# "DESIGNING, ANALYSIS & FABRICAION OF AN ATV ROLLCAGE"

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# "DESIGNING & ANALYSIS OF FORMULA CAR"

Dissertation Submitted to

**University of Petroleum & Energy Studies**

For Partial Fulfillment of the Requirements

For the Award of the Degree

## BACHELOR IN TECHNOLOGY

## IN

## AUTOMOTIVE DESIGN ENGINEERING

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Mandeep Malhotra

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**Underguidance**: Mr. Parag Mantri

BE (Mechanical Engineering), MS,

PhD (Aerospace Engineering), Assistant Professor

**University of Petroleum & Energy Studies,**

**Dehradun, Uttarakhand**

# TO WHOMSOEVER IT MAY CONCERN

This is to certify that, Mr.**Abhishek Dewan(r140206002), Mr. Avinash Chandra(r140206014), Mr. Mandeep Malhotra(r140206031) & Mr. Priya Darshan Lohani(r140206045)**, Bachelor students of Automotive Design Engineering, University of Petroleum and Energy Studies, have worked on '**DESIGNING, ANALYSIS & FABRICATION OF AN ATV & DESIGNING &ANALYSIS FORMULA FRAME'.** They have successfully completed the project for fourth year at University of Petroleum & Energy studies, Dehradun, Uttarakhand.

Their contribution in the project is significant and useful to us. I wish for their best future.

**DR. PARAG MANTRI,**

BE (Mechanical Engineering), MS, PhD(Aerospace Engineering)

**Assistant Professor**

# DECLARATION

We, Mr. **Abhishek Dewan(r140206002), Mr. Avinash Chandra(r140206014), Mr. Mandeep Malhotra(r140206031) & Mr. Priya Darshan Lohani(r140206045)**, Bachelor students of Automotive Design Engineering, University of Petroleum and Energy Studies, Dehradun hereby declare that the dissertation entitled **"DESIGNING, ANALYSIS & FABRICATION OF AN ATV & DESIGNING &ANALYSIS FORMULA FRAME'** embodies the report of project work carried out at 'University of Petroleum and Energy Studies, Dehradun for fourth year under guidance of **DR. PARAG MANTRI,** BE (Mechanical Engineering), MS, PhD(Aerospace Engineering),**Assistant Professor.** This work has been submitted for the partial fulfillment of the requirement for the award of the honorable degree 'Bachelor of Technology in Automotive Design Engineering'.

**Date: MAY 10, 2010**

# ACKNOWLEDGEMENT

During the period we carried out our project work, we have an honor to receive a valuable support and able guidance from numerous sources that helped to shape it and provided a continuous feedback and kind support.

First and foremost we would like to express our deep sense of gratitude and indebtedness to our project guide **DR. PARAG MANTRI,** BE (Mechanical Engineering), MS, PhD(Aerospace Engineering),**Assistant Professor** for his valuable support, able guidance, constructive criticism and consistent encouragement during the course of this project. I would like to acknowledge and extend my heartfelt gratitude to him for his perpetual energy, enthusiasm and judicious attitude without which this project would not have been possible.

It's an honor for us to express our thanks and obligations to **Mr. Pankaj Kumar Sharma (Assistant Professor)**, course coordinator, Automotive Design Engineering, UPES, Dehradun for his timely help and constant encouragement throughout our project period. Lastly, we offer our kind regards to our peers and friends and to all of those who have supported us in any respect to improve the quality of our work.

# ABSTRACT

Designing, modeling & fabrication of a vehicle is the basic requirement, but how safe is that vehicle for driver, passengers & outsiders is comes under testing of vehicle.

During modeling & designing it can be analyzed with the help of software by taking factor of safety which is very higher in actual testing; if the vehicle can pass software analysis test then only we can say that it is a safe vehicle for driver, passengers & outsiders.

In current we are going to design, fabricate an ATV rollcage and design of formula frame with the help of software(**SOLIDWORKS 2008 version)** analysis will be shown that regarding front impact test, roll over test, side impact test & rear impact test our designed vehicle is safe.

This dissertation includes the optimum vehicle design parameter selection methodology by using advance software tools and concept of mechanics.

# Table of contents

# PART 1:"DESIGNING, ANALYSIS & FABRICATION OF AN ATV"

## 1.1 ABOUT AN ATV:

An **all-terrain vehicle** (**ATV**), also known as a **quad**, **quad bike**, **three-wheeler**, or **four wheeler**, is defined by the American National Standards Institute (ANSI) as a vehicle that travels on low pressure tires, with a seat that is straddled by the operator, along with handlebars for steering control. As the name implies, it is designed to handle a wider variety of terrain than most other vehicles.

By the current ANSI definition, ATVs are intended for use by a single operator, although some companies have developed ATVs intended for use by the operator and one passenger. These ATVs are referred to in this notice as tandem ATVs.


The rider sits on and operates these vehicles like a motorcycle, but the extra wheels give more stability at slower speeds. Although typically equipped with three or four wheels, six-wheel models exist for specialized applications.

## 1.2 INTRODUCTION

From the making of any raw material into a well finished product we need go for its designing. There are several steps required like:

1. Need for designing
2. Availability of resources
3. Selection of resources
4. Alternatives
5. Selection of alternatives.
6. Designing of product
7. Final design
8. Analysis of design
9. Optimization of design

## 1.3 VEHICLE DESIGN OBJECTIVE

The vehicle design should be attractive to consumers because of its visual appearance, performance, reliability and ease of operation and maintenance. It should also be manufacturable using predominantly semi-skilled labor and standard machining tools.

## 1.4 VEHICLE CONFIGURATION

The vehicle has four (4) wheels not in a straight line. The vehicle is capable of carrying one (1) person 190.3 cm (6'3") tall weighing 113.4 kg (250 lb).

## 1.5 MAXIMUM VEHICLE DIMENSIONS

Width: 162.56 cm (64 in) at its widest point (the widest point of the vehicle and not necessarily t he wheel track width) with the wheels pointing forward at static ride height.
Vehicles exceeding this dimension will not be allowed to run in any dynamic event.

## 1.6 ROLL CAGE OBJECTIVE

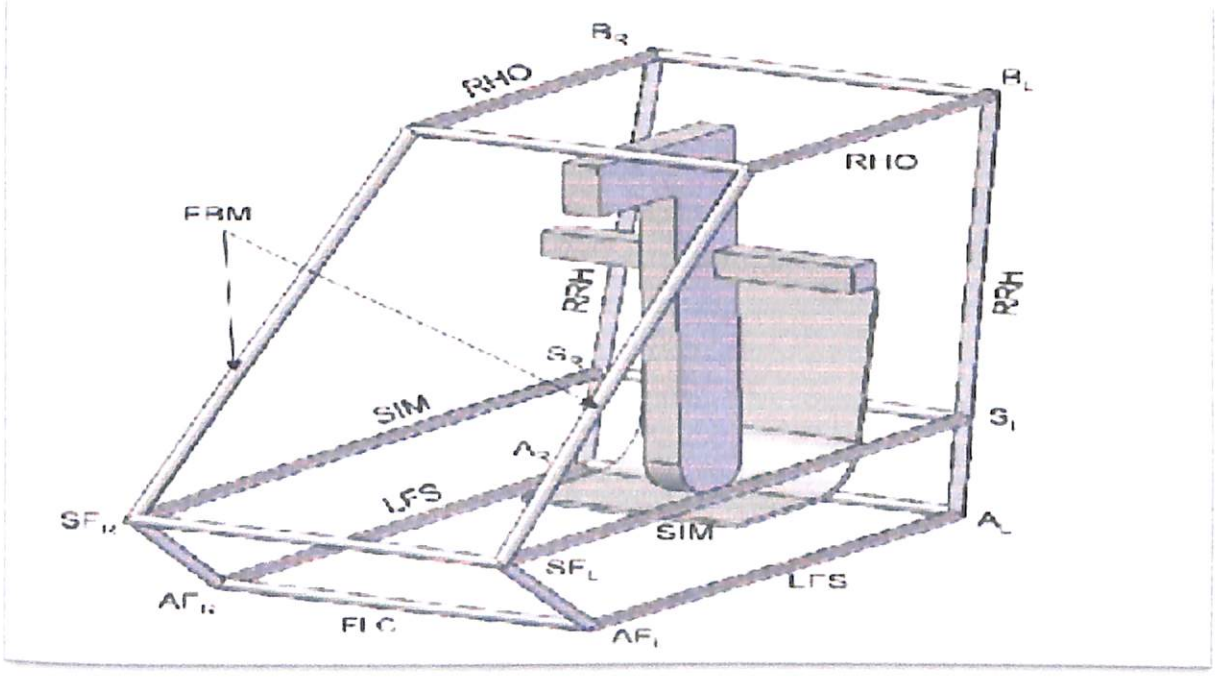
The purpose of the roll cage is to provide a minimal three dimensional space surrounding the driver. The cage must be designed and fabricated to prevent any failure of cage integrity. The cage must be large enough for the driver's torso, knees, shoulders, elbows, hands and arms must have a minimum of 3in of clearance from the envelope created by the structure of the car.

## 1.7 ELEMENTS OF ROLL CAGE

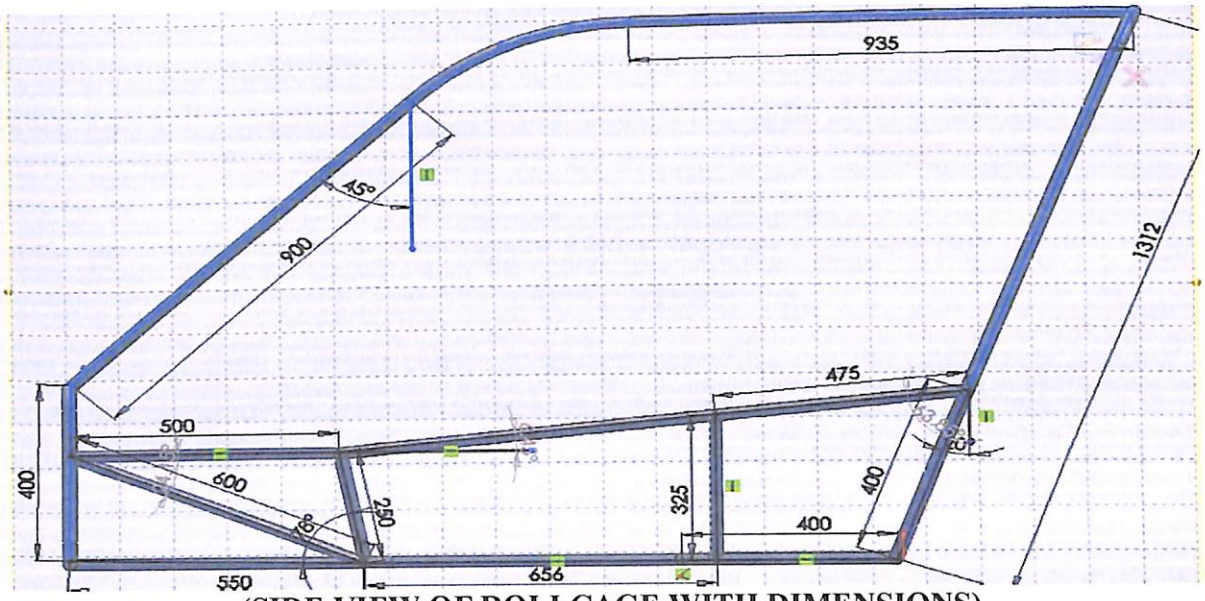
The elements of roll cage that must fulfill design are:

- Rear roll hoop (RRH)
- Rear hoop overhead member (RHO)
- Front bracing member (FBM)
- Lateral cross member (LCM)
- Lower frame side (LFS)
- Front lateral cross member (FLC)
- Side impact member (SIM)

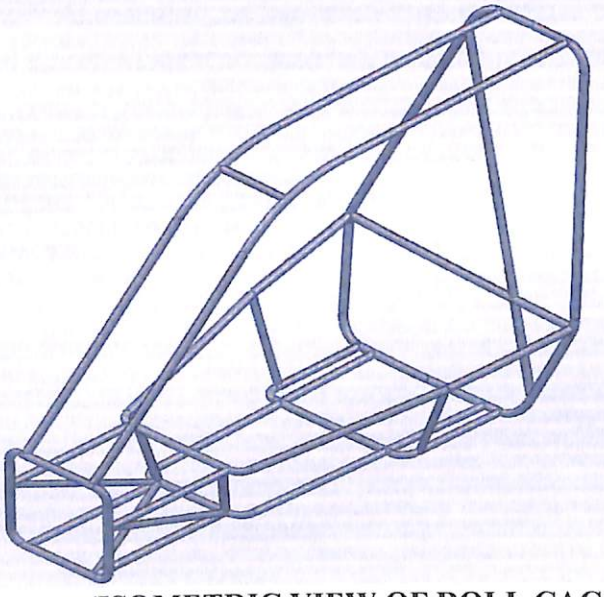
All these members are shown in the fig. below:



# 2. ACTUAL DESIGN OF ROLLCAGE




(SIDE VIEW OF ROLLCAGE WITH DIMENSIONS)



(ISOMETRIC VIEW OF ROLL CAGE)

# 2.1 DESIGN & ANALYSIS OF ROLLCAGE

***Designing Analysis has been done with the help of COSMOS Xpress under Solidworks 2008 version.***

## 2.1.a ROLLCAGE DESIGN METHODLOGY

After selection of appropriate tube material **AISI 1018 STEEL** and size next step was to setup some design considerations. These design considerations include:

1. Roll cage should be safe for driver in worst case accidents.

(***Front impact, side impact & rear impact test***)

**2.** Roll cage should have minimum possible weight so as to provide better braking and acceleration characteristics, without violating safety consideration.

**3.** It should have sufficient space to accommodate driver and all other components while being as compact as possible.

4. It should ensure easy get in and out of the driver.

5. Ergonomics was an integral part of the design process of the roll cage.

6. Cheaper as if it will launch in the market; it will be economical.

7. More safer for driver as tested for front, side & rear impact test.

## 2.2 DESIGING & ANALYSIS STEPS FOR FRONT IMPACT TEST

1-Modeling

2-Applying material

3-Restrain the part

4-Applying force

5-Choosing reference plane

6-Run for analysis

7-Results

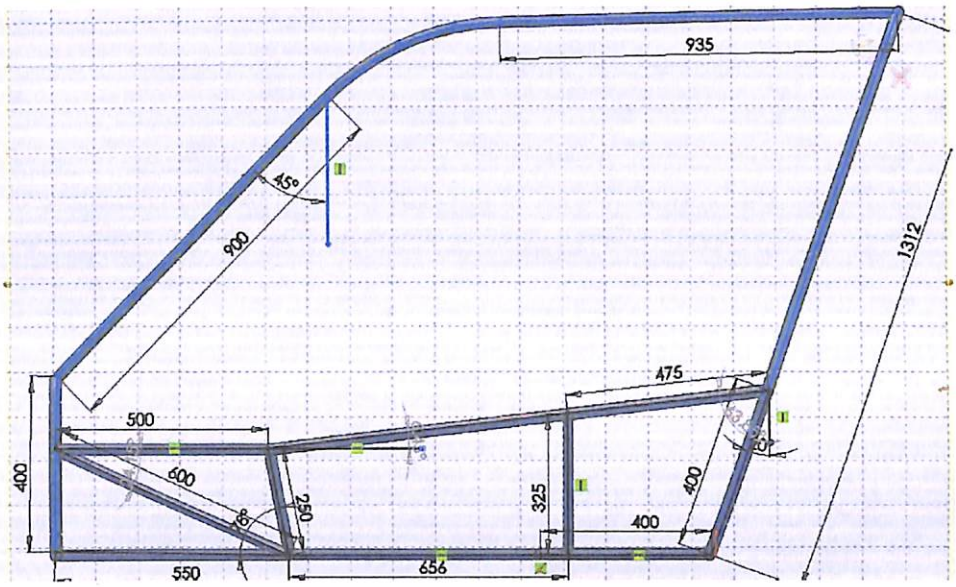
8-Design report

9-Optimization of design

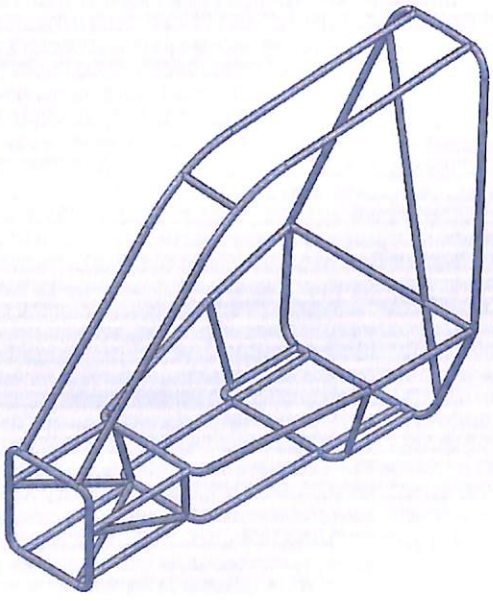
## A-MODELING

Modeling has been done with the help of **SOLIDWORKS 2008 SP** version software; using major commands like sweep, loft, reference planes, extrude & extrude cut etc.

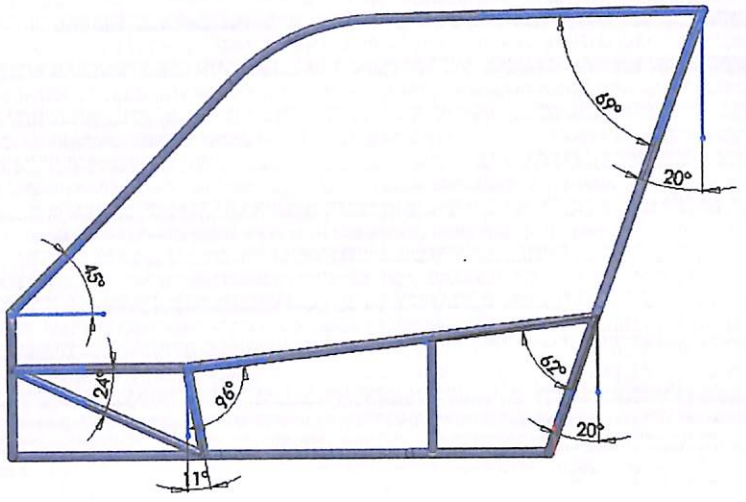
All the dimensions are in **MM** in the below snaps of AN ATV rollcage-




**(SIDE VIEW OF ROLLCAGE)**



**(ISOMETRIC VIEW OF ROLL CAGE)**




**(SIDE VIEW WITH ANGLES)**

## B-APPLYING MATERIAL

Once the model is designed we apply material according to availability of material in software or if it is not available in software we can upload the material by adding materials property.

We have chosen **AISI 1018 steel**. With below composition-

**AISI 1018** low alloy steel is selected for fabrication as it has following properties:

| Component | Weight% |
|---|---|
| C | 0.18-0.23 |
| P | Max 0.4 |
| Fe | 97.3-98.22 |
| Mn | 0.3-0.6 |
| S | Max 0.05 |
| Si | 0.15-0.35 |

### Physical & mechanical properties:

| | |
|---|---|
| **Density** | **7.85 g/cc** |
| **Hardness** | 111 annealed at 870◦C |
| **Tensile strength, ultimate** | 670 Mpa |
| **Tensile strength, yield** | 394 Mpa |
| **Elongation at break** | 36.5% |
| **Modulus of elasticity** | 190-210 Gpa |
| **Bulk modulus** | 140 Gpa |
| **Poison ratio** | 0.29 |
| **Shear modulus** | 80 Gpa |

### Thermal properties:

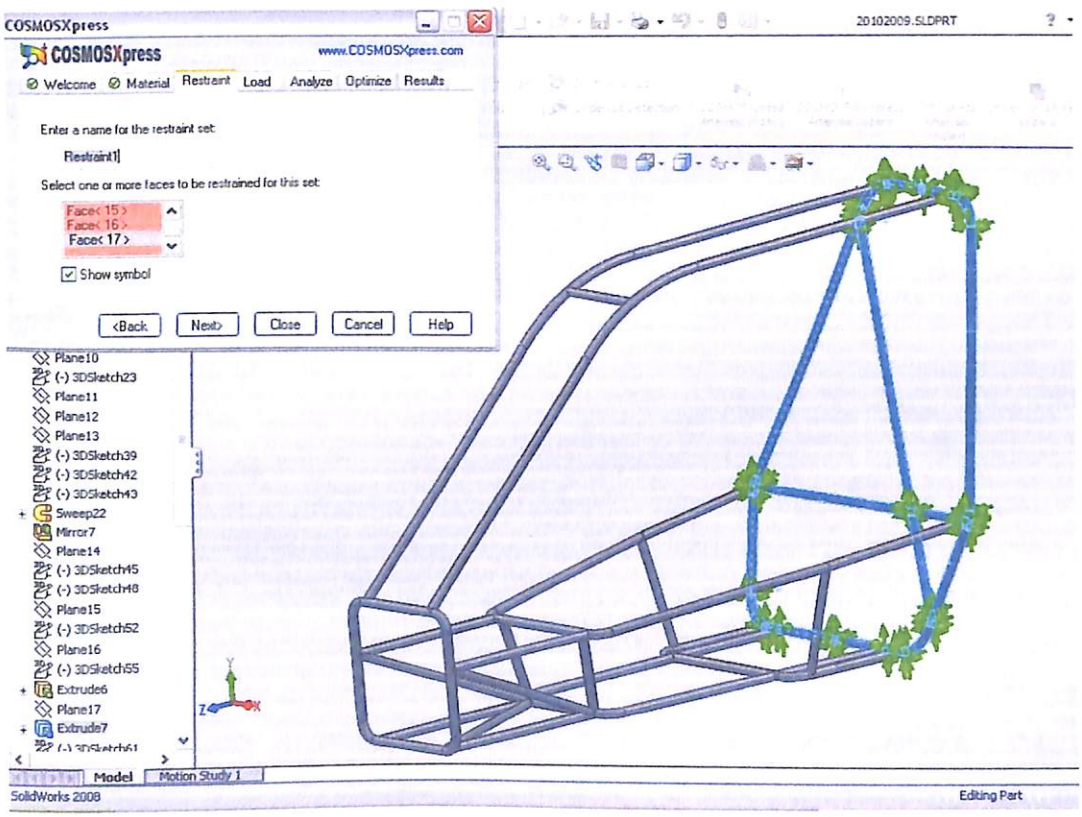
| | |
|---|---|
| **Specific heat capacity** | **0.477 J/g-◦C (50-100◦C)** |
| **Specific heat capacity at elevated temp.** | 0.837 J/g-◦C (750-880◦C) |
| **Thermal conductivity** | 42.7W/m-K (100◦C) |
| **Thermal conductivity at elevated temp.** | 40.7 W/m-K (300◦C) |

The advantage of selecting this material over other materials is that it has:

- Greater harden ability.
- Less distortion and cracking
- Greater stress relief at given hardness
- Higher elastic ratio and endurance strength
- Greater high temperature strength
- Better machinability at high hardness
- Greater ductility at high strength.

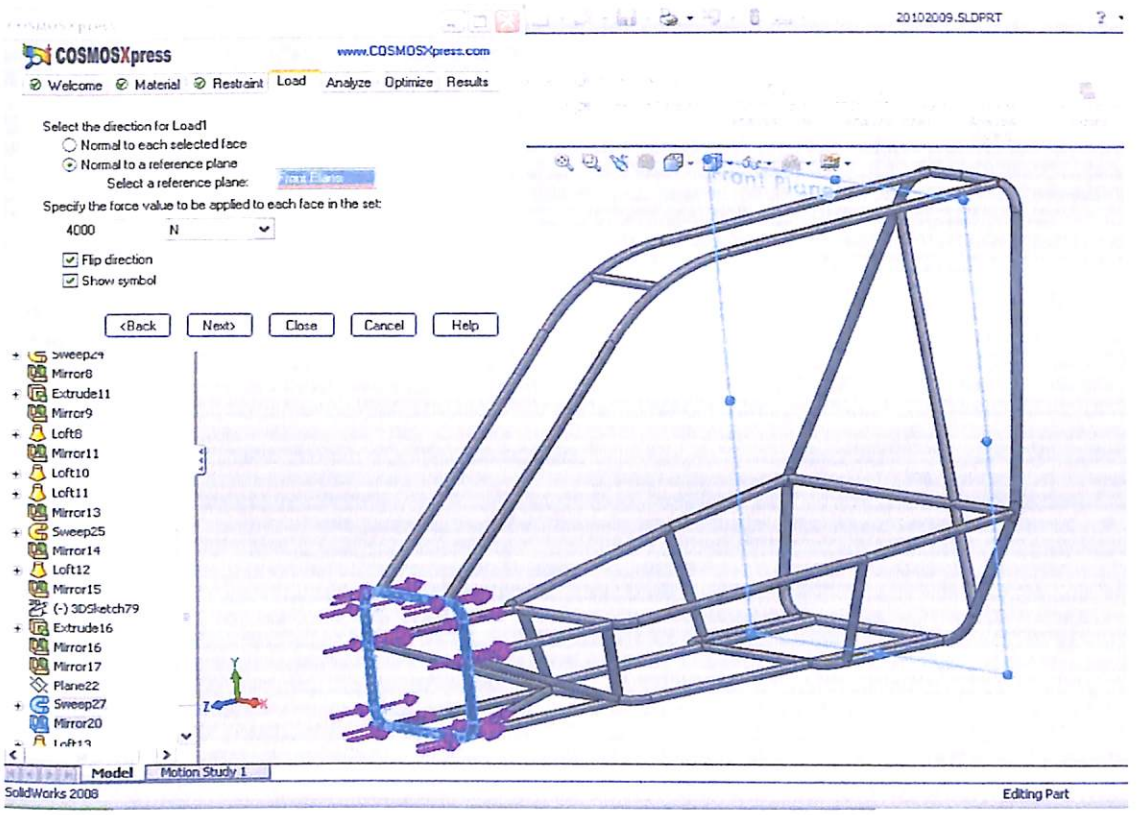
## C-RESTRAIN THE PART

To do analysis we have to first restrain some part of rollcage which will be least affected for that force. It means to fix some part with reference to which force will apply as shown in below snap with dark blue color-



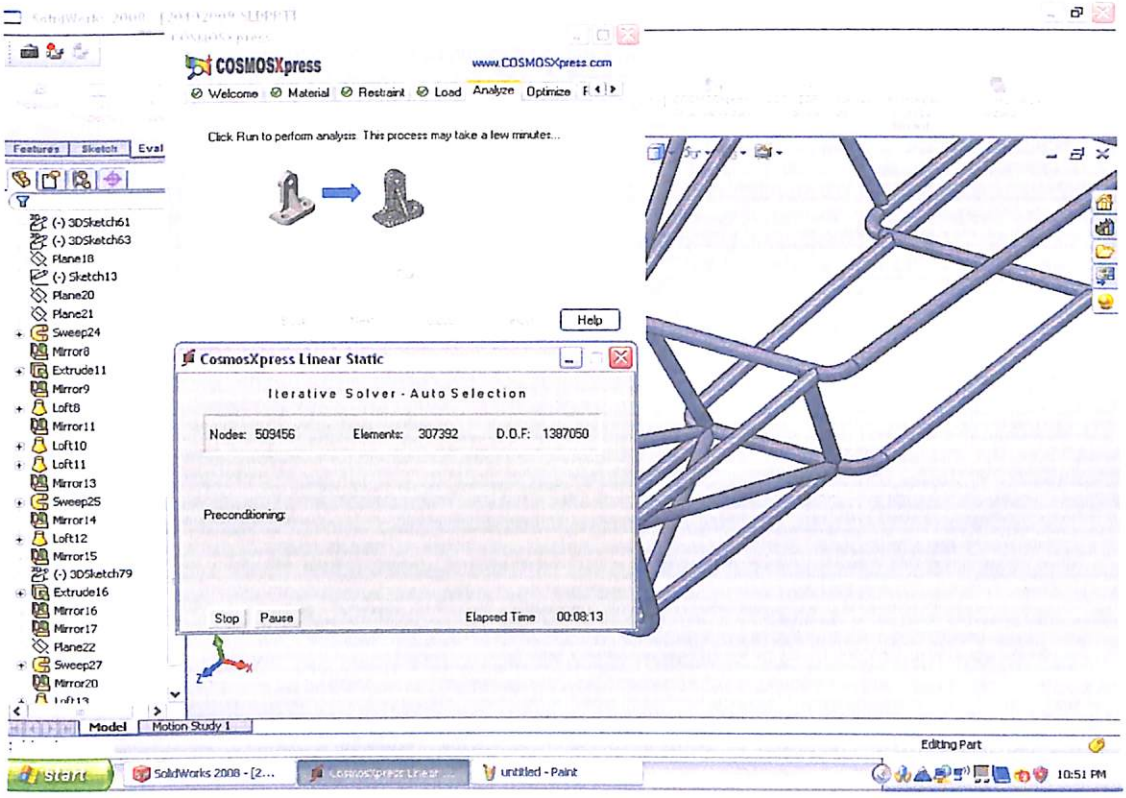
# D-APPLYING FORCE & CHOOSING REFERANCE PALNE

After restrain step we apply force on the required face with the reference of plane which is perpendicular to the application of force. In the below snap a force of **4000N** has been applied on for **FRONT IMPACT TEST** on front face which is perpendicular to the front plane.



## E-RUN FOR ANALYSIS

By choosing appropriate element size we RUN the model for analysis. During analysis the software shows the no **NODES, ELEMENTS & DEGREE OF FREEDOM** as show in below snap-

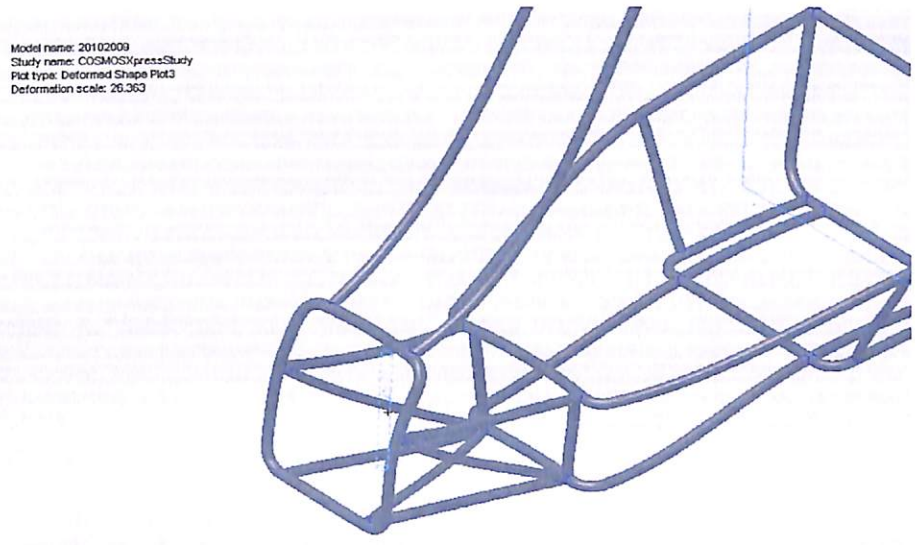



## F-RESULTS

At a force of 4000N analysis has been done for ***FRONT IMPACT, SIDE IMPACT & REAR IMPACT, WITH FACTOR OF SAFETY 2.***

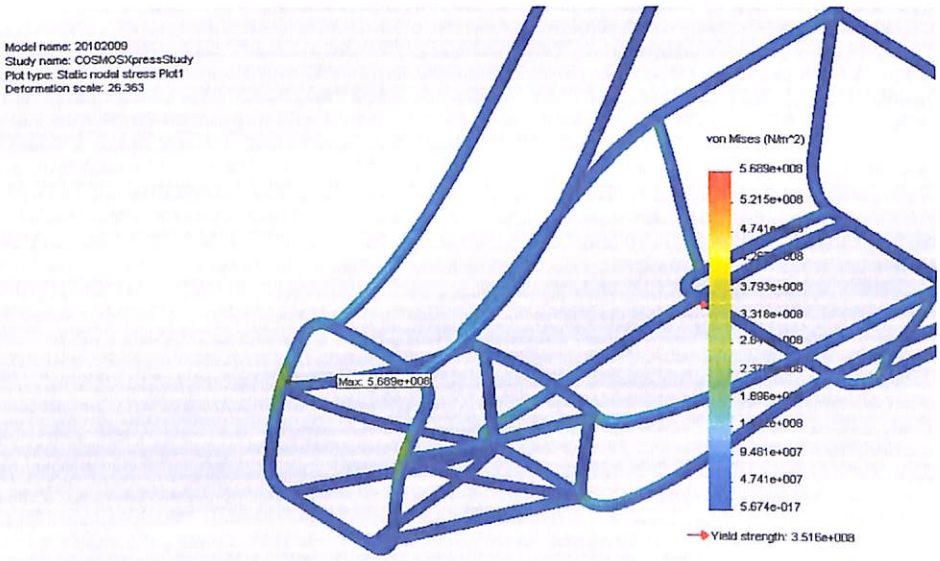
## RESULTS OF FRONT IMPACT TEST-

a- Deformed shape plot for front impact; at scale of **26.363**



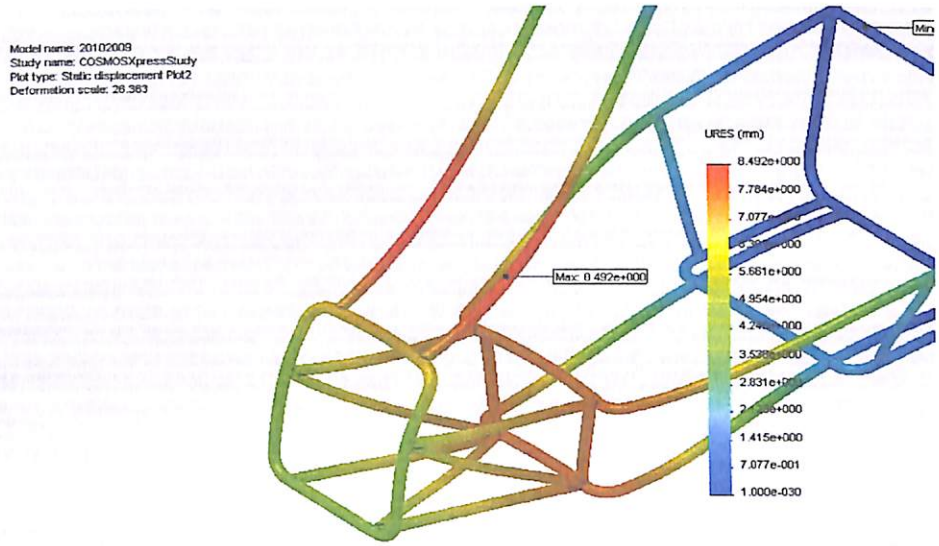

**(DEFORMED SHAPE PLOT)**

b- Static nodal stress plot of front impact, deformation start at a scale of 26.363



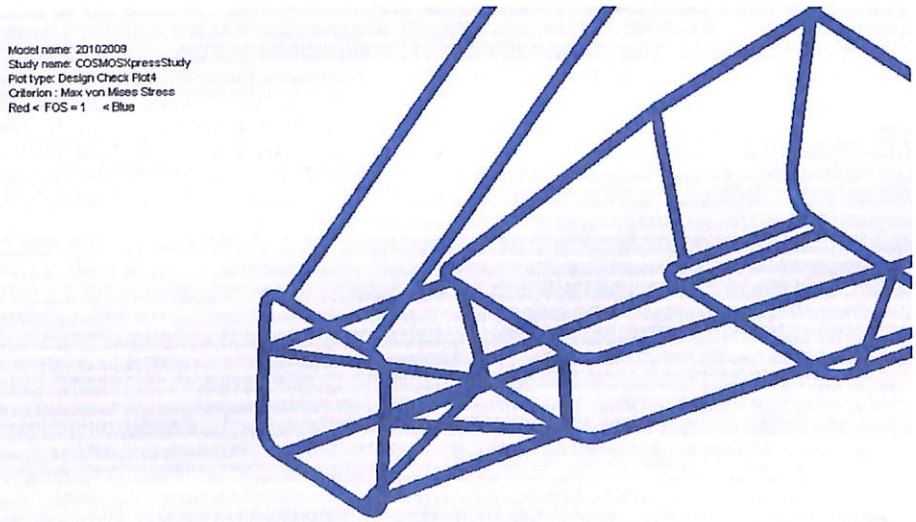

**(STATIC NODAL STRESS PLOT)**

c- Static displacement plot of front impact; at scale of 26.363




**(STATIC DISPLACEMENT PLOT)**

d- Design check shows that weather the design we are using for analysis is valid or safe according to software analysis.




**(DESIGN CHECK PLOT)**

# G-DESIGN REPORT

The ***below analysis report is generated by software itself*** showing the details of element size, type, restrain faces, force on face etc.

1. **File Information**
2. **Materials**
3. **Load & Restraint Information**
4. **Study Property**
5. **Results**
    a. **Stress**
    b. **Displacement**
    c. **Deformation**
    d. **Design Check**
6. **Appendix**

---

## 1. File Information

**Model name:** 20102009

**Model location:** C:\Documents and Settings\kansal\Desktop\baja drawing\20102009.SLDPRT

**Results location:** C:\Documents and Settings\kansal\Desktop

**Study name:** COSMOSXpressStudy (-Default-)

---

## 2. Materials

| No. | Body Name | Material | Mass | Volume |
|---|---|---|---|---|
| 1 | 20102009 | [SW]AISI 1018 | 84.8389 kg | 0.0107391 m^3 |

---

## 3. Load & Restraint Information

| Restraint | | |
|---|---|---|
| **Restraint1 <20102009>** | on **17 Face(s)** immovable (no translation). | |

| Load | | |
|---|---|---|
| **Load1 <20102009>** | on **8 Face(s)** apply force **-4000 N** normal to reference plane with respect to selected reference **Front Plane** using uniform distribution | |

## 4. Study Property

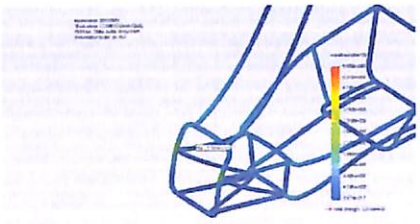
| Mesh Information | |
|---|---|
| Mesh Type: | Solid Mesh |
| Mesher Used: | Standard |
| Automatic Transition: | Off |
| Smooth Surface: | On |
| Jacobian Check: | 4 Points |
| Element Size: | 6 mm |
| Tolerance: | 0.3 mm |
| Quality: | High |
| Number of elements: | 307392 |
| Number of nodes: | 509456 |
| Time to complete mesh(hh;mm;ss): | 00:07:51 |
| Computer name: | TOSHIBA-8BABD84 |

| Solver Information | |
|---|---|
| Quality: | High |
| Solver Type: | Automatic |

# 5. Results

## 5a. Stress

| Name | Type | Min | Location | Max | Location |
|---|---|---|---|---|---|
| Plot1 | VON: von Mises Stress | 5.67368e-017 N/m^2 | (-0.717772 mm, 733.772 mm, -240.633 mm) | 5.68884e+008 N/m^2 | (-202.524 mm, 261.844 mm, 1537.87 mm) |

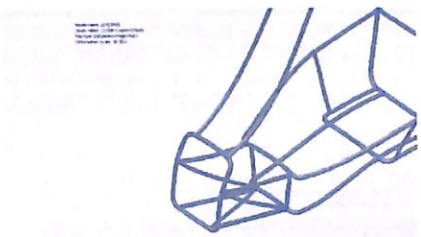
| 20102009-COSMOSXpressStudy-Stress-Plot1 |
|---|
| JPEG |
| VIEW  |

## 5b. Displacement

| Name | Type | Min | Location | Max | Location |
|---|---|---|---|---|---|
| Plot2 | URES: Resultant Displacement | 0 mm | (294.263 mm, -2.3188 mm, 20.8254 mm) | 8.49195 mm | (123.738 mm, 588.071 mm, 1367.87 mm) |

| 20102009-COSMOSXpressStudy-Displacement-Plot2 |
| --- |
| JPEG |
| VIEW  |

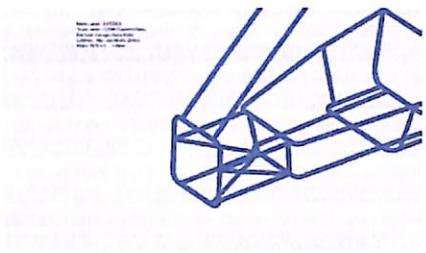
## 5c. Deformation

| 20102009-COSMOSXpressStudy-Deformation-Plot3 |
| --- |
| JPEG |
| VIEW  |

## 5d. Design Check

| 20102009-COSMOSXpressStudy-Design Check-Plot4 |
| --- |
| JPEG |

VIEW



## 6. Appendix

| | |
|---|---|
| **Material name:** | [SW]AISI 1018 |
| **Description:** | |
| **Material Source:** | Used SolidWorks material |
| **Material Library Name:** | SolidWorks Materials |
| **Material Model Type:** | Linear Elastic Isotropic |

| Property Name | Value | Units |
|---|---|---|
| Elastic modulus | 2e+011 | N/m^2 |
| Poisson's ratio | 0.29 | NA |
| Mass density | 7900 | kg/m^3 |
| Yield strength | 3.5157e+008 | N/m^2 |

**Note:**

COSMOSXpress design analysis results are based on linear static analysis and the material is assumed isotropic. Linear static analysis assumes that: 1) the material behavior is linear complying with Hooke's law, 2) induced displacements are adequately small to ignore changes in stiffness due to loading, and 3) loads are applied slowly in order to ignore dynamic effects.

Do not base your design decisions solely on the data presented in this report. Use this information in conjunction with experimental data and practical experience. Field testing is mandatory to validate your final design. COSMOSXpress helps you reduce your time-to-market by reducing but not eliminating field tests.

## H-OPTIMIZATION OF DESIGN

After analysis & design we optimize the design that it will be safe for that force & factor of safety with applied material.

## 2.3 REAR IMPACT TEST

Rear impact test is very important in case of rear collision, because this rollcage design is for rear mounted engine & rear wheel drive so vehicle should be safe enough for driver from rear side also.

## DESIGNING & ANALYSIS STEPS FOR REAR IMPACT TEST

1-Modeling

2-Applying material

3-Restrain the part

4-Applying force

5-Choosing reference plane

6-Run for analysis

7-Results

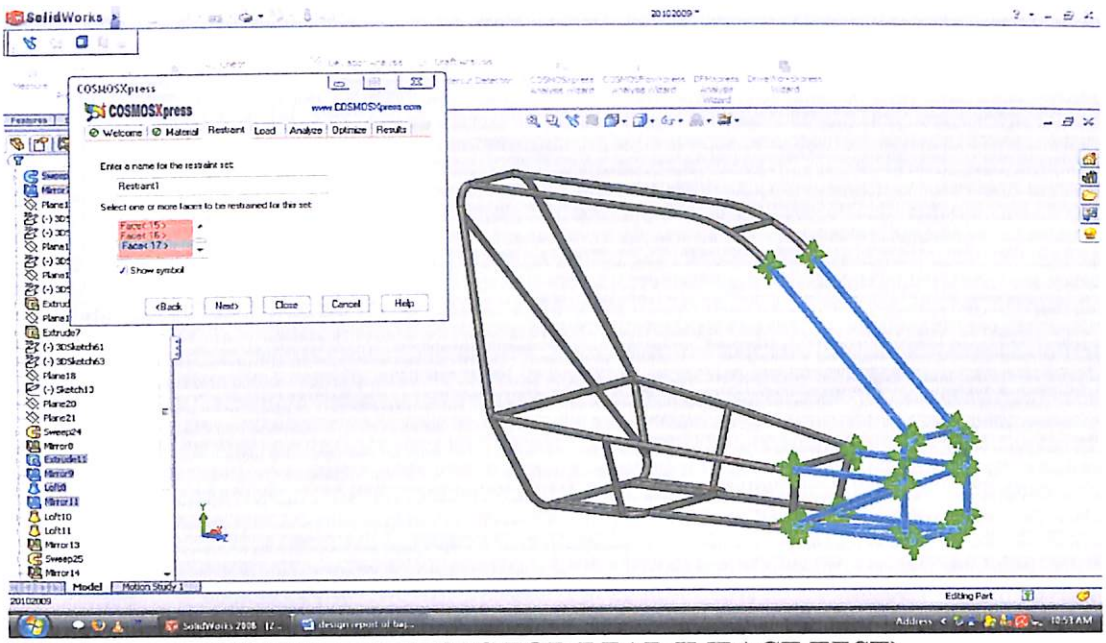
8-Design report

9-Optimization of design

As following previous steps-

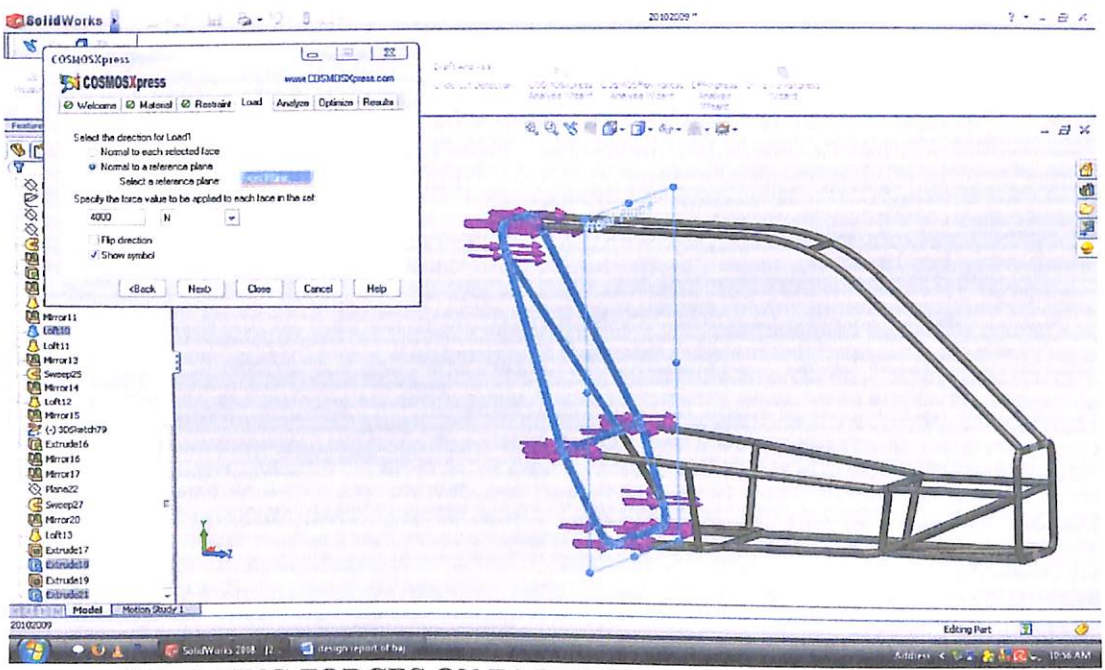
Modeling & applying material has been done.

# A-RESTRAIN




(RESTRAIN FACES FOR REAR IMPACT TEST)

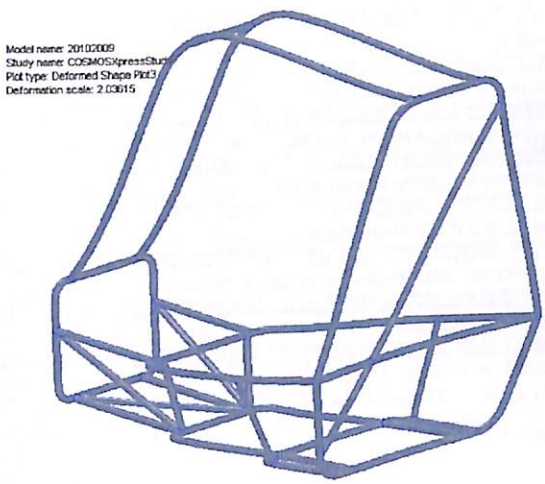
# B-APPLYING FORCES & REFERENCE PLANE




(APPLYING FORCES ON FACES FOR REAR IMPACT TEST)

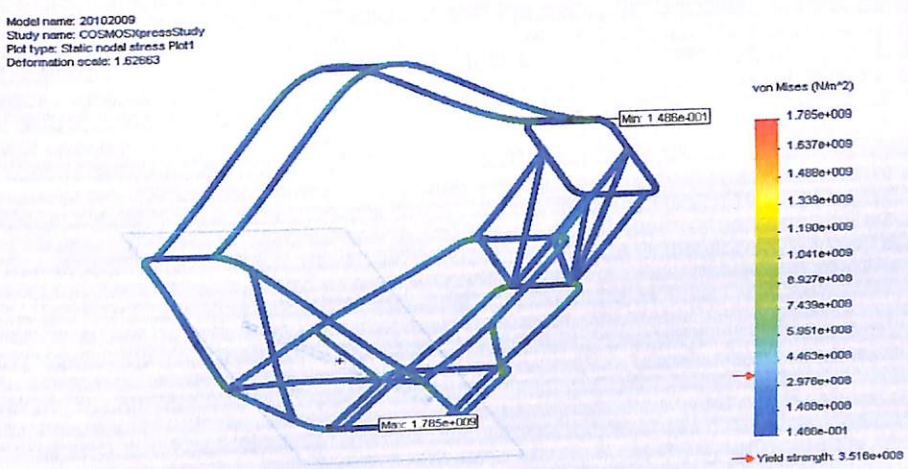
# C-RESULTS

A-deformed shape plot for rear impact test



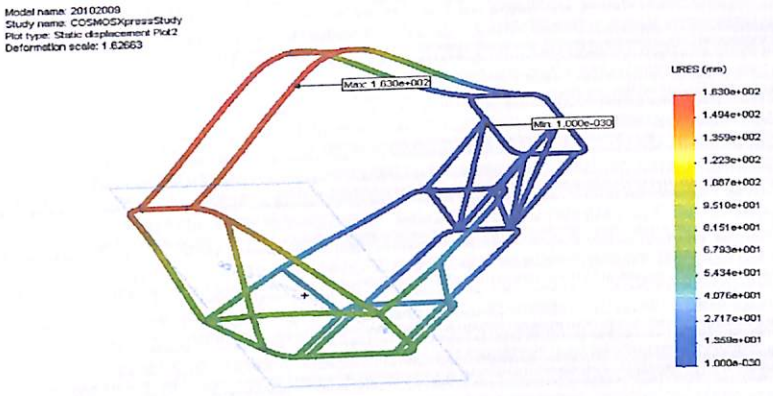

**(DEFORME SHAPE PLOT)**

b- Static nodal stress plot for rear impact; at scale of 1.62663



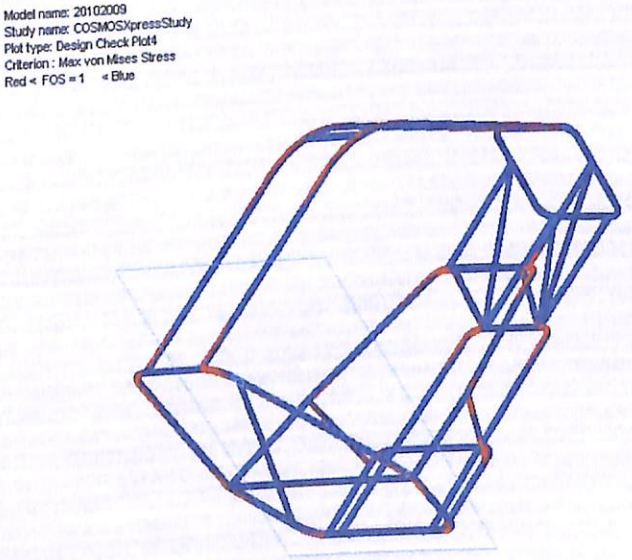

**(NODAL STRESS PLOT)**

c- Static displacement plot for rear impact; at scale of 1.62663




**(STATIC DISPLACEMENT PLOT)**

d- Design check plot for rear impact




**(DESIGN CHECK PLOT)**

# D-DESIGN REPORT

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## File Information

1. **Materials**
2. **Load & Restraint Information**
3. **Study Property**
4. **Results**
   a. **Stress**
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5. **Appendix**

---

## 1. File Information

| | |
|---|---|
| **Model name:** | 20102009 |
| **Model location:** | C:\Documents and Settings\DewaN\Desktop\20102009.SLDPRT |
| **Results location:** | c:\docume~1\dewan\locals~1\temp |
| **Study name:** | COSMOSXpressStudy (-Default-) |

---

## 2. Materials

| No. | Body Name | Material | Mass | Volume |
|---|---|---|---|---|
| 1 | 20102009 | [SW]AISI 1018 | 84.7686 kg | 0.0107302 m^3 |

## 3. Load & Restraint Information

| Restraint | | |
|---|---|---|
| **Restraint1 <20102009>** | on **7 Face(s)** immovable (no translation). | |

| Load | | |
|---|---|---|
| **Load1 <20102009>** | on **15 Face(s)** apply force **4000 N** normal to reference plane with respect to selected reference **Front Plane**using uniform distribution | |

## 4. Study Property

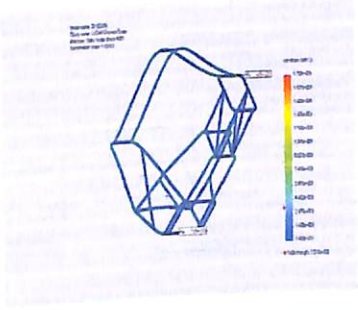
| Mesh Information | |
|---|---|
| Mesh Type: | Solid Mesh |
| Mesher Used: | Standard |
| Automatic Transition: | Off |
| Smooth Surface: | On |
| Jacobian Check: | 4 Points |
| Element Size: | 6 mm |
| Tolerance: | 0.3 mm |
| Quality: | High |
| Number of elements: | 308096 |
| Number of nodes: | 510526 |
| Time to complete mesh(hh;mm;ss): | 00:05:42 |
| Computer name: | DEWAN-EB96A90D1 |

| Solver Information | |
|---|---|
| Quality: | High |
| Solver Type: | Automatic |

# 5. Results

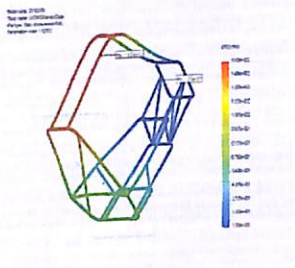
## 5a. Stress

| Name | Type | Min | Location | Max | Location |
|---|---|---|---|---|---|
| Plot1 | VON: von Mises Stress | 0.148586 N/m^2 | (-5.9019 mm, 399.799 mm, 1560.65 mm) | 1.78535e+009 N/m^2 | (299.646 mm, 12.6758 mm, 25.428 mm) |

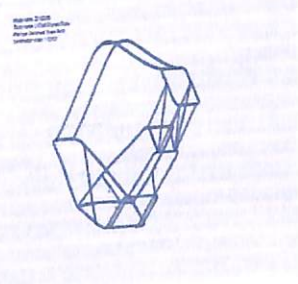
| 20102009-COSMOSXpressStudy-Stress-Plot1 |
|---|
| JPEG |
| VIEW  |

## 5b. Displacement

| Name | Type | Min | Location | Max | Location |
|---|---|---|---|---|---|
| Plot2 | URES: Resultant Displacement | 0 mm | (150.499 mm, 16.6007 mm, 1556.15 mm) | 163.022 mm | (-148.738 mm, 1220.66 mm, 414.209 mm) |

| 20102009-COSMOSXpressStudy-Displacement-Plot2 |
| --- |
| JPEG |
| VIEW  |

**5c. Deformation**

| 20102009-COSMOSXpressStudy-Deformation-Plot3 |
| --- |
| JPEG |
| VIEW  |

### 5d. Design Check

| 20102009-COSMOSXpressStudy-Design Check-Plot4 |
|---|
| JPEG |
| VIEW  |

## 6. Appendix

| | |
|---|---|
| **Material name:** | [SW]AISI 1018 |
| **Description:** | |
| **Material Source:** | Used SolidWorks material |
| **Material Library Name:** | SolidWorks Materials |
| **Material Model Type:** | Linear Elastic Isotropic |

| Property Name | Value | Units |
|---|---|---|
| Elastic modulus | 2e+011 | N/m^2 |
| Poisson's ratio | 0.29 | NA |
| Mass density | 7900 | kg/m^3 |
| Yield strength | 3.5157e+008 | N/m^2 |

**Note:**

COSMOSXpress design analysis results are based on linear static analysis and the material is assumed isotropic. Linear static analysis assumes that: 1) the material behavior is linear complying with Hooke's law, 2) induced displacements are adequately small to ignore changes in stiffness due to loading, and 3) loads are applied slowly in order to ignore dynamic effects.

Do not base your design decisions solely on the data presented in this report. Use this information in conjunction with experimental data and practical experience. Field testing is mandatory to validate your final design. COSMOSXpress helps you reduce your time-to-market by reducing but not eliminating field tests.

## E-OPTIMIZATION OF DESIGN

After analysis & design report we can optimize the design that this design will be safe & good with stand under above mentioned conditioned.

## 2.4 SIDE IMPACT TEST

As mentioned above front & rear impact test; side impact test is also very important. For this while designing the rollcage we create an envelope for driver so that there should be a clearance of 3-6inches from nearest rollcage member from driver's body & there should be proper space so that driver can get out of vehicle in maximum 5seconds.

## DESIGNING & ANALYSIS STEPS

1-Modeling

2-Applying material

3-Restrain the part

4-Applying force

5-Choosing reference plane

6-Run for analysis

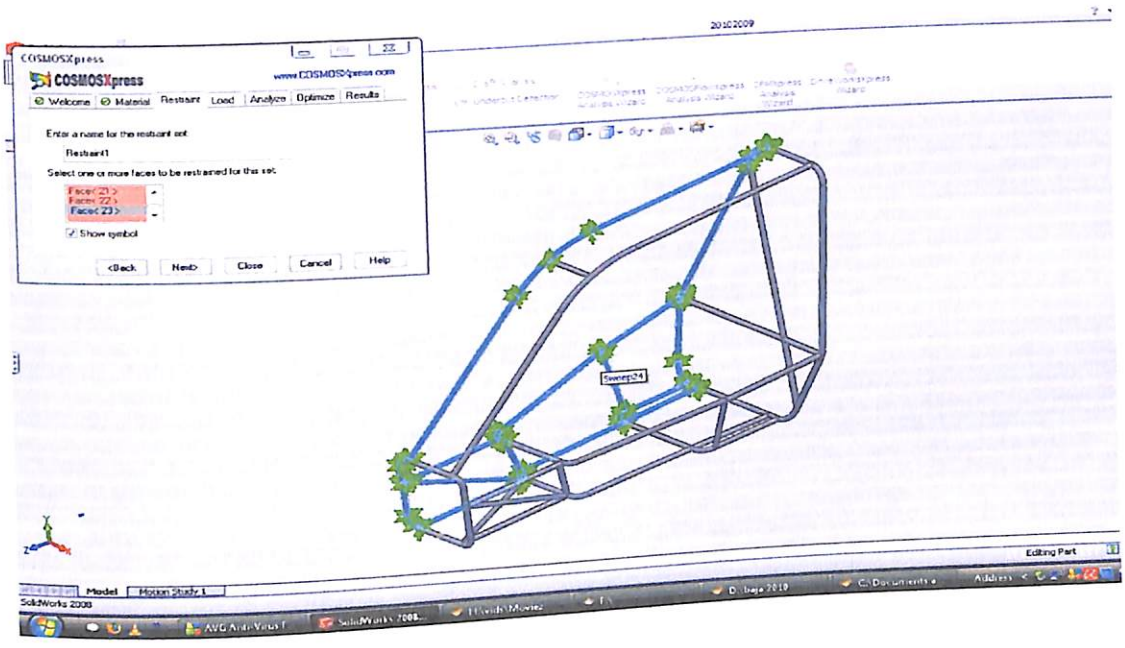
7-Results

8-Design report

9-Optimization of design

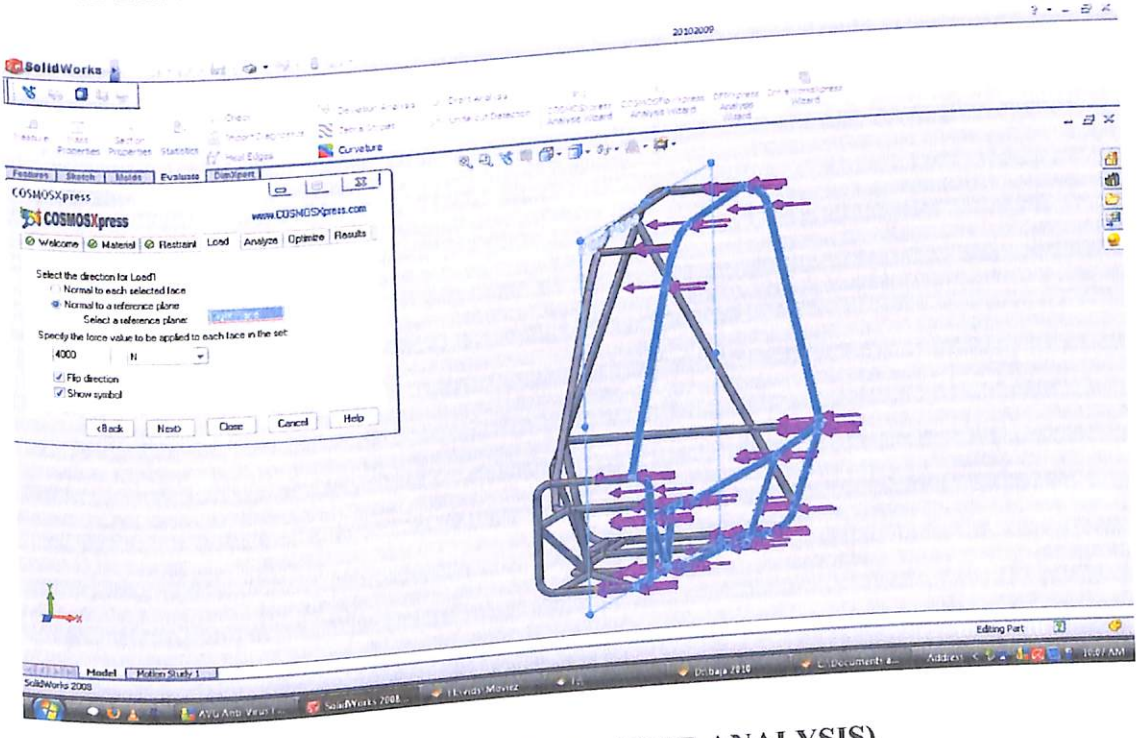
As following previous steps after modeling & applying material.

## A-RESTRAIN




(RESTRAIN FACES FOR SIDE IMPACT TEST)

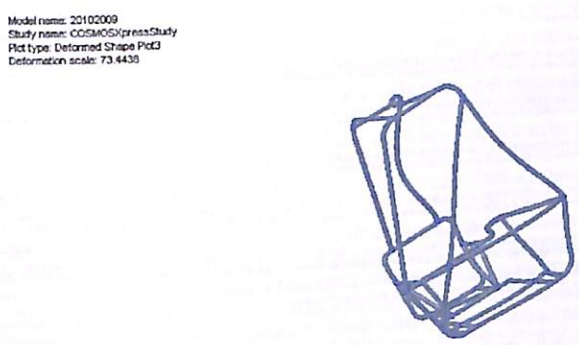
## B-APPLYING FORCE & REFERENCE PLANE




(FORCES ON FACES FOR ANALYSIS)

# C-RESULTS

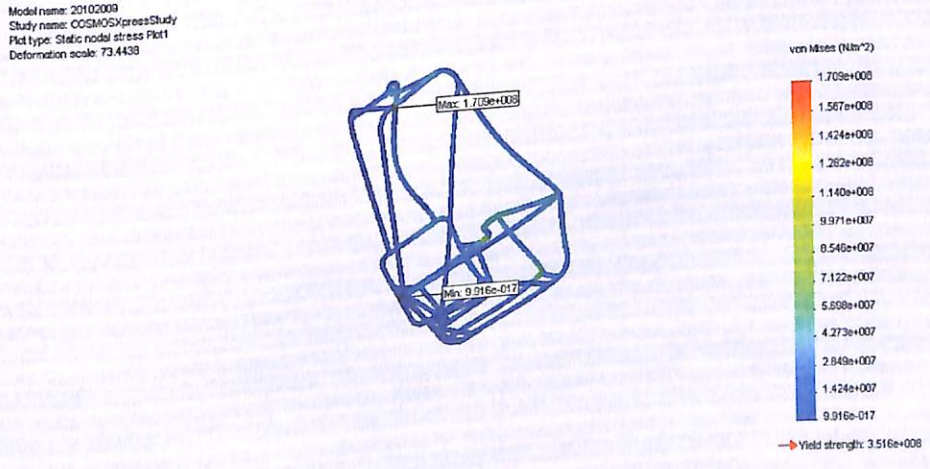
a-deformed shape plot side impact test




**(DEFORMED SHAPE PLOT)**

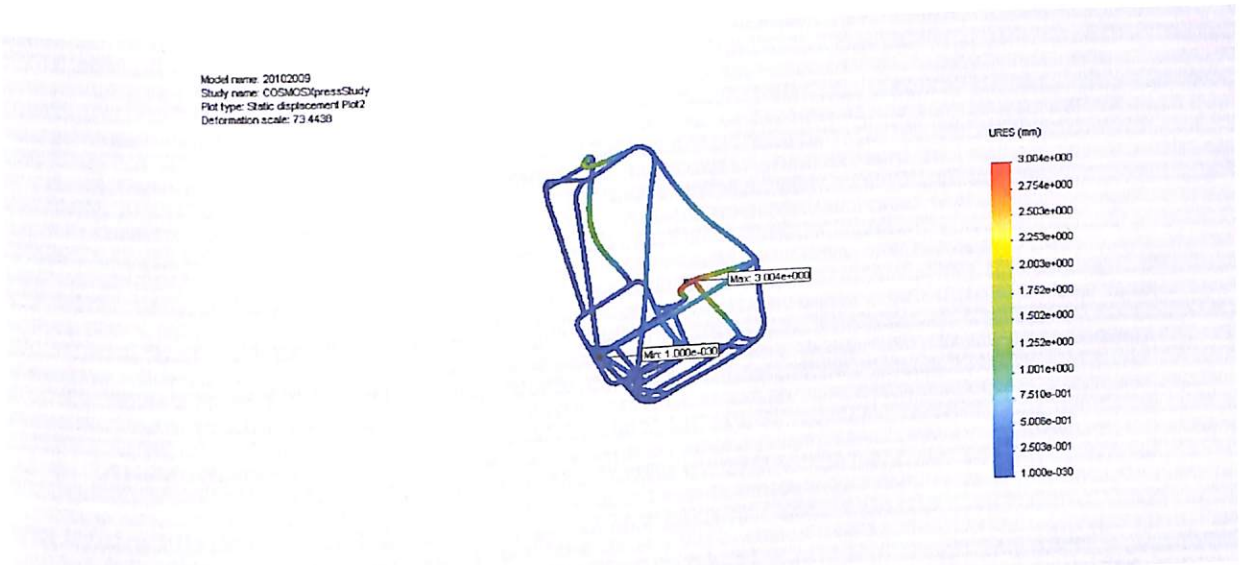
b-static nodal analysis for side impact test; at scale of 73.4438

.



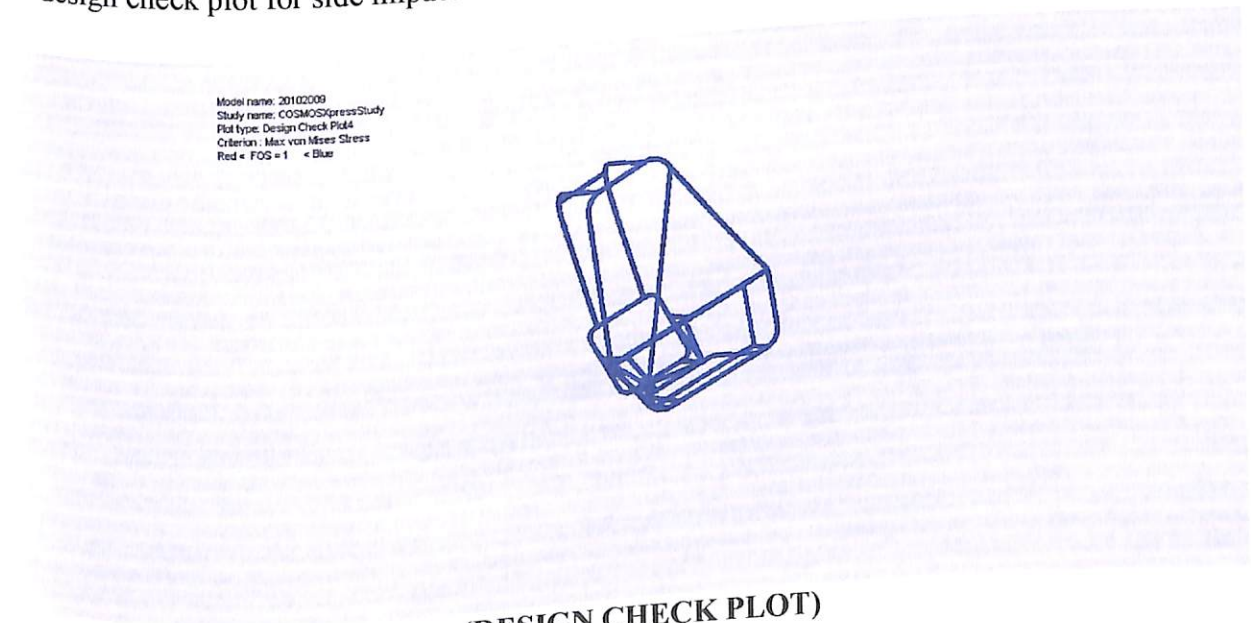

**(STATIC NODAL STRESS PLOT)**

**c-static displacement plot for side impact test; at the scale 73.4438**




**(STATIC DISPLACEMENT PLOT)**

d-design check plot for side impact test




**(DESIGN CHECK PLOT)**

# D-DESIGN REPORT

***The below analysis report is generated by software itself*** showing the details of element size, type, restrain faces, force on face etc.

1. **File Information**
2. **Materials**
3. **Load & Restraint Information**
4. **Study Property**
5. **Results**
    a. **Stress**
    b. **Displacement**
    c. **Deformation**
    d. **Design Check**
6. **Appendix**

## 1. File Information

**Model name:** 20102009

**Model location:** D:\baja 2010\20102009.SLDPRT

**Results location:** C:\Documents and Settings\Kensal\Desktop

**Study name:** COSMOSXpressStudy (-Default-)

## 2. Materials

| No. | Body Name | Material | Mass | Volume |
|---|---|---|---|---|
| 1 | 20102009 | [SW]AISI 1018 | 84.7686 kg | 0.0107302 m^3 |

## 3. Load & Restraint Information

| Restraint | | |
|---|---|---|
| **Restraint1 <20102009>** | on **22 Face(s)** immovable (no translation). | |

| Load | | |
|---|---|---|
| **Load1 <20102009>** | on **23 Face(s)** apply force **1000 N** normal to reference plane with respect to selected reference **Right Plane** using uniform distribution | |

## 4. Study Property

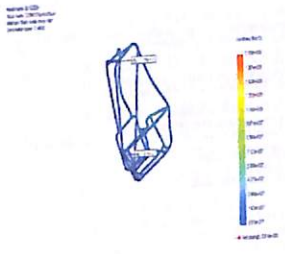
| Mesh Information | |
|---|---|
| Mesh Type: | Solid Mesh |
| Mesher Used: | Standard |
| Automatic Transition: | Off |
| Smooth Surface: | On |
| Jacobian Check: | 4 Points |
| Element Size: | 10 mm |
| Tolerance: | 0.5 mm |
| Quality: | High |
| Number of elements: | 95793 |
| Number of nodes: | 173047 |
| Time to complete mesh(hh;mm;ss): | 00:01:13 |
| Computer name: | DEWAN-EB96A90D1 |

| Solver Information | |
|---|---|
| Quality: | High |
| Solver Type: | Automatic |

# 5. Results

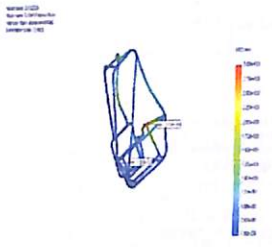
## 5a. Stress

| Name | Type | Min | Location | Max | Location |
|---|---|---|---|---|---|
| Plot1 | VON: von Mises Stress | 9.91585e-017 N/m^2 | (378.002 mm, 316.696 mm, 474.996 mm) | 1.70928e+008 N/m^2 | (119.491 mm, 1233.15 mm, -424.233 mm) |

| 20102009-COSMOSXpressStudy-Stress-Plot1 |
|---|
| JPEG |
| VIEW  |

## 5b. Displacement

| Name | Type | Min | Location | Max | Location |
|---|---|---|---|---|---|
| Plot2 | URES: Resultant Displacement | 0 mm | (206.649 mm, 55.9485 mm, 1560.65 mm) | 3.00383 mm | (-387.331 mm, 329.487 mm, 426.571 mm) |

| 20102009-COSMOSXpressStudy-Displacement-Plot2 |
| --- |
| JPEG |
| VIEW  |

**5c. Deformation**

| 20102009-COSMOSXpressStudy-Deformation-Plot3 |
| --- |
| JPEG |
| VIEW  |

### 5d. Design Check

| 20102009-COSMOSXpressStudy-Design Check-Plot4 |
|---|
| JPEG |
| VIEW  |

## 6. Appendix

| | |
|---|---|
| **Material name:** | [SW]AISI 1018 |
| **Description:** | |
| **Material Source:** | Used SolidWorks material |
| **Material Library Name:** | SolidWorks Materials |
| **Material Model Type:** | Linear Elastic Isotropic |

| Property Name | Value | Units |
|---|---|---|
| Elastic modulus | 2e+011 | N/m^2 |
| Poisson's ratio | 0.29 | NA |
| Mass density | 7900 | kg/m^3 |
| Yield strength | 3.5157e+008 | N/m^2 |

**Note:**

COSMOSXpress design analysis results are based on linear static analysis and the material is assumed isotropic. Linear static analysis assumes that: 1) the material behavior is linear complying with Hooke's law, 2) induced displacements are adequately small to ignore changes in stiffness due to loading, and 3) loads are applied slowly in order to ignore dynamic effects.

Do not base your design decisions solely on the data presented in this report. Use this information in conjunction with experimental data and practical experience. Field testing is mandatory to validate your final design. COSMOSXpress helps you reduce your time-to-market by reducing but not eliminating field tests.

## E-OPTIMIZATION OF DESIGN

After analysis & design report we can optimize the design that this design will be safe & good to withstand under above mentioned conditioned.

# 3.FABRICATION OF AN ATV:

## 3.1 FACTORS FOR SELECTION OF MATERIALS:

### PROPERTIES OF MATERIAL

- The properties of the material define specific characteristics of the material and form the basis for predicting behavior of the material under different conditions.
- The important properties of material are:
  1. Mechanical e.g. stresses.
  2. Thermal e.g. heat or cold.
  3. Chemical e.g. water, chemicals.
  4. Electrical e.g. power, current.
  5. Radiation e.g. ultraviolet, nuclear.

### PERFORMANCE REQUIREMENTS

- The material of which a part is composed must be capable of embodying or performing a part's function without failure.

### MATERIAL'S RELIABILITY

- The reliability is the degree of probability that a product, and the material of which it is made, will remain stable enough to function in service for the intended life of the product without failure.

### SAFETY

- A material must safely perform its function; otherwise the failure of the product made out of it may be catastrophic in air-planes and high pressure systems.

### PHYSICAL ATTRIBUTES

- Physical attributes such as configuration, size, weight and appearance sometimes also serve functional requirements.

### ENVIRONMENTAL CONDITIONS

- The environment in which the product operates strongly influence service performance. Humidity, water or chemicals can cause corrosion and subsequent failure of materials.

### AVAILABILITY

- A material must be readily available, and available in large quantity foe the intended application.

### DISPOSABILITY AND RECYCLABILITY

- These are newest constrains and increasingly important factors in material selection.

### ECONOMIC FACTORS

- Cost perhaps more often than any other constraint, is the controlling factor in a given materials application problem. The total cost of a material for a given application is made up of two components: the cost of the materials and the cost of processing the materials into the finished part or product.

After considering above factors we concluded to select **AISI 1018 STEEL**
*(properties refer to table on page 12).*

## 3.2 PROCESS FOR FABRICATION

Step 1: Cutting of pipes according to desired dimensions with the help of cutting machines.

Step 2: Bending of pipes according to dimensions with the help of manual bending machine.

Step 3: Removing sharp edges with the help of files & angle grinder. Then giving shape with the bench grinder on the edges.

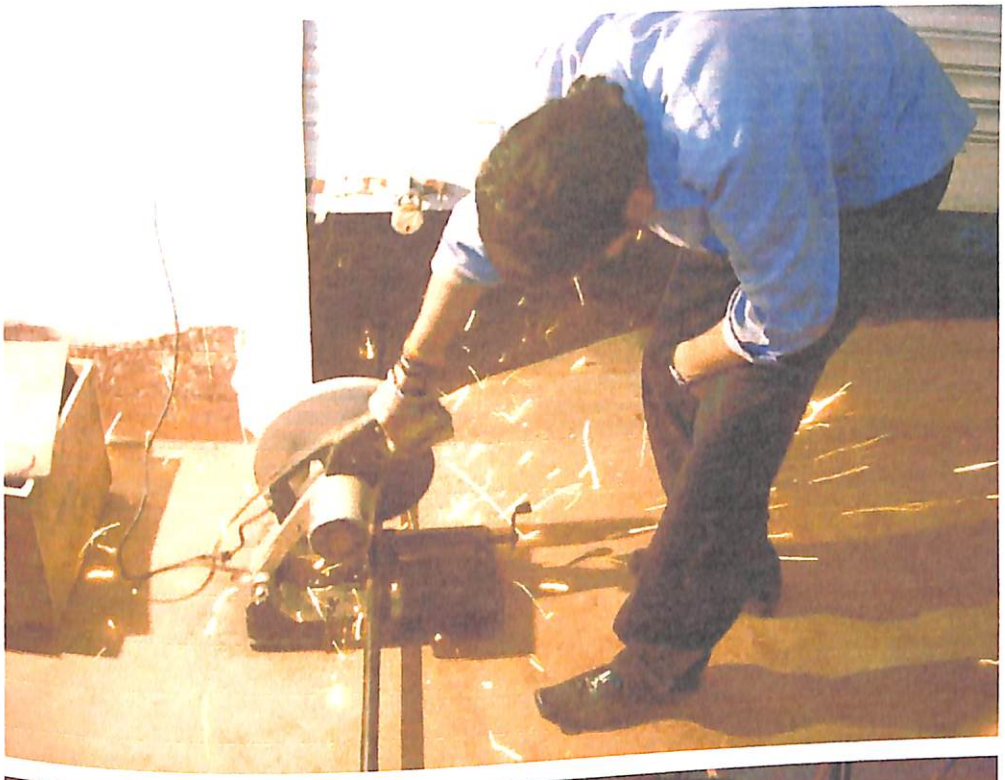
Step 4: Joining of pipes with the help of *MIG welding.*

Advantages of MIG welding over other welding:

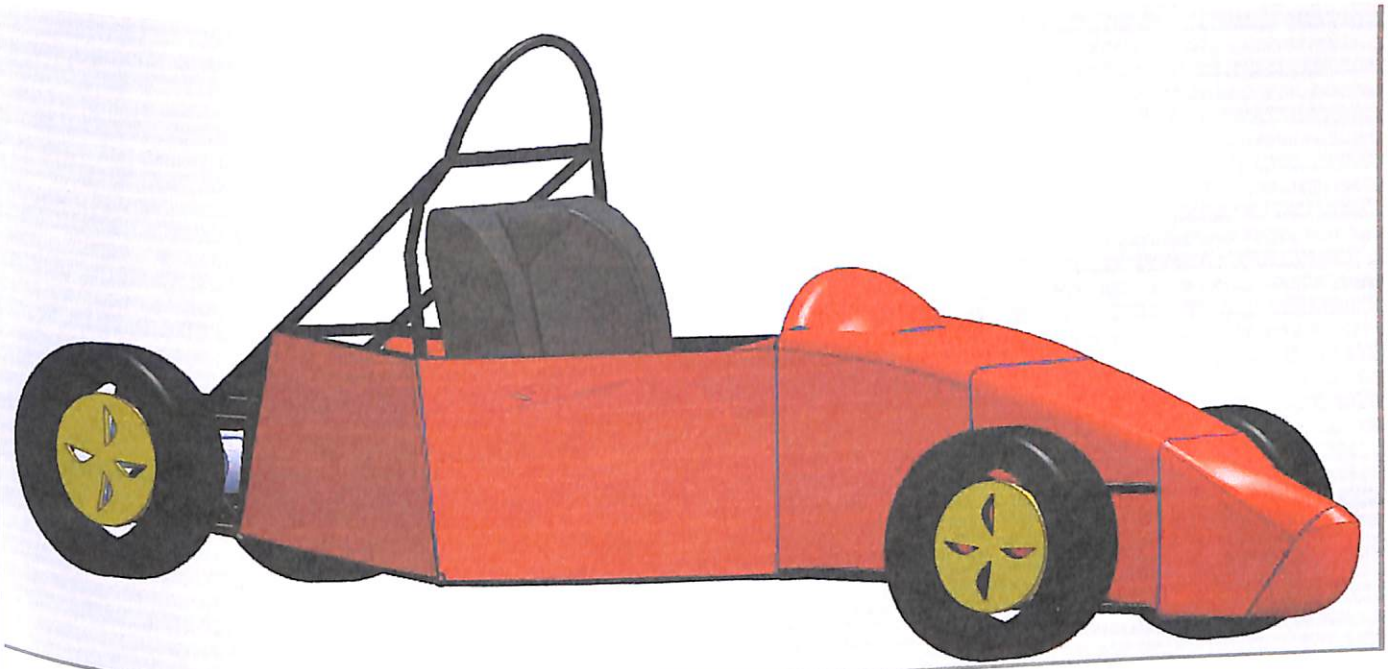
- It is simplest of all.
- It is easily portable.
- A big range of metals and their alloys can be welded.
- Welding can be carried out in any position with highest weld quality.
- There are no fumes and particles of slag, the arc and metal transfer is clear and thus welding control is bit easy.
- Because of less flux coated electrodes, the chances of slag entrapment and other related defects are very less.
- It doesn't use stick electrodes and it is faster as compared to other welding.

Step 5: final finishing of the rollcage.

## 3.3 SNAP SHOTS OF FABRICATION



# PART 2:"DESIGNING &ANALYSIS FORMULA FRAME"



## 1.ABOUT FORMULA 1 VEHICLE

*Formula cars refer to the open wheeled single seater motorsport.Its origin lies in the nomenclature that was adopted by the FIA for all of its post-World War II single seater regulations, or formulae. The best known of these formulae are Formula One*

These cars are mending to run ON-ROAD, with a speed range of 0-160km/h (in less than 5seconds) with engine specification of 1000cc or higher.

These cars have rear mounted engine with rear wheel drive, very good aerodynamic structure & very low ground clearance to achieve high speed within few seconds. The fabrication of these cars need lighter material, high quality welding, wider tires (not more than 350 mm) and steering system with low steering ratio to withstand on this much high speed.

## 2. OBJECTIVE

*"In this project our aims to design formula1 frame with good aerodynamic structure, application of lighter material & then analyze design at 4000N force for front impact test."*

# 3.FRAME DESIGN METHODLOGY

After selection of appropriate tube material **AISI 4130 STEEL** and size next step was to setup some design considerations. These design considerations include:

9- Frame should be safe for driver in worst case accidents.

(***Front impact, in case of F1 cars front impact is more important than others***)

**2.** Frame should have minimum possible weight so as to provide better braking and acceleration characteristics, without violating safety consideration as speed and acceleration is more important for F1 cars.

**3.** It should have sufficient space to accommodate driver and all other components while being as compact as possible.

**4**. It should ensure easy get in and out of the driver.

**5**. Ergonomics was an integral part of the design process of the frame.

**6.** The shape of frame is more aerodynamic & having good ground clearance according to the Indian road conditions.

**7-** The shown design & analysis has been done using minimum bars & supports so if the design is valid for the minimum supports & bars it will definitely withstand with more supports.

**8-** Using material **AISI 4130 STEEL** which is lighter than other materials having better TENSILE strength.

**9-** The frame is based on **HONEY COMB** structure.

**10-** We have done analysis with minimum bar & support required so there are variation in analysis design & actual design.

# 4. DESIGNING AND ANALYSIS STEPS

1-Modeling

2-Applying material

3-Restrain the part

4-Applying force

5-Choosing reference plane

6-Run for analysis

7-Results

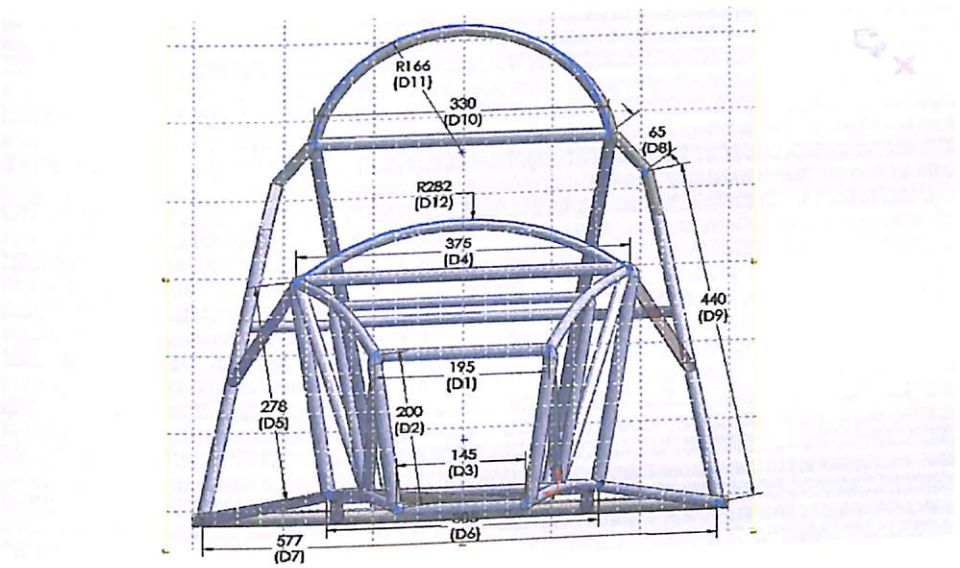
8-Design report

9-Optimization of design

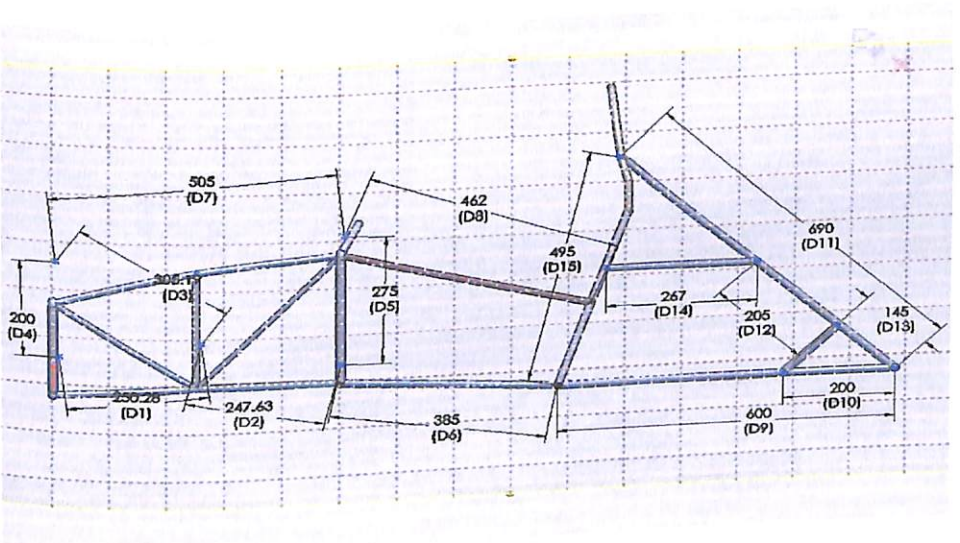
## A-MODELING

Modeling has been done using **SOLIDWORKS 2008 SP VERSION** software major commands like sweep, loft, selecting plane etc.

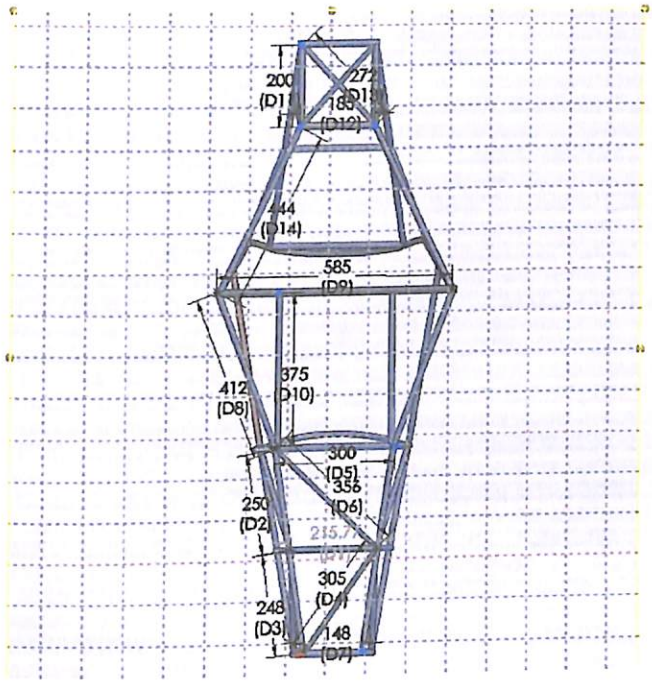
( all dimensions of frame are in MM)



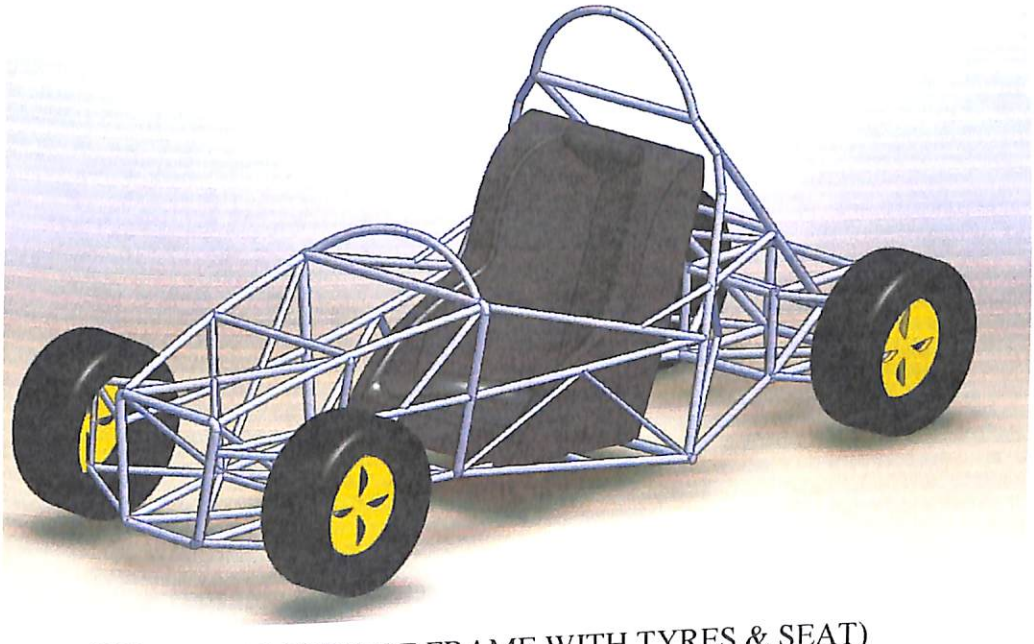

(FRONT VIEW OF FRAME)



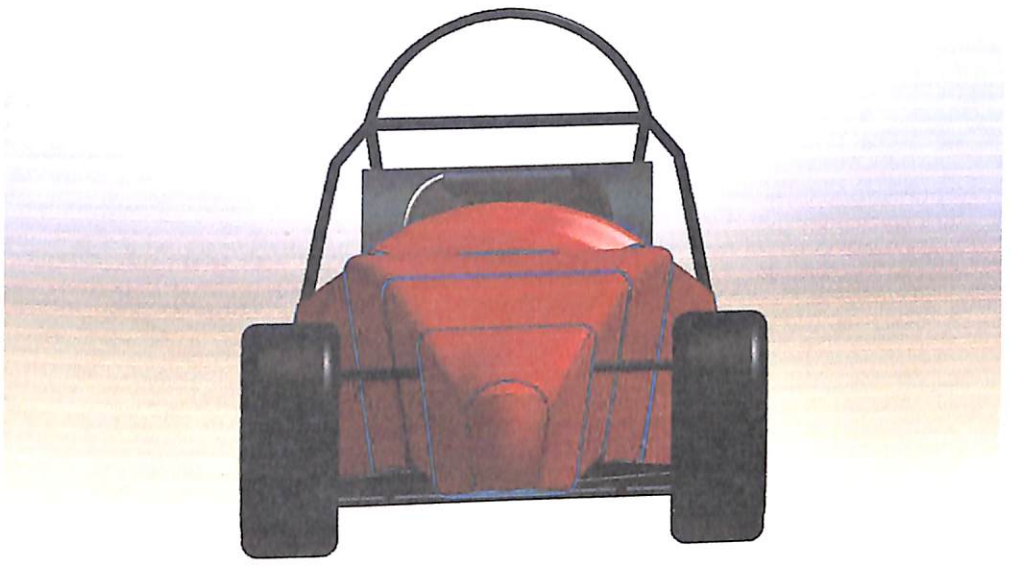

(SIDE VIEW OF FRAME)



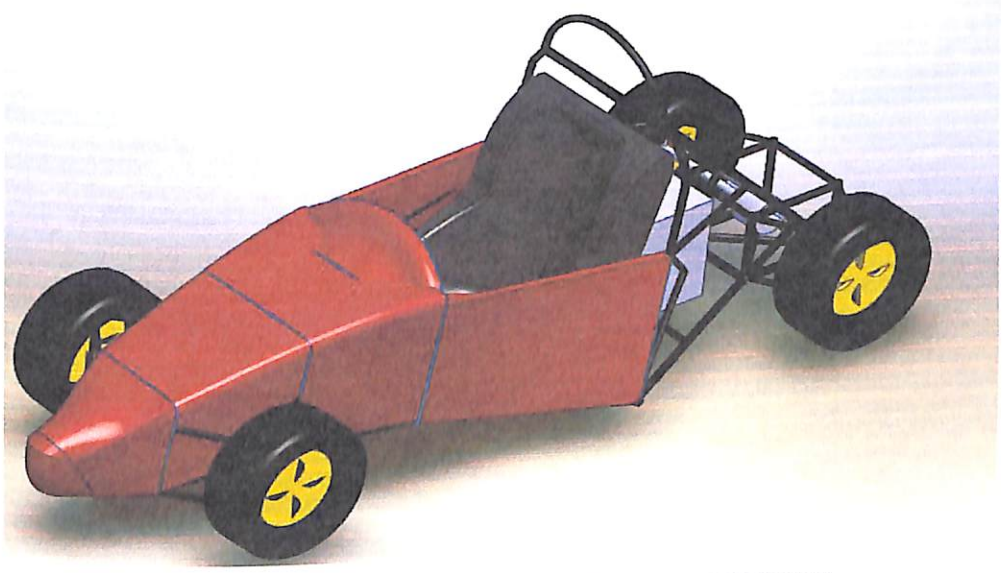

(TOP VIEW OF FRAME)



(ISOMETRIC VIEW OF FRAME WITH TYRES & SEAT)



(FRONT VIEW OF COMPLETE FORMULA VEHICLE)



(ISOMETRIC VIEW OF COMPLETE FORMULA VEHICLE)

## B-APPLYING MATERIAL

Conditions like ***availability of material, light weight, high strength, good welding properties*** keeping in mind we have chosen **AISI 4013 STEEL**, having below properties-

**Composition**

| Element | Weight % |
|---|---|
| C | 0.28-0.33 |
| Mn | 0.40-0.60 |
| P | 0.035 (max) |
| S | 0.04 (max) |
| Si | 0.15-0.30 |
| Cr | 0.80-1.10 |
| Mo | 0.15-0.25 |

**Mechanical Properties**

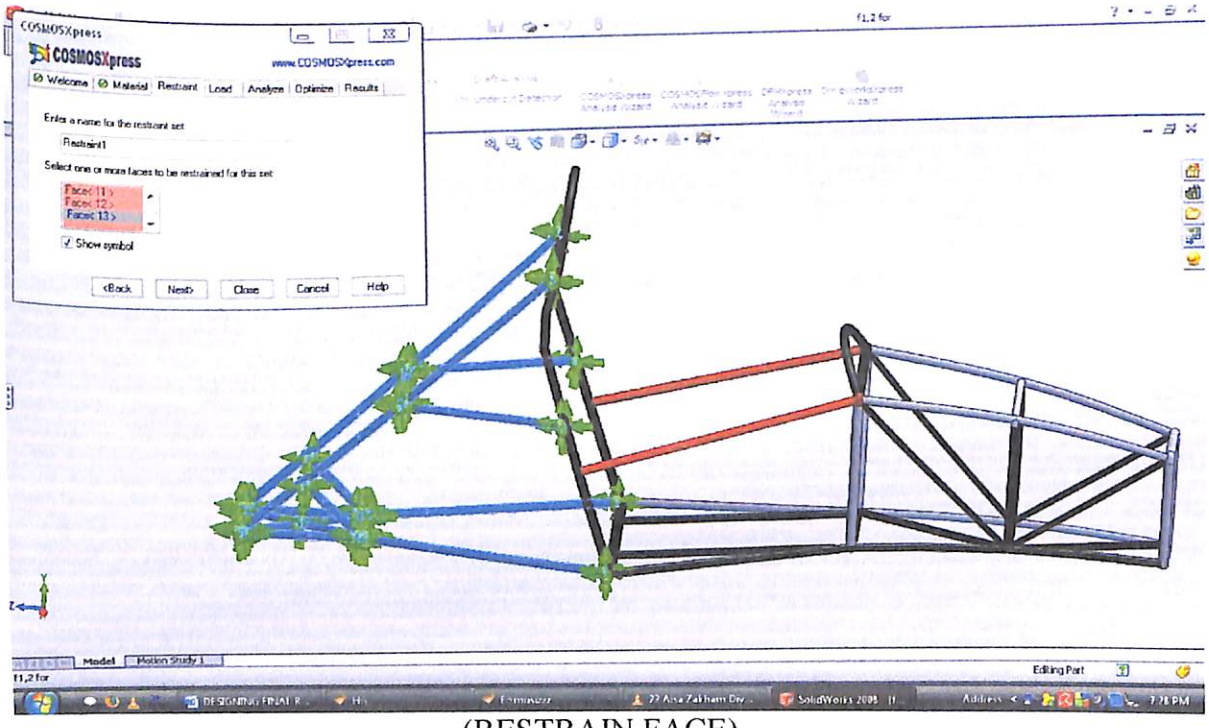
| Properties | | Conditions | |
|---|---|---|---|
| | | T (°C) | Treatment |
| **Density** (×1000 kg/m$^3$) | 7.7-8.03 | 25 | |
| **Poisson's Ratio** | 0.27-0.30 | 25 | |
| **Elastic Modulus** (GPa) | 190-210 | 25 | |
| **Tensile Strength** (Mpa) | 560.5 | | |
| **Yield Strength** (Mpa) | 360.6 | 25 | annealed at 865°C |
| **Elongation** (%) | 28.2 | | |
| **Reduction in Area** (%) | 55.6 | | |
| **Hardness** (HB) | 156 | 25 | annealed at 865°C |
| **Impact Strength** (J) | 61.7 | 25 | annealed at 865°C |

**Thermal Properties**

| Properties | | Conditions | |
|---|---|---|---|
| | | T (°C) | Treatment |
| **Thermal Conductivity** (W/m-K) | 42.7 | 100 | |
| **Specific Heat** (J/kg-K) | 477 | 50-100 | |

## C-RESTRAIN

To do analysis we have to first restrain some part of rollcage which will be least affected for that force. It means to fix some part with reference to which force will apply as shown in below snap with dark blue color-



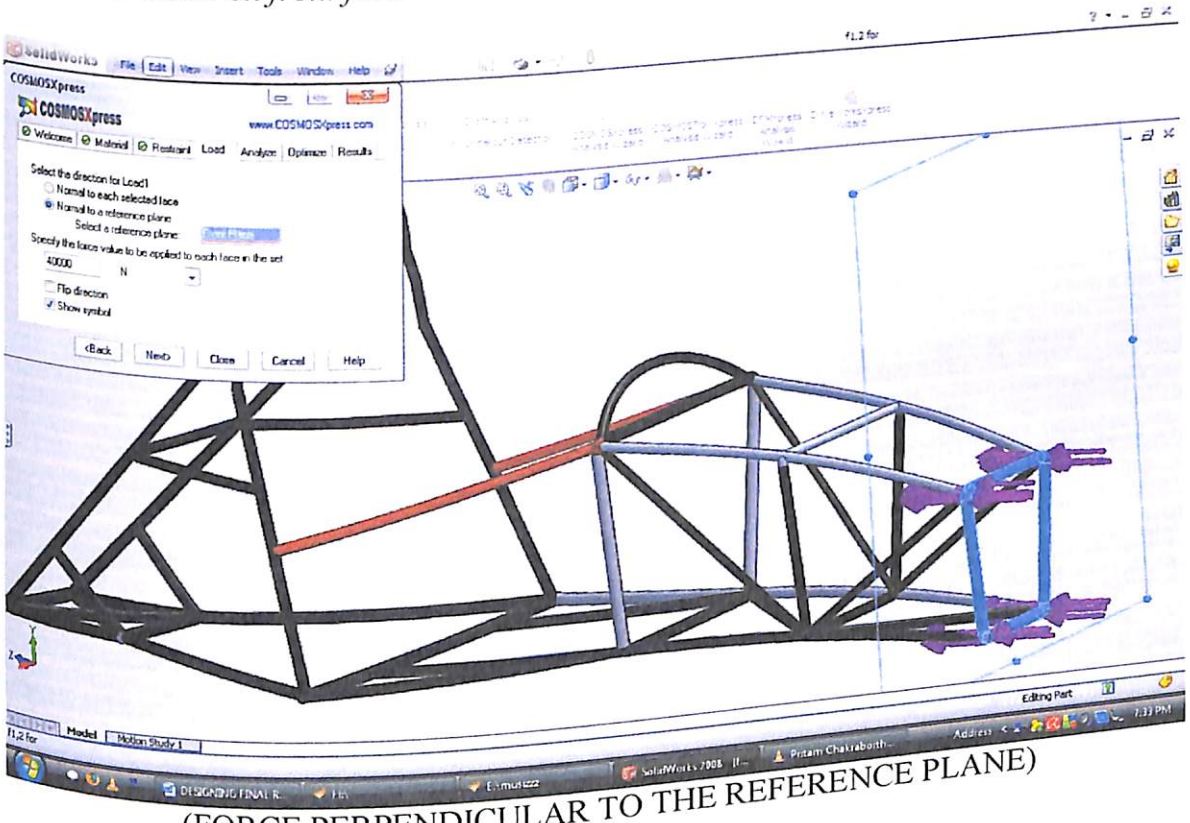

(RESTRAIN FACE)

# D-APPLYING FORCES & REFERENCE PLANE

In case of front impact test we select the face which will come first while collision. The force here; as shown is perpendicular to the plane.

We always test the vehicle beyond the force it will experience in real collision so that it will be safer for driver.

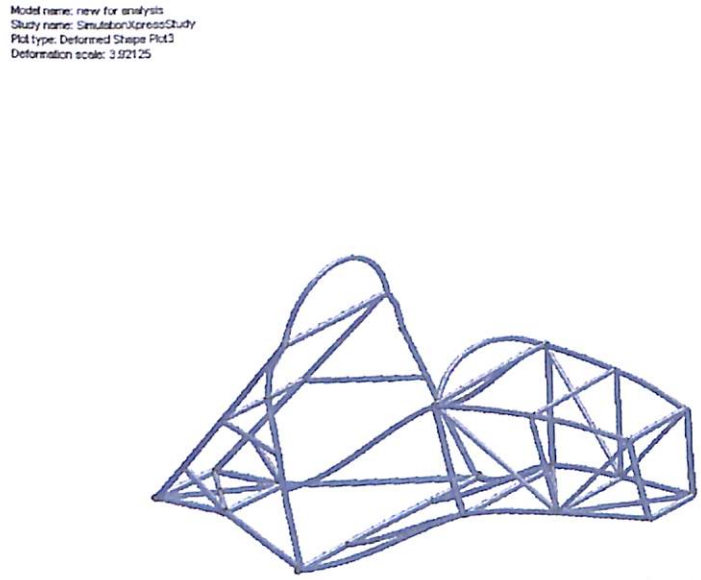
Here force is *4000N on front face*.




(FORCE PERPENDICULAR TO THE REFERENCE PLANE)

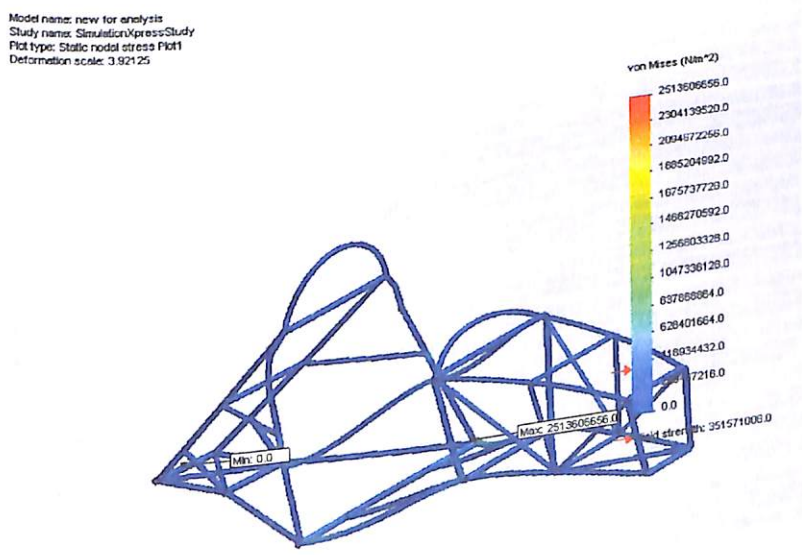
# E-RESULTS

a- Deformed shape plot for front impact test; at scale of 3.92126



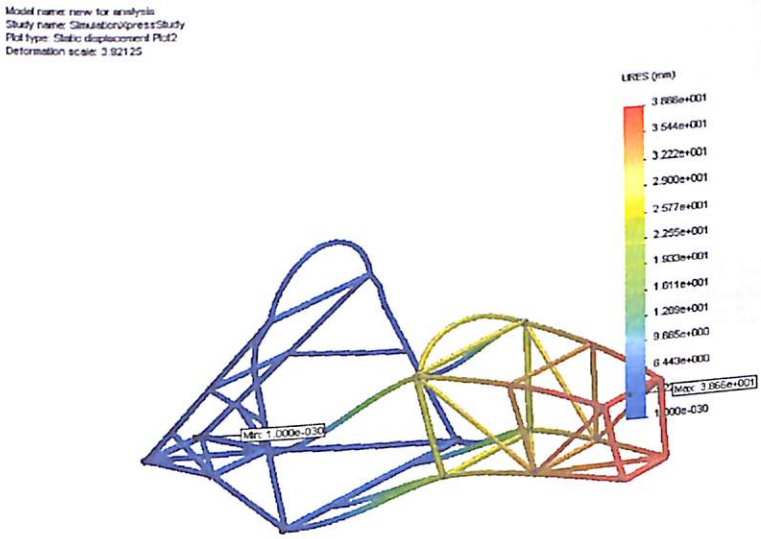

(DEFORMED SHAPE PLOT)

b-static nodal stress plot for front impact test



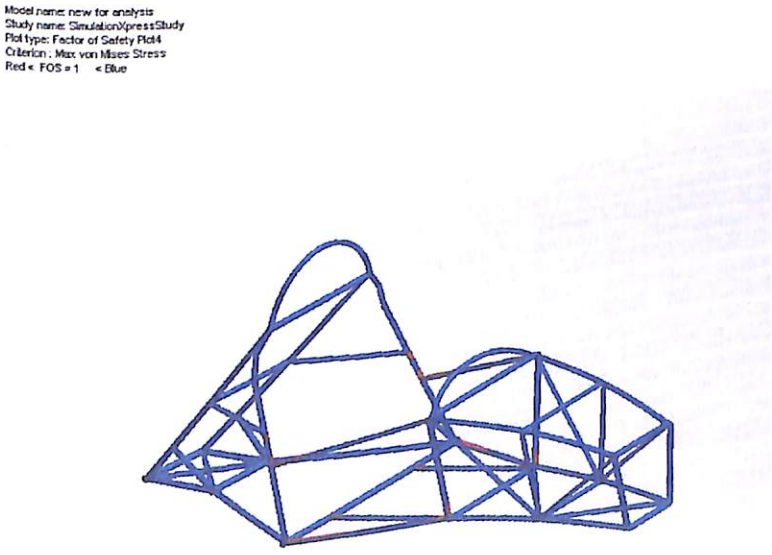

(STATIC NODAL STRESS PLOT)

c-displacement plot for front impact test; at scale of 3.1925




(DISPLACEMENT PLOT)

d-design check for front impact test; at scale of 3.92125



# F-DESIGN REPORT

The ***below analysis report is generated by software itself*** showing the details of element size, type, restrain faces, force on face etc.

1. **File Information**
2. **Materials**
3. **Load & Restraint Information**
4. **Study Property**
5. **Results**
    a. **Stress**
    b. **Displacement**
    c. **Displacement**
    d. **Factor of Safety**
6. **Appendix**

## 1. File Information

**Model name:** new for analysis

**Model location:** C:\Documents and Settings\cad\Desktop\new for analysis.SLDPRT

**Results location:** C:\Documents and Settings\cad\Desktop

**Study name:** SimulationXpressStudy (-Default-)

## 2. Materials

| No. | Body Name | Material | Mass | Volume |
|---|---|---|---|---|
| 1 | new for analysis | [SW]AISI 4130 | 18.5103 kg | 0.00234308 m^3 |

## 3. Load & Restraint Information

| Fixture | | |
|---|---|---|
| **Restraint1 <new for analysis>** | on **15 Face(s)** immovable (no translation). | |

| Load | | |
|---|---|---|
| **Load1 <new for analysis>** | on **8 Face(s)** apply force **4000 N** normal to reference plane with respect to selected reference **Front Plane** using uniform distribution | |

## 4. Study Property

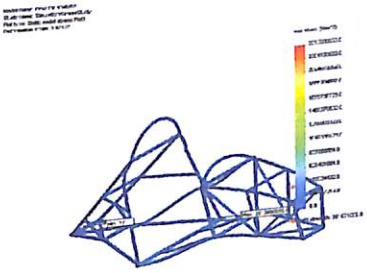
| Mesh Information | |
|---|---|
| Mesh Type: | Solid Mesh |
| Mesher Used: | Standard mesh |
| Automatic Transition: | Off |
| Smooth Surface: | On |
| Jacobian Check: | 4 Points |
| Element Size: | 4.5 mm |
| Tolerance: | 0.225 mm |
| Quality: | High |
| Number of elements: | 187233 |
| Number of nodes: | 326161 |
| Time to complete mesh(hh;mm;ss): | 00:03:59 |
| Computer name: | COELAB0010 |

| Solver Information | |
|---|---|
| Quality: | High |
| Solver Type: | Automatic |

# 5. Results

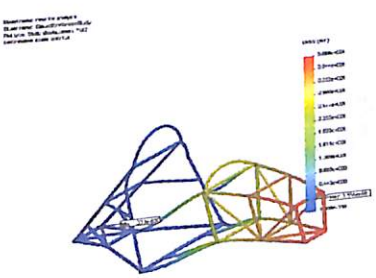
## 5a. Stress

| Name | Type | Min | Location | Max | Location |
|---|---|---|---|---|---|
| Plot1 | VON: von Mises Stress | 6.20506e-024 N/m^2 | (112.203 mm, -12.8118 mm, 1485.22 mm) | 2.51361e+009 N/m^2 | (-182.499 mm, -14.7587 mm, 889.533 mm) |

| new for analysis-SimulationXpressStudy-Stress-Plot1 |
|---|
| JPEG |
| VIEW  |

## 5b. Displacement

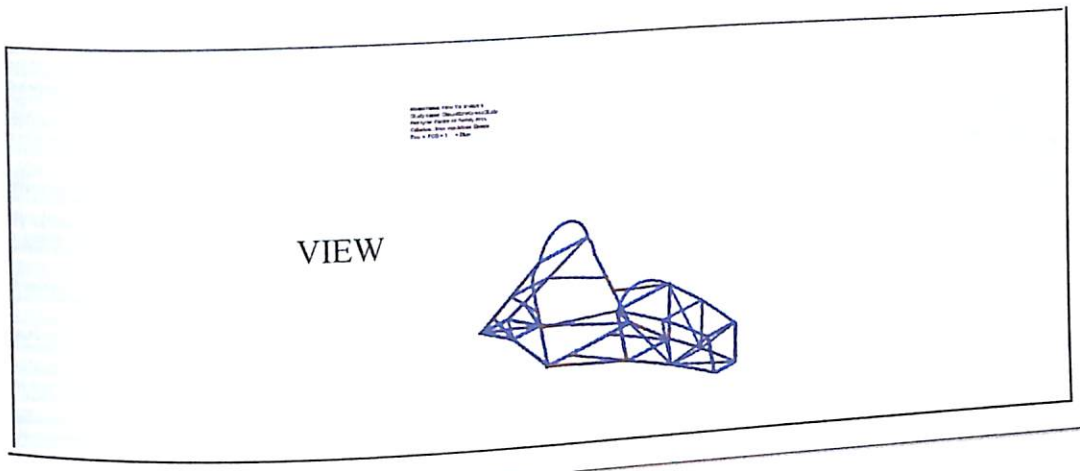
| Name | Type | Min | Location | Max | Location |
|---|---|---|---|---|---|
| Plot2 | URES: Resultant Displacement | 0 mm | (-20.4578 mm, 235.743 mm, 1229.3 mm) | 38.661 mm | (124.228 mm, 337.863 mm, 20.1616 mm) |

| new for analysis-SimulationXpressStudy-Displacement-Plot2 |
|---|
| JPEG |
| VIEW  |

## 5c. Displacement

## 5d. Factor of Safety

| new for analysis-SimulationXpressStudy-Factor of Safety-Plot4 |
|---|
| JPEG |




# 6. Appendix

| | |
|---|---|
| **Material name:** | [SW]AISI 4130 |
| **Description:** | |
| **Material Source:** | |
| **Material Model Type:** | Linear Elastic Isotropic |
| **Default Failure Criterion:** | Max von Mises Stress |
| **Application Data:** | |

| Property Name | Value | Units |
|---|---|---|
| Elastic modulus | 2e+011 | N/m^2 |
| Poisson's ratio | 0.29 | NA |
| Mass density | 7900 | kg/m^3 |
| Yield strength | 3.5157e+008 | N/m^2 |

**Note:**

SolidWorks SimulationXpress design analysis results are based on linear static analysis and the material is assumed isotropic. Linear static analysis assumes that: 1) the material behavior is linear complying with Hooke's law, 2) induced displacements are adequately small to ignore changes in stiffness due to loading, and 3) loads are applied slowly in order to ignore dynamic effects.

Do not base your design decisions solely on the data presented in this report. Use this information in conjunction with experimental data and practical experience. Field testing is mandatory to validate your final design. SolidWorks SimulationXpress helps you reduce your time-to-market by reducing but not eliminating field tests.

# G-OPTIMIZATION OF DESIGN

After analysis & design we optimize the design that it will be safe for that force & factor of safety with applied material.

# RESULTS

## ANALYSIS RESULTS

After successful sizing and analysis of the vehicle, the results were obtained that provide a significant data base that according to results to applied forces on AN ATV & FORMULA1 car are sufficient safe.

## PRACTICAL RESULT

AN ATV is fabricated & tested in natural environment conditions. The vehicle withstands in all conditions without any fault.

This shows that the analysis & practical results are safe for the vehicle.

# CONCLUSION

In this project, the modeling & analysis of **AN ATV & FORMULA 1** vehicle has been done. The project deals with the designing, modeling, analysis & fabrication of **AN ATV** & designing, modeling & analysis of **FORMULA 1 frame**. The analysis result shows that in case if front, side or rear impact the vehicle is safe. Also the material applied is economical & has good properties regarding vehicles.