
•Factor of safety is 2.

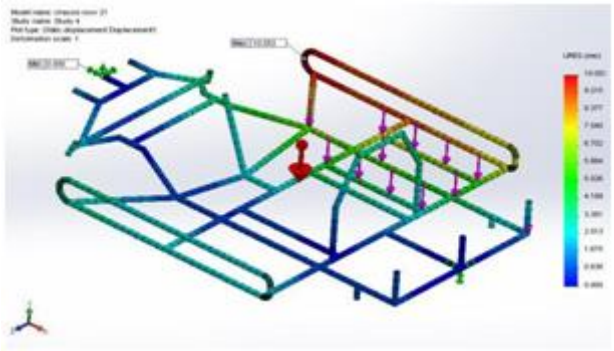

Fig.22: Heave Analysis (Displacement)

•Maximum displacement is 10mm on bumpers. Since bumpers are free cantilever members displacement of 10 mm doesn't make any difference on the strength of chassis.

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