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DESIGN AND ANALYSIS OF GO KART CHASSIS

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Abstract: **Now days as we are moving towards the development, we have to improve our technology. One of the big step towards the technological improvement is in automotive sector .This is possible by creativity and innovation of young automobile enthusiasts.**

The National Go Kart Racing is the one of the way which provide the platform for doing innovations and showing creativity for students. The Go-kart, by definition, has no suspension and no differential. They are usually raced on scaled down tracks, but are sometimes driven as entertainment or as a hobby by non-professionals. [1]

This paper deals with the Design and Analysis of Roll Cage for the Go Kart. In a Go Kart Student Car the roll cage is one of the main components. It form the structure or the main frame of the vehicle on which other parts like Engine, Steering, and Transmission are mounted. We have made the 3D model of Go Kart and Roll Cage in Catia-V5.

Roll Cage comes under the sprung mass of the Vehicle. There are a lot of forces acting on vehicle in the running condition. These forces are responsible for causing crack initiation and deformation in the vehicle. Deformation results in Stress Generation in the Roll Cage. Hence it is important to find out these areas of maximum Stresses. In this paper an attempt is made to find out these areas by carrying out FEA of the Roll Cage. We have carried out Crash Analysis (Front and Side Impact), Torsional Analysis.. All these Analysis have been carried out in Hyper Works 11.0. The design procedure follows all the rules laid down by NKRC Rule Book for Go Kart Type Cars. [2]

Keywords: **Go Kart, Roll Cage, Material, Model, Catia-V5, Finite Element Analysis, Hyper works.**

1. INTRODUCTION

There are many motor sports in the world. Bikes, Cars, Formula one are examples of them. The drivers in these are very professionals and accurate. They can drive it very fast. But there are also motor sports which do not need professional drivers and need no great speed. The vehicles used are also very cheap. Such a motor sport is Go-karting. They resemble to the formula one cars but it is not as faster as Fl and also cost is very less. The drivers in go-karting are also not professionals. Even children can also drive It. Go-karts have 4 wheels and a small engine. They are widely used in racing in US and also they are getting popular in India. [1]. The Go-kart is a vehicle which is compact, simple, lightweight and easy to operate. The go-kart is designed for flat track racing so, its ground clearance is very small as compare to other vehicle hence it skips the suspension. [3]

In this Era the automobile industry has changes drastically so the importance of safer vehicle increased day by day. This paper deals with design of chassis frame for Go Kart and Various loading tests like Front Impact, Rear Impact & Side Impact test have been conducted on the roll cage. Roll Cage can be called as skeleton of a vehicle Chassis usually refers to the lower body of the vehicle including the tires, engine, frame, driveline and suspension. Out of these, the frame provides necessary support to the vehicle components placed on it.

Also the frame should be strong enough to withstand shocks, twists, vibrations and other stresses. The roll cage design is tested against all modes of failure by conducting various simulation and stress analysis with aid of hyper works Software while doing so, the main focus remained on considering mass of every component including driver, effect due to gravity. [4] Moreover, the roll cage is made by welding pipes together. First a proper design of the frame or the roll cage is carried out. The pipes are cut in the required lengths. If required, bending of the pipes are also done. Then notching is done of these pipes. These pipes are then joined or connected by welding them together. [2]

2. OBJECTIVES

The objectives of paper are as follows:

1. The selection of material for chassis.

2. To construct the appropriate chassis for go-kart.

3. To determine the maximum stress concentration areas. [3]

3. SCOPE OF THE PROJECT

Go-karting is a big craze to the Americans and Europeans. It is initially created in United States in 1950s and used as a way to pass spare time. Gradually it became a big hobby and other countries followed it.

In India go-karting is getting ready to make waves. A racing track is ready in Nagpur for go-karting. Indian companies are also producing go-karts in small scale. MRF and Indus motors are the major bodies in karts and they are offering karts between 1 lakh and 3 lakh. But to make go-karts popular, the price must come down.

For that, many people are trying to build one under 1 lakh and we had also take up the challenge and make our under 70 K. This is to dream come true. A go-kart just under Rs. 70,000/-. So we are sure that our project will have to high demand in the industry and also we are hoping to get orders from the racing guns. [1]

2.1 Model of Go Kart in CATIA V-5 Software

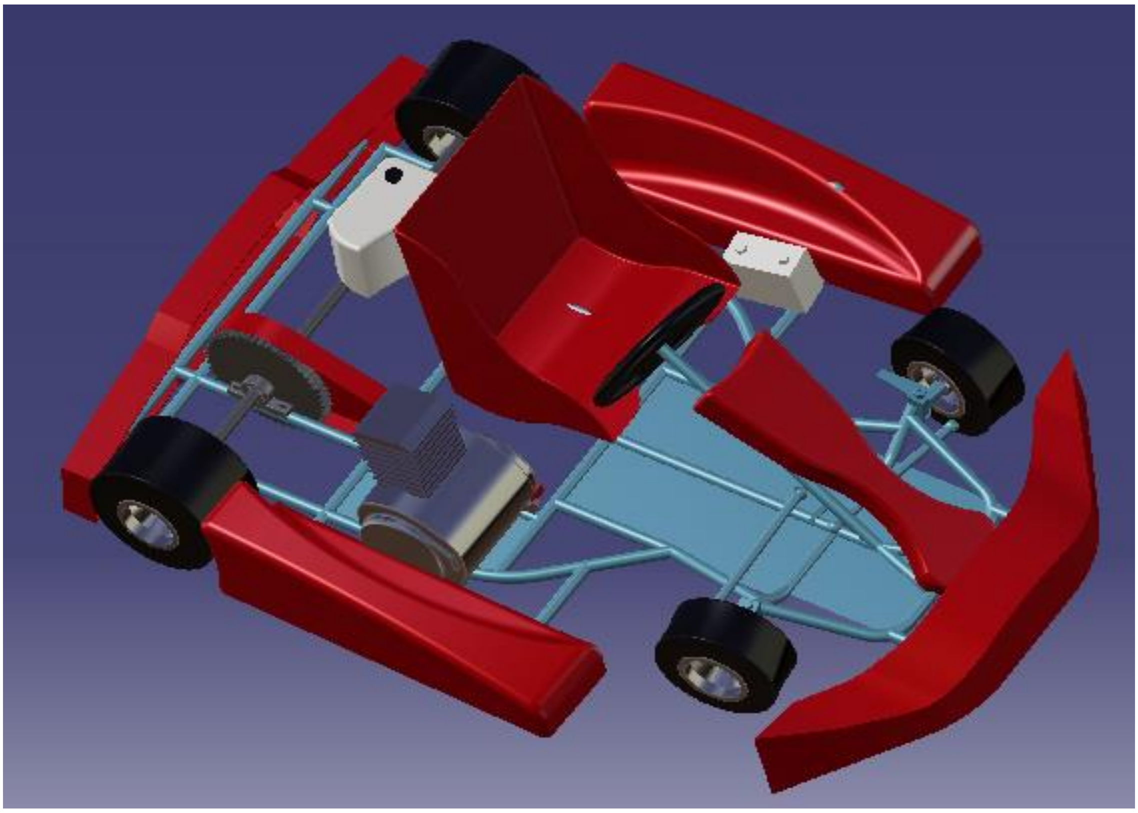

FIG NO-1 Model of Go Kart

4. ABOUT GO -KARTS

Go-kart is a simple four-wheeled, small engine, single sealed racing car used mainly in United States. They were initially created in the 1950s.Post-war period by airmen as a way to pass spare time. Art Ingels is generally accepted to be the father of karting. He built the first kart in Southern California in 1956. From them, it is being popular all over America and also Europe.

A Go-kart, by definition, has no suspension and no differential. They are usually raced on scaled down tracks, but are sometimes driven as entertainment or as a hobby by non-professionals. 'Carting is commonly perceived as the stepping stone to the higher and more expensive ranks of motor sports. Kart racing is generally accepted as the most economic form of motor sport available. As a free-time activity, it can be performed by almost anybody and permitting licensed racing for anyone from the age of 8 onwards.

Kart racing is usually used as a low-cost and relatively safe way to introduce drivers to motor racing. Many people associate it with young drivers, but adults are also very active in karting. Karting is considered as the first step in any serious racer's career. It can prepare the driver for highs-speed wheel-to-wheel racing by helping develop guide reflexes, Precision car control and decision-making skills. In addition, it brings an awareness of the various parameters that can be altered to try to improve the competitiveness of the kart that also exist in other forms of motor racing. [1]

4.1 Go-Karts In India

Go-karts emerged in India in 2003 from MRF, which has a 125cc four-stroke engine, which produce 15 bhp of power, which costs around 3 lakh. Indus motors are also offering Go-karting for 1 lakh to 3 lakh. There are racing tracks in Nagpur for go-karting, which is known as the home of go-karts in India. Many people take part in the racing and is getting popular. [1]

4.2 Go-Karts In Foreign Countries

Go-karts in foreign countries have much more performance than the Indians. One type is a single engine 160cc 4-stroke kart with a maximum speed of around 40 mph and second type, a twin-engine 320cc 4-strolce kart used in outdoor with a maximum speed of 70 mph. There are hundreds of racing traces in US for karting and also they are much more professional than the Indians. [1]

5. PARTS OF A GO –KART

In a Go-Kart, there are mainly six parts. They are

1. Chassis
2. Engine
3. Steering
4. Transmission
5. Tires
6. Brake [1]

6. DESIGN METHODOLOGY

Design of any component is consists of three major principles:

1. optimization 2.safety 3.comfort

The primary objective of the roll cage is to provide a 3-dimensional protected space around the driver that will keep the driver safe. Its secondary objectives are to provide reliable mounting locations for components, be appealing, low in cost, and low in weight. These objectives were met by choosing a roll cage material that has good strength and also weighs less giving us an advantage in weight reduction.

A low cost roll cage was provided through material selection and incorporating more continuous members with bends rather than a collection of members welded together to reduce manufacturing costs. The modeling of the roll cage structure is done by using catia v-5 software. This design is checked by Finite Element Analysis. We have focused on every point of roll cage to improve the performance of vehicle without failure of roll cage. We began the task of designing by conducting extensive research of go kart roll cage through finite element analysis. [6]

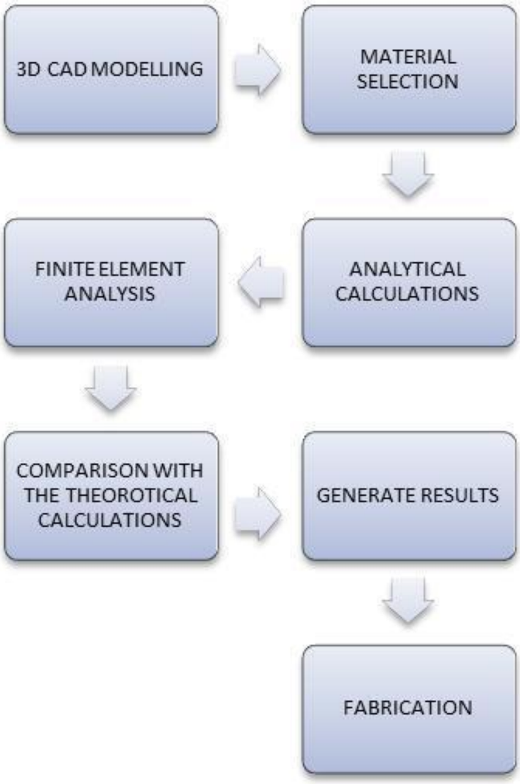

FIG NO-2 Flow Chart of Design [5]

6.1 ***Modeling:*** 3-D modeling was done using Catia v-5 software as shown in Fig.3

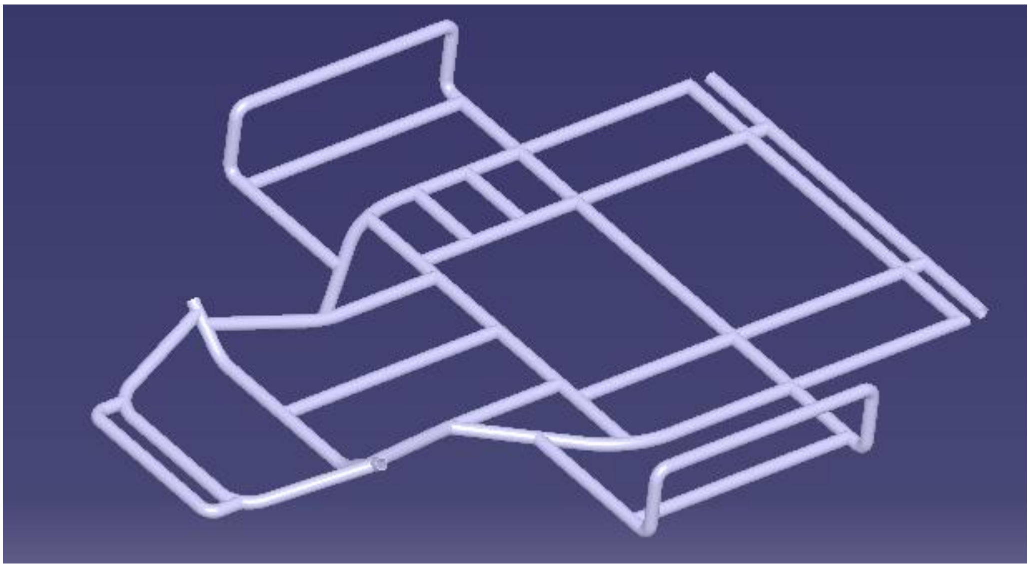

FIG NO-3 Model of Chassis

6.2 Material Selection

The selection of material was a tedious task for us as it had many constraints of weight, structural resilience towards various types of forces, torsional rigidity, factor of safety under application of various loads and also market availability with pricing and cost constraints.

The roll cage that was designed by the design team was analyzed after application of various loads as calculated by the legitimate procedures and mathematical calculations based on physical theories. The main intention behind selecting various materials and deciding on one material for the roll cage and the other parts is to get the best and safest results in case of driver's safety and real time load bearing capability. [7] The bumper provides the safety by absorbing maximum impact force and protects the chassis.

The amount of carbon in steel is important to determine the strength, hardness, and providing desired strength, endurance, safety and reliability of the vehicle. The material used for chassis are various grades of steel or aluminum alloys. The main component of steel is carbon which increases the hardness of material of chassis. Aluminum alloy is expensive than steel so mainly steel is used to constructs the chassis. [3] The chassis is made up of AISI-1018 which is a medium carbon steel. This material was selected due to its good Combination of all of the typical traits of Steel – high tensile strength, ductility, light weight, better weldability and comparative ease of machining. [5]

The properties of the material are presented in Table. 1

TABLE NO -1 Properties of Materials [7]

PROPERTIES	AISI1010	AISI1015	AISI1018	AISI1020
Density (gm/cc)	7.87	7.87	7.87	7.87
Tensile Strength (Mpa)	365	385	440	420
Yield Strength (Mpa)	305	325	370	350
Modulus Of Elasticity (Gpa)	190-210	190-210	205	205
Shear Modulus (Gpa)	80	80	80	80
Poisson Ratio	0.27-0.3	0.27-0.3	0.29	0.29
Elongation in Break (50mm)	20%	18%	15%	15%
BHN	105	111	126	121
Rockwell Hardness	60	64	71	68
Thermal Conductivity (W/mK)	49.8	51.9	51.9	51.9

6.2.1 Chassis

The chassis of go-kart is a skeleton frame made up of pipes and other materials of various cross sections. The chassis of go-kart must consist of stability, torsional rigidity, as well as it should have relatively high degree of flexibility as there is no suspension. It can also adequate strength to sustain load of operator and other accessories. The chassis is design by convenience and safety for operator. The chassis was designed for a safe ride and the load is applied on it without compromising the structural strength.

Be aware that you want a strong but light frame. We suggest 2.7mm thick tubing, either square or round (or both) depending on preference. The bending operation of the material used should be easier. By adding filler material to the notched area during welding operation strength of frame can be increase. [3] Circular cross-section is employed for the chassis development as it helps to overcome difficulties as increment in dimension, rise in the overall weight and decrease in performance due to reduction in acceleration. Circular section is always a preferred over other cross section become it resist the twisting effects. Circular section is selected for torsional rigidity. [8]

6.3. Theoretical Calculations Of Chassis

For O.D. =26.5 mm and I.D = 21 mm, thickness 2.7 mm.

Mass of chassis =22.914 kg.

Volume =0.003 mm^2

C.G. of chassis - G_x =24.308 mm, G_y = -910.497 mm, G_z =53.41mm

If consider

Chassis = 30 kg, Driver = 60 kg, Steering = 10 kg, Rear axle & brake = 30 kg, Engine = 30 kg, Fuel tank & battery =10 kg

Total weight=170 kg.

Now take total weight of vehicle=170 kg.

Front impact=170*4*9.81= 6670.80 N

$R_A + R_B - 6670.8 = 0$

$M_A = 0$

$-R_B * 381 + 6670.8 * 381/2 = 0$

$R_B = 3335.4$ N

$R_A = 3335.4$ N

$F_{BR} = 0$ N

$F_{BL} = 3335.4$ N

$F_{AR} = 3335.4 - 6670.8 = -335.4$N

$F_{AL} = 0$ N

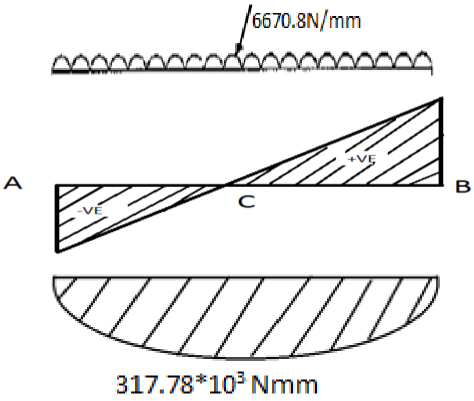

FIG NO- 4 SFD and BMD Diagram.

$M_C = 0$

$M_C = -3335*381/2+17.5*381/2*381/4=0$

$M_C = -635317.\ 5+317539.69$

$M_C = -317.78*10^3$N.mm

Now by taking σ_{yield} and calculate,

$\sigma_{yield} = 370$ N/mm^2

$\sigma_b = M * b * y / I$

$370 = (317.78*10^3 *13.25)/ (\pi/64[26.4^4 - d_i^4]$

$18.16 = 4.21*10^6 / (26.5^4 - d_i^{4)}$

$D_i = 22.61$ mm

Thickness=26.5-22.6=3.89/2=1.92 mm

Check the design for dimensions of pipes available in market that are as follows…

Now for thickness =2.7mm and d_i=21.1mm, d_o=26.5 mm

$\sigma_b = 4.21*10^6 / (\pi/64*[26.5^4 - 21.1^4])$

$\sigma_b = 4.21*10^6 / (14.48*10)$

$\sigma_b = 290.75$ N/mm^2

Working $\sigma_b < \sigma_{b\ yield.}$

FOS =370/290.75=1.27.

6.3.1 Frame Dimension

As we proceed, we keep in mind strength, aesthetics, and low manufacturing cost. The dimensions were given that they would fit well with the other components and drivers, we have provided some bends to improve aesthetics, strength and integrity of our frame members as well as decrease the manufacturing cost and time. As per the NKRC rule book we have provided the clearance of 2 inches from body. [7]

TABLE NO-2 Specifications of Chassis [9]

SR. NO.	CHASSIS MATERIAL	SPECIFICATIONS
1	Type (Seam or Seamless) & Grade	Seamless
2	OD (outer diameter)	26.5mm
3	Wall thickness	2.7mm
4	Cross section (circular, Rectangular, Square)	Circular
5	Material testing Certificate (Yes/No)	Yes

TABLE NO-3 Vehicle Dimensions [9]

SR. NO.	VEHICLE DIMENSIONS	MEASUREMENT
1	Max width of vehicle with wheels pointing forward direction	51 inches
2	Length of vehicle (front to rear bumper max extended length)	70 inches
3	Wheel base (42 inches to 56 inches)	43 inches
4	Wheel track (At least 75% of minimum wheel base)	33inches
6	Ground Clearance (Minimum 1 inch)	2 inches

TABLE NO-4 Powertrain Specifications [9]

SR. NO.	POWER TRAIN	SPECIFICATIONS
1	Engine type	Single cylinder, Gasoline (YAMAHA Gladiator)
2	Maximum Capacity	130cc
3	transmission type(Manual, CVT , Centrifugal Clutch)	Manual
4	Maximum speed	80km/hr
5	Power train guard	Provided

6.4. Finite Element Analysis (FEA)

Finite element analysis (FEA) is a computerized method for predicting how a product reacts to real-world forces, vibration, and other physical effects. Finite element analysis shows whether a product will break, wear out, or work the way it was designed. Here we divide the roll cage into small sizes known as element and collective elements on the model form a mesh.

The computer analyses the elements and shows us a collective result. The computer solves by the computational method provided. The material and structure of roll cage was finalized and then FEA was performed on it. It is tested whether the roll cage will be able to withstand torsion, impact.

The analysis was done in HyperWorks 11.0 .We choose to do 2D shell analysis as it gives appropriate result. Elements selected were 2D R-TRIAS. [2]

Following tests were performed on the roll cage. (i) Front impact (ii) Side impact (iii) Rear impact (iv)Torsion analysis

6.4.1. Front Impact Analysis

6.4.1.1 IMPACT LOAD CALCULATION: In front collision test, the go-kart collides with a stationary rigid wall and comes to rest. Using the projected vehicle/driver mass of 170 kg, the impact force was calculated based on a G-load of 4.

F = ma …. (1)

= 170*4*9.81

= 6670.8 N

Impulse time = weight*(velocity/load)… (2)

= 170*(22.22/6670.8)

= 0.57 seconds

We apply 6670.8 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. [6]

6.4.1.2 MESHING: Meshing is probably the most important part in any of the computer simulations, because it can show drastic changes in results.

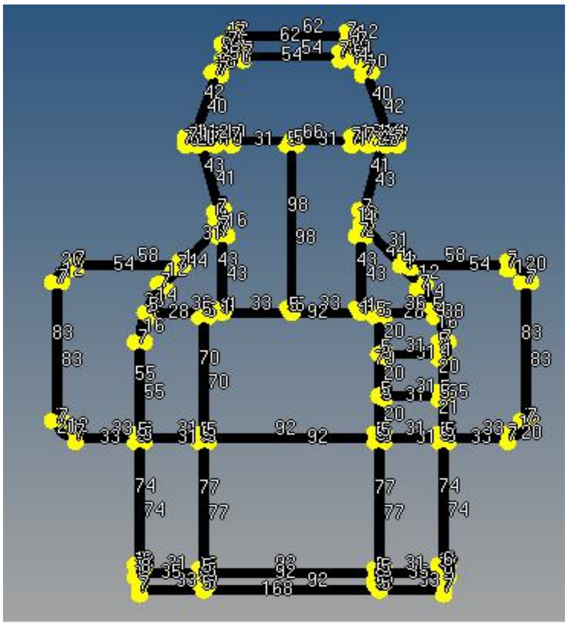

FIG NO-5 Meshing

6.4.1.3 LOADING AND CONSTRAIN: The load equal to 6670.8N is applied on front bumper and chassis is constrained at the Centre.

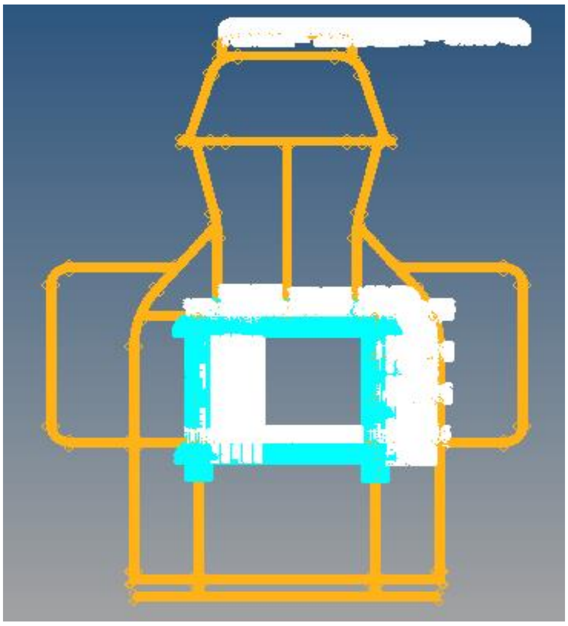

FIG NO-6 Front Loading and Constrain

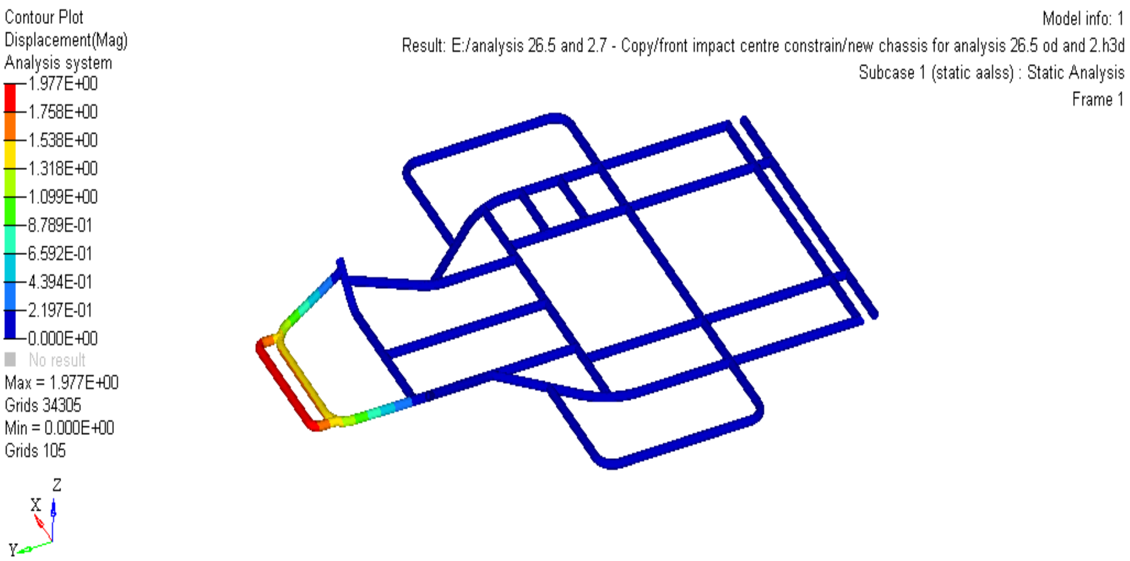

FIG NO-7 Displacement Analysis

Maximum deformation: 1.97 mm

Maximum deformation for the rear impact is also under the safe limit & not affects the safety of driver.

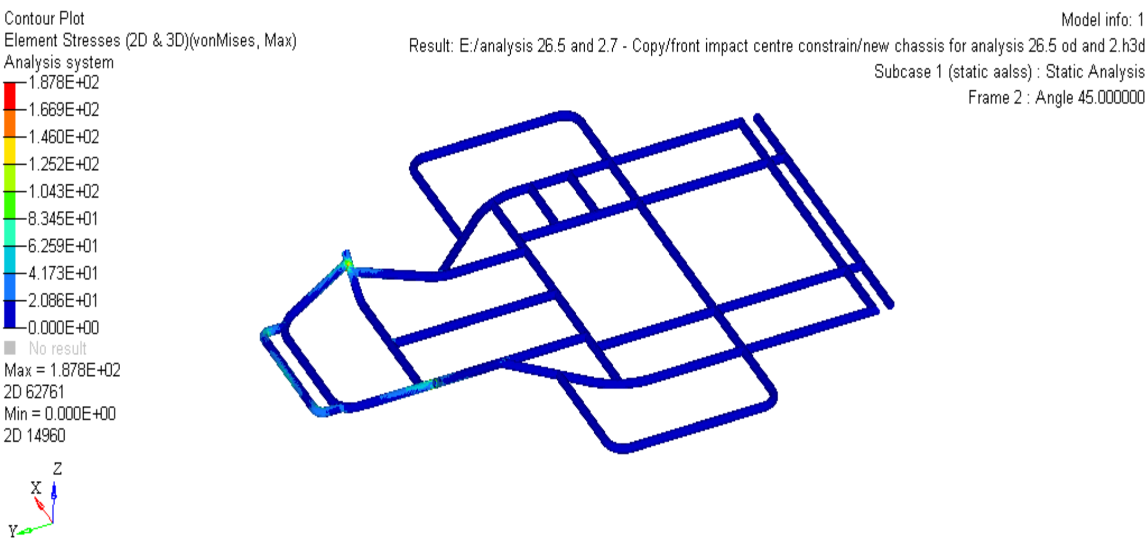

FIG NO-8 Stress Analysis

6.4.1.4 RESULTS

Maximum Stress = $1.87*10^2$ MPa

Incorporated Factor of Safety = σ_{yt}/σ_{max}… (3)

= 370/1.87*10

= 1.98

As factor of Safety greater than one that is working stress is less than yield stress of material, hence design is safe against specified stress.

6.4.2 Rear Impact Analysis

6.4.2.1 IMPACT LOAD CALCULATION: Using the projected vehicle/driver mass of 400 kg, the impact force was calculated based on a G-load of 4.

F = ma …. (1)

= 170*4*9.81

= 6670.8 N

Impulse time = weight*(velocity/load)… (2)

= 170*(22.22/6670.8)

= 0.57 seconds

We apply 6670.8 N from the front for the test of rear impact of the roll cage structure of the vehicle for determining strength at the time of rear collision. [6]

6.4.2.2 LOADING AND CONSTRAIN: The load equal to 6670.8N is applied on front bumper and chassis is constrained at the Centre.

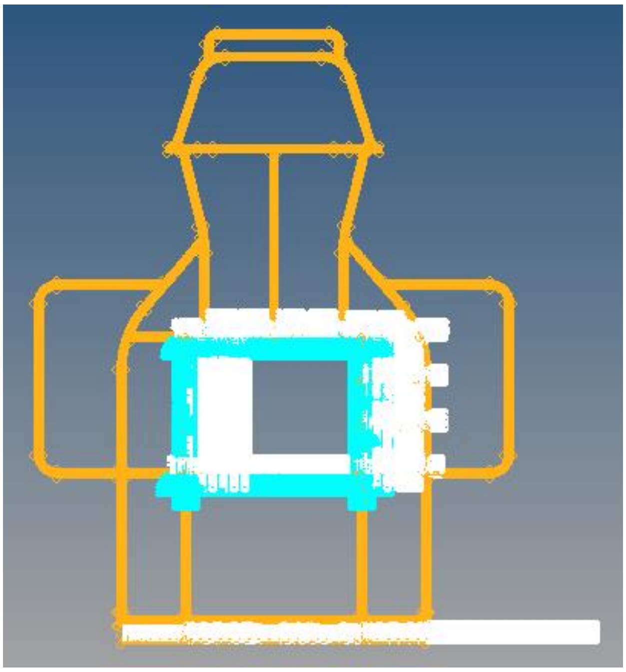

FIG NO-9 Rear Impact Loading and constrain

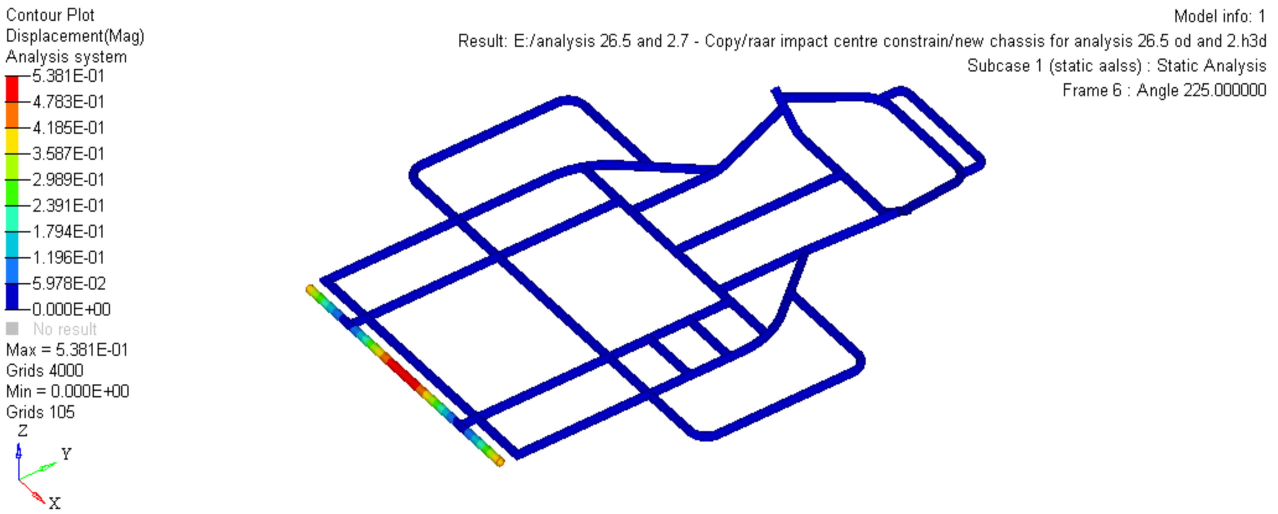

FIG NO-10 Displacement Analysis

Maximum deformation: 0.54 mm

Maximum deformation for the rear impact is also under the safe limit & not affects the safety of driver.

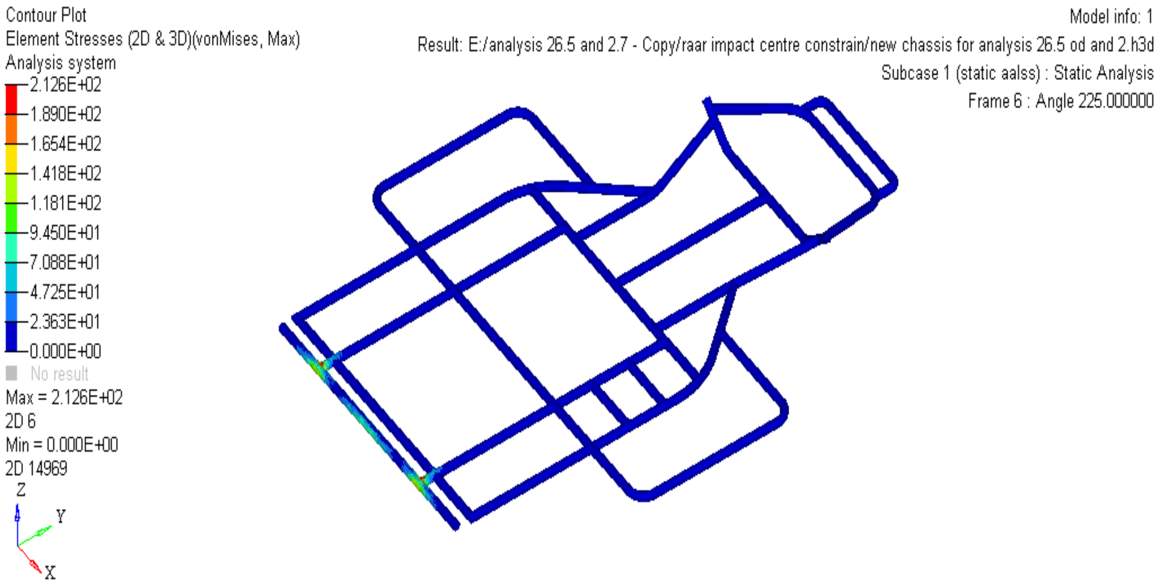

FIG NO-11 Stress Analysis

6.4.2.3 RESULTS

Maximum Stress = $2.13*10^2$ MPa

Incorporated Factor of Safety = σ_{yt}/σ_{max}… (3)

= 370/2.13*10

= 1.74

As factor of Safety greater than one that is working stress is less than yield stress of material, hence design is safe against specified stress.

6.4.3 Side Impact Analysis

6.4.3.1 IMPACT LOAD CALCULATION: Using the projected vehicle/driver mass of 400 kg, the impact force was calculated based on a G-load of 2.

F = ma

= 170*2*9.81

= 3335.4N

Impulse time = weight*(velocity/load)

= 170*(22.22/3335.4)

= 1.13seconds

We apply 3335.4 N from the side for the test of side impact of the roll cage structure of the vehicle for determining strength at the time of side collision. [6]

6.4.3.2 LOADING AND CONSTRAIN: The load equal to 3335.4N is applied on front bumper and chassis is constrained at the Centre.

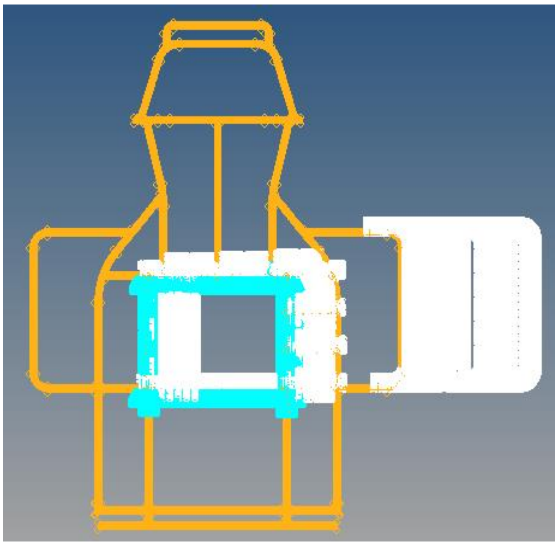

FIG NO-12 Side Impact Loading and constrain

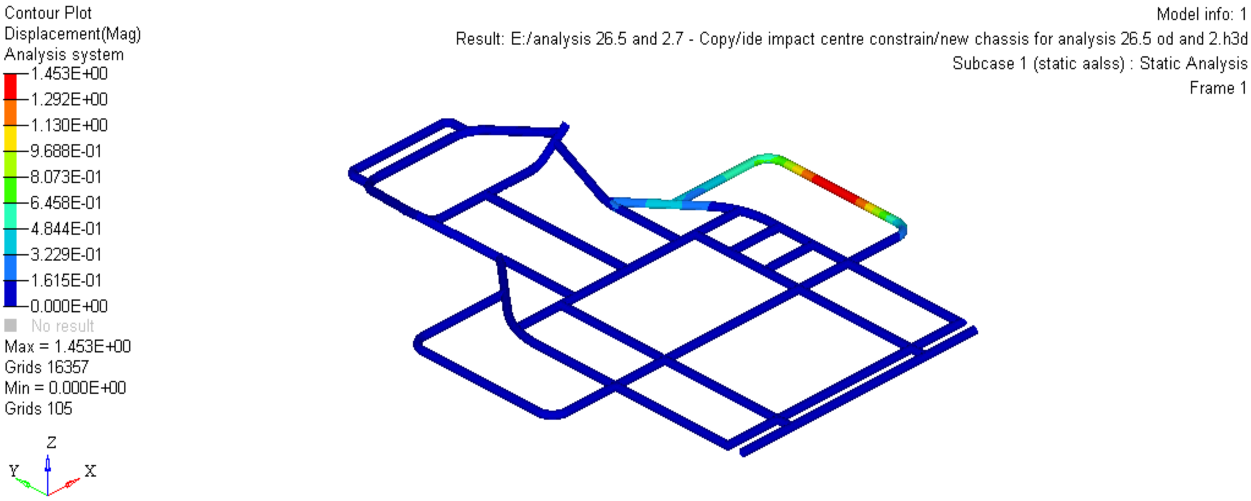

FIG NO-13 Displacement Analysis

Maximum deformation: 1.5 mm

Maximum deformation for the side impact is also under the safe limit & not affects the safety of driver.

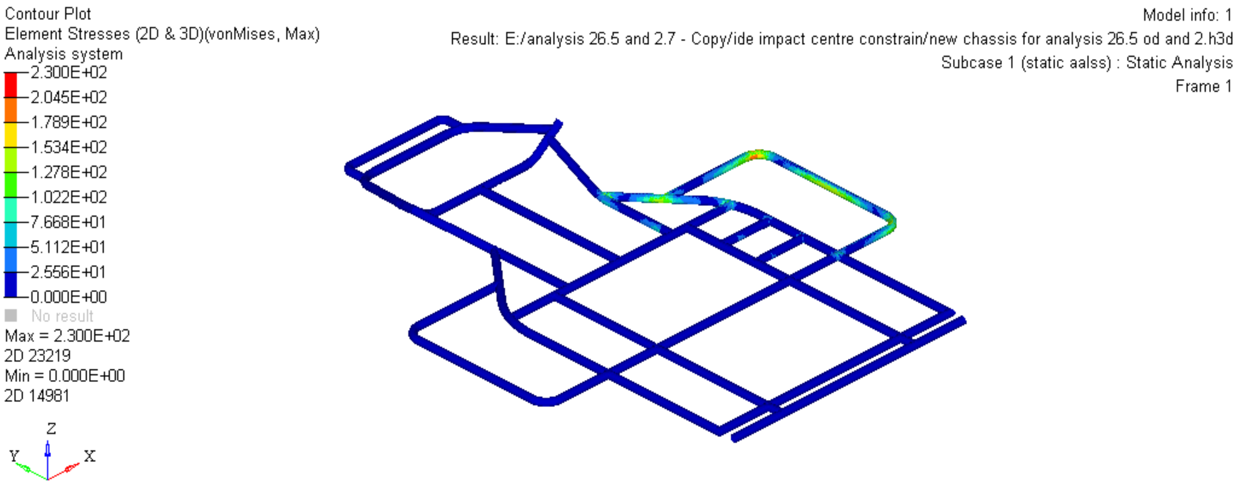

FIG NO-14 Stress Analysis

6.4.3.3 RESULTS

Maximum Stress= $2.30*10^2$ MPa

Incorporated Factor of Safety= σ_{yt}/σ_{max}

$= 370/2.30*10^2$

$= 1.61$

As factor of Safety greater than one that is working stress is less than yield stress of material, hence design is safe against specified stress.

6.4.4 TORSION ANALYSIS

6.4.4.1 IMPACT LOAD CALCULATION: Using the projected vehicle/driver mass of 400 kg, the impact force was calculated based on a G-load of 2.

F = ma

= 170*1*9.81

= 1667.7 N

Impulse time = weight*(velocity/load)

= 170*(22.22/1667.7)

= 2.27seconds

We apply 1667.7 N from the side for the test of side impact of the roll cage structure of the vehicle for determining strength at the time of side collision. [6]

6.4.4.2 LOADING AND CONSTRAIN

The load equal to 1667.7N is applied on front bumper and chassis is constrained at the Centre.

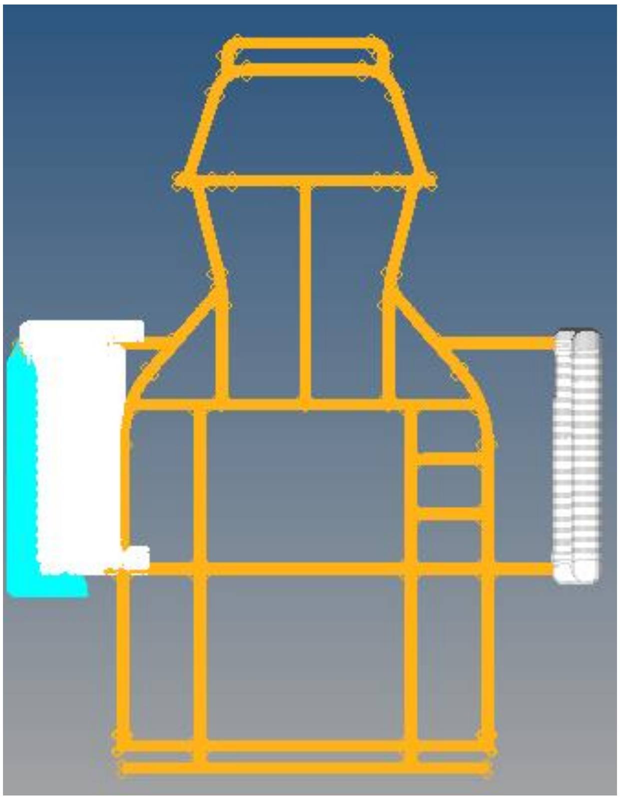

FIG NO-15 Side Impact Loading and Constrain

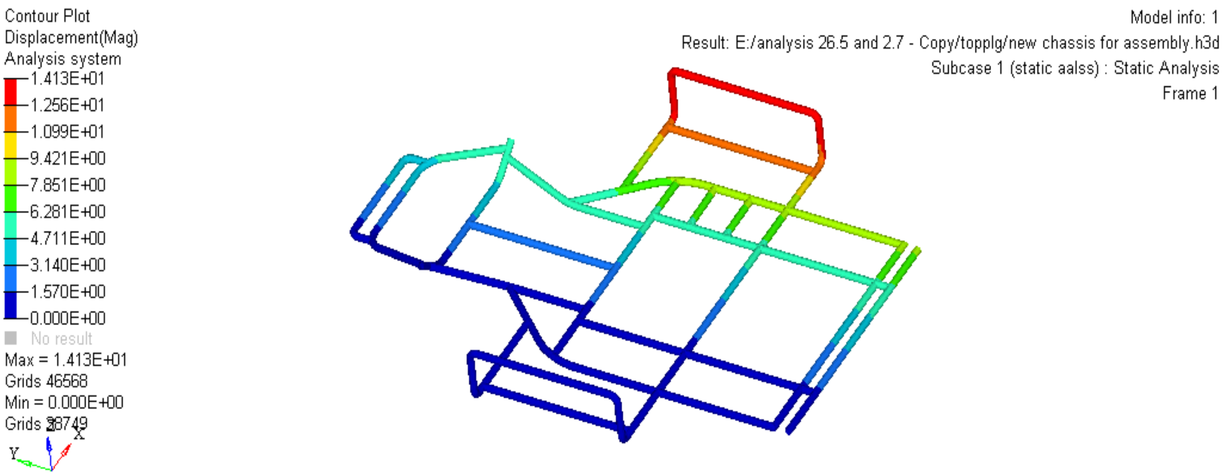

FIG NO-16 Displacement Analysis

Maximum deformation: 14.13 mm

Maximum deformation for the side impact is also under the safe limit & not affects the safety of driver.

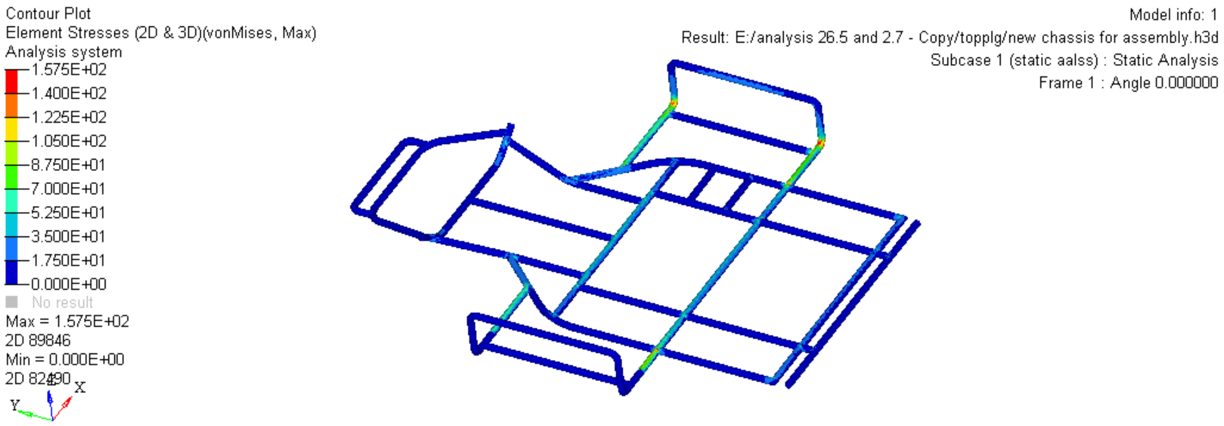

FIG NO-17 Stress Analysis

6.4.4.3 RESULTS

Maximum Stress= $1.57*10^2$ MPa

Incorporated Factor of Safety= σ_{yt}/σ_{max}

$= 370/1.57*10^2$

$= 2.36$

As factor of Safety greater than one that is working stress is less than yield stress of material, hence design is safe against specified stress.

7. ACKNOWLEDGMENTS

It's my pleasure to thank Mr. Girish Mekalke Sir, Mr.D.A.Chougale Sir, Mr.S.S.Sutar sir for providing me constant support and suggestions. Their experience and advices were invaluable to my ability to make an accurate analysis.

8. CONCLUSION

The FEA Analysis shown that the vehicle can sustain 4G force from front as well as rear & 2G force from side and that the deformation & stresses are within the permissible limits. The basic need of a Go-kart, which is lower weight to strength ratio and lesser clearance is also satisfied by the roll cage. Keeping the manufacturing in mind, I have tried to make the design optimum and simple. Thus it can be concluded that this roll cage demonstrates good strengths against the collision from front, rear, as well as side. Factor of safety is under the safe limit and can be used to make a Go- kart.

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